Public Comments

Introduction Narrative:

If you buy into this being an Agrarian Occupancy, the facility is exempt from the Model Codes of the State of North Dakota except Mechanical/Plumbing Codes and Electrical Codes.

However, consider the intensity of use and size of these buildings (the Gestation Facility alone is more than 2x and approaching 3x the size of a football field – see Photo #5.1), the potential of negative environmental effects, and the Life Safety of the workers in this facility. In an effort to protect the lives of the workers, mitigate the potential costs in loss of property and insurance claims, and to protect the environment, we ask that the following concerns in the application, concerns over the quality of the design documentation, and ultimately concerns of the configuration and details of the design itself, be carefully considered prior to the issuing of the permit itself, and that notwithstanding if a permit is issued, when considering and stipulating the official Approval Conditions of the permit.

If this commercial facility is permitted, and these concerns are not addressed, and where appropriate, integrated into the Approval Conditions of the Permit, who will safeguard this Community?

A building of this size and intensity, in any other setting, would have serious code requirements to protect the Health, Safety and Welfare of the Public. If approved, we demand that the State Health Department use whatever tools (Approval Conditions) are available to truly live up to The NSHD purpose and mission statement:

> ***"The mission of the North Dakota Department of Health is to protect and enhance the health and safety of all North Dakotans and the environment in which we live."***

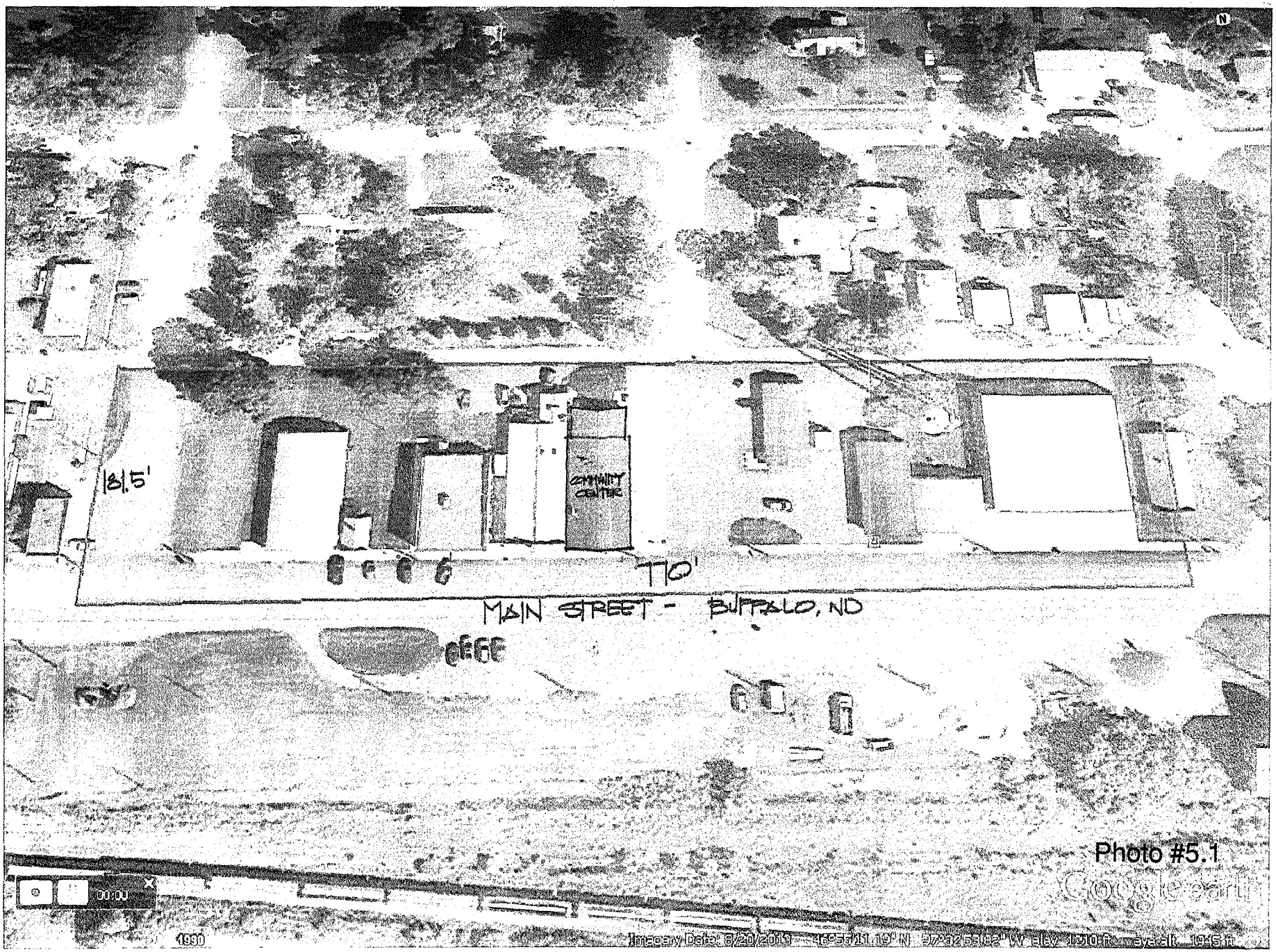
181.5'
COMMUNITY CENTER
770'
MAIN STREET - BUFFALO, ND
Imagery Date: 8/20/2013

Photo #5.1

Concerns on the Permit Application

Concerns on the Permit Application – Technical Specifications

When reviewing the technical portions of the illegal permit application, there are some real concerns regarding the care and quality of the work. One would expect a nearly flawless submittal (in terms of technical aspects), due to the intensity, size, and exposures of this facility.

General Quality of the Submittal:

17 locations where material requirements are not included/referenced

2 conflicts in the material requirements

Specific Issues: Section 5: Technical Specifications of the (illegal) Permit Application

Page 4: No references for "Methods 1, 2, or 3".

Page 5: Testing – no frequency of tests specified.

Page 6: "strip 4"- 6" of topsoil" is noted on the drawings – soil borings note 6+" - Placing fill on organics is a potential for consolidation and differential settlement.

Conflict with geotextile splice overlap on page 7, 18" or 24"?

Page 7: "If Proctor Density tests are to be performed on-site..." Why wouldn't they be required?

Page 9: Nine different notations to material requirements that are not included in the documents or referenced to a Standard

Page 10: Compressive Strength is not specified.

Page 12: Incorrect reference to "Section 24".

Page 14: Expansion Joints/Control Joints referenced to locations on the drawings and are not indicated on the drawings.

Waterstop specified by reference that is not included - the waterstop is a critical assembly for this facility. It should be definitively specified and should be subject to inspection.

Page 15: Reference to Section 24 which does not apply (two locations).

Page 16: Rates of application for curing compound are meaningless without a Product/material specified.

Page 17: Non-shrink grout not specified.

Page 18: Reference to "Nebraska Department of Roads" as a standard is not likely known by North Dakota Contractors.

Page 19: Rebar material requirements are referenced to non-existent Specifications.

ACI Standard 318 only is referenced. ACI 350R-89 is referenced in the North Dakota Livestock Program Design Manual, and is appropriate for the quality of care that the concrete in this facility should meet and should be included.

Page 20: Inspection of rebar is not included, however is critical to insure quality.

Page 22: Insure that ACI 350R-89 is met in regards to placing and coverage/protection.

Page 23: Incomplete directive under 3.10.1.6.

Page 24: Pipe bedding is not specified.

Page 25: Reference to Bedding "if required" - Bedding is a requirement to prevent settlement at fill areas.

Page 29: Redundant specification back to 2.6.

The above referenced items, as any one item do not pose a significant issue as long as they are remedied though a revised submittal. Collectively, however, they indicate a pervasive tendency that this technical specification was submitted as a nonresponsive boiler plate effort, or a submittal lacking professional quality control. Whatever the reason for the volume of errors, it raises concerns about the balance of the work product.

Concerned Citizens of Buffalo requires a stringent review as to whether this submittal meets minimum standards for its approval, however, as a minimum, all corrections must be made prior to the issuance of a permit.

Site Review Concerns

Site Review Concerns

40 Acres/1,263,690 S.F. Approx. 400,000 S.F. Impervious Surface Area/32%

The drainage of this 40 acres currently sheet drains into established field cuts/tillable drainage swales. Not all of the 40 acres drain into the same singular point that the proposed site modifications now cause (photo #5.2).

Please review the comments from Roger Kluck, P.E., civil engineer (Exhibit 5A, attached) regarding deficiencies in the storm water/runoff design/calculations/requirements.

The (illegal) Permit Application site plan indicates a 5 row shelter belt/tree planting surrounding the 40 acre site, and Part 9C: Order Control Plan, Article G. Best Management Practices , Paragraph 4 of the (illegal) Permit Application states "Vegetative barriers is proposed as a part of the plan to reduce odor" is also part of the (illegal) Permit Application. The concern is that there are no planting schedule/planting details/specifications in the permit application to establish this "vegetative barrier" and it will not get installed unless mandated. In the event it would be installed, it would be several years before it would have in any impact of beneficial service unless substantial specimen plants are utilized and maintained.

Please find the recommendations (Exhibit 5B, attached) that must be implemented in the Approval Conditions (from a qualified landscape company) as to the type, size, and spacing of plant materials, to make this a meaningful effort. Ongoing maintenance would also be expected under the Approval Conditions.

The (illegal) Permit Application indicates that water will be gained from onsite wells, these are not located on the plans (to insure safe setbacks from compost structures and runoff areas). It has been confirmed that the Applicant has approached Cass Rural Water for service to the site. It is assumed that the water usage will be in the magnitude of 500,000 gallons per day. Concerned Citizens demand, in the event that rural water is used, that a statement from Cass Rural be obtained to indicate this does not endanger the reliable supply of water to the City of Buffalo and the

surrounding water users and that any utilization/installation cost of this service be borne by the Applicant, and not passed on to the current users.

Ground Water/Subsurface Construction/Foundation Concerns/Site Elevation

Ground Water

The deep manure holding pits of the GDU/Isolation Facility and the Gestation Facility have a subgrade elevation of 1138.8 (with drain tile outlet elevation of 1137.0) and the water table, according to the soil boring logs (within only 2 hrs wait time – normally, especially in clay soils, the drilling company comes back 12 to 24 hrs later to establish the "static level"), indicate elevations of 1141.1 and 1142.9. This means that the "deep holding pits" have exposures of 4.1' and 5.9' (respectfully) into the water table. Again these water table depths were documented with only a 2 hr wait time and were executed during what can be characterized as a "dry late summer and fall".

The presence of this ground water presents additional very concerning issues. One of these concerns is that the shallow ground water has not been tested for its content. The following article elaborates on that issue and on the other concerns.

Subsurface Construction

From the permit application, 2" granular subgrade fill is documented under the deep pit slabs. The drain tile is 4" diameter connecting into 6" diameter end tile. The 4" tile runs longitudinal under the facilities on 40' centers.

From the (illegal) Permit Application it is stated;

> *"Leak Detection:*
> *Drain tile will be placed under the deep pits of the gestating barn and the isolation barn that will serve a dual purpose: (1), it will collect any clean water from outside the deep pits, thereby acting as a leak detection system, and (2), it will collect and clean water from outside water sources from applying pressure to the walls as well as premature deterioration of the concrete. Water collected in the drain tile will be collected in a shallow containment pond."*

That statement acknowledges the potential for leaks in the pits. Thus the real threat of the sump water being "effluent" and not "clean water". There is a concern that if a leak develops, there is no way of addressing it without a very interruptive structural repair effort, say nothing of the timeliness of actions before the leak is detected and acted upon.

Concerned Citizens demand the following concerns be addressed by adding the subsequent resolutions/mitigation efforts be added to the Approval Conditions. Due to the extremely high potential of hydrostatic pressure under the deep pit floor slabs, increase the granular subgrade to at least the depth of the tile (4" or 6" respectively) it is feeding, reduce the spacing of the tile to 20' centers, and require that the granular fill be a free draining "pea rock" or similar material. These changes will be necessary to reduce the hydrostatic pressure from beneath the pit slabs, and to carry away any "leaks" from the pit that may contaminate the ground water.

Further, to reduce the potential for ground water and surface water runoff, the sump water must be treated like "effluent" and be "completely contained" not just retained. It cannot be allowed to run across the property to the south. This containment pond must meet the requirements outlined in the ND Department of Health, North Dakota Livestock Program Design Manual, Section 5 and any other applicable requirements of that publication.

As mentioned previously, this sump water has not been tested for salts, alkalinity, etc. The permit application design will have this water running across the neighboring agriculture crop land (to the south). This must not be allowed for two reasons; first, it has the potential to "poison" the topsoil and reduce crop yields by adversely affecting the PH balance in the soil. Secondly, it will result in an almost continuous flow of water into field drainage cuts that already collect the bulk of the upstream water and make the SW ¼ of Section 4 one of the last fields that can be accessed in the spring due to wetness. Allowing the increased flow of surface water and adding shallow subsurface water will exasperate this existing condition making it impossible to till and plant in a timely manner each spring, thus negatively impacting the neighbor's crop operations (see photo #1 for confirmation of the

water flow). The Owner of that agricultural land is committed to take separate legal action to protect this from happening.

Foundation Concerns

The pit construction (slabs and walls) will be subject to considerable forces both hydraulic (from the manure within and from ground water) and from surloading of the adjacent site. Further the concrete with be subject to severe sulfate exposure due to the contained manure and potential contaminated ground water. These concrete assemblies are required by the North Dakota Livestock Program Design Manual to meet the requirements of ACI (American Concrete Institute Standards) 318-89, ACI 350-89 and ACI 351R-93/AWWA (1994).

Mix design, rebar coverage and placement are all in question. With the amount of initial curing shrinkage, due to lack of control joints, and temperature movement (5+" as calculated under the Design/Plan Analysis portion of this report), due to the size and lack of expansion joints, the concrete structure will see a deterioration after only a couple years of seasonal temperature stress and movement. As per publication ACI 350 – Requirements for Concrete Exposed to Sulfate-Containing Solutions, Table 4.3.1, the mix design (required to be 5000 PSI compressive strength and sulfate resistant additives – pozzolan, utilized), pit liner, rebar coverage and placement all must be integrated into the Approval Conditions to reduce potentials for deterioration of the concrete structure and subsequent environmental contamination. It is an engineering fact/standard of care, that when loading can be expected from either side of a foundation wall, a double matt (inner and outer) should be utilized to contain the tensile forces on each of the opposite face of the wall and to minimize elongation of rebar to minimize how much a crack can open – thus minimizing leaks. The (illegal) Permit Application does not include a double matt. Further, it is common practice (and also contained in the North Dakota Livestock Program Design Manual, page 36) to protect "steel and other corrodible material".

To meet this requirement, the Permit Application would require epoxy coated rebar and misc. embedded items (anchor bolts, embedded angles etc.) be fabricated of

stainless steel items in the Approval Conditions to protect this facility (if approved) into the future. None of these requirements have been meet.

One of item, which may seem insignificant, is the specification, location and details for water stops both at construction joints (joints between concrete pours) and assembly joints (joints between walls and stabs etc.). These assemblies are critical to contain contamination from "leaking" into the ground water. These assemblies need to be of high quality, carefully specified and detailed, and finally, inspected.

Site Elevation

The biggest singular requirement that must be placed into the Approval Conditions, is to require that the site elevation (individual deep pit structures) be raised above the established ground water table. Failure to do so will immerse the manure pits well into the established water table and expose the water table to an inferior design destined to leak and cause contamination. The invert of the drain tile should be at least 1' above the reported water table due to seasonal variation and some "freeboard" to protect the ground water from potential contamination. This translates into setting the subgrade of the GDU/Isolation Facility and the Gestation Facility to approximately 1145.0, effectively getting the pits and the associated drainage assemblies approximately 1' above the established ground water elevation.

Additional Construction Concerns

Additional Construction Concerns

Differential Settlement

The Farrowing Facility footings and foundations (shallow pit) bear on fill material, the Gestation Facility footings and foundations (deep pit) bear on excavated ground (undisturbed). Further, the soils directly below the fill (under the Farrowing Facility) have a very low bearing capacity rated at 5 blows per foot – as noted from the "N" Values (Blows/Ft) from the Soil Boring Logs.

Given the size of these facilities, and the vastly differing bearing characteristics of the soils, there is a very high potential of differential settlement within the footprint of each facility and between the facilities. There is a 10" connecting PVC sewer pipe that connects these two facilities (100' apart), and it is set at .5% slope and is gravity fed. The potential for problems include constant plugging to outright pipe shear/failure and subsequent ground water contamination.

Water Table Level/Borings

As previously mentioned, the static water level was documented in a time frame of 2 hrs after the initial drill. In clay type soils is can take a minimum of 24 hrs, to as long as a week, for the water level to stabilize to its static or uninterrupted levels.

Within the North Dakota Livestock Program Design Manual, under Section 4. SITE SELECTION AND ASSESSEMENT STANDARDS, Article 4.3.2 Site Assessment Requirements, it states:

> *"There shall be a minimum of three soil evaluations in the manure storage structure area..."*

This requirement has not been met at the deep pit of the GDU/Isolation Facility nor the Fallowing Facility – both of which not only receive the manure, but also contribute to the storage capacity of the facility.

Facility Plans

Given that this structure is an "agrarian" occupancy, and that it is not subject to a local jurisdiction of authority, in terms of general building code enforcement, however, due to the size, use, and intensity of its function, and potential of risk to animals, people and environment, NDDH must require that basic building plans of the superstructure be submitted for some level of review. Only site design and foundation details have been submitted under this permitting exercise. This when one of the buildings will be subject to over 5" of temperature movement in its foundation, and over 7" of temperature movement in the metal structure above (see expansion calculations at the beginning of this section).

Critical construction activities and assemblies such as excavation (inspection of trenches), rebar placement, concrete forms, waterstops, etc. all should be subject to special inspections and/or independent inspections from a qualified construction inspection agency.

Mechanical/Ventilation

No information is included in the Permit Application that deals with specific movement of the air through the facility, especially from the manure pits.

Bio-filtration is not included in the submittal under Section 9A: OPERATION & MAINTENACE GUILDLINES, Article IV. (Oder Control). It has been mentioned several times by supporters of this facility, that claim to have knowledge of this fact, that, the facility will be use "odor filtration" and that "...odor will not be a problem - These are lean and green and there are "after burners" that eliminate the smell...".

Given that assurance, the Concerned Citizens demand that Bio-filtration of the exhaust air leaving these facilities be installed and maintained as an Approval Condition.

Electrical

No information is included in the Permit Application that deals with specific conditions of the electrical service and systems.

The following excerpt comes from the University of Minnesota Extension Fact sheet of September 5, 2012:

> *Foaming on the manure surface in deep-pit barns is not a new phenomenon, but until recently spontaneous foaming was rare. Foaming incidence has increased significantly since 2008 and concerns over the potential hazards posed by foam have risen accordingly.*

It is a very well-known condition that in the Midwest there have been problems with manure foam forming over the top of the manure when in deep storage pits. These recent studies have looked at the effectiveness of using rumensin to treat these pits. Spreading of the manure containing this chemical has not been approved.

The following is also an excerpt from the above referenced publication:

> *Note that **neither** Rumensin 90 **nor** Coban (both trade names for rumensin) is environmentally approved to be added to manure in a pit if the nutrients will be added to the land.*

The following excerpt is from a white paper titled "Op Ed: Fundamental Problems", dated September 2010, by Bob Watson and included in the publication "Unintended Health and Environmental Consequences of CAFO Agriculture" by Bob Watson and Larry Stone:

> *Based on the conversations with producers at the World Pork Expo, this op-ed concerned the problem of foaming in pits beneath hog confinements, exacerbating the already serious problem of dead pigs and flash fire caused by hydrogen-sulfide and methane*

The concern for flammable build-up remains in these pits and with documented fires which results in almost total loss of livestock. One such fire which occurred May 11, 2015 near Jasper Minnesota, resulted in the death of two workers that were cleaning the facility, and a total loss of structure.

A report from the Kansas Chapter of the Sierra Club titled "Pig Confinement Technology Risks Deadly Fires" dated August 12, 2013 states;

> *In 2011 and 2012 there were at least 22 hog barn fires in the U.S. and Canada that killed over 28,000 pigs.*

Given the real exposure/existence of explosive/flammable gases being released and subsequent potential of flash over fires, it is imperative to consider classifying all electrical devices – that is making lights, switches, motors, etc. explosion proof. Given these conditions, the Concerned Citizens demand that all electrical devices be "Class 1 Division 1" (explosion proof) as an Approval Condition.

Summary

Summary

Like the review of the technical specifications there are a multitude of concerns, however unlike the technical specifications, any one of the above referenced design/configuration concerns, can pose a significant issue to create serious risks to animals, environment, and people. Collectively, they create a facility that cannot be permitted to move ahead and again give cause to deny the approval of this illegal permit application due to the pervasive tendency of these multiple concerns.

Again, the Concerned Citizens of Buffalo request a close review as to whether this submittal meets minimum standards for its approval. In the case of the afore mention design/configuration concerns, **ALL** corrections/modifications must be included as an Approval Condition, prior to the issuance of a permit to protect animals, environment, and people from serious risks.

LEE FRAASE

The first page of this permit application lists the elevation at 1,142 feet. Next is site drainage. The permit application states "that the facility drains south with the help of surface drains located in the field. The drains flow into the road ditch a half-mile south of the site. The road ditch flows south under the road into other ditches, into Buffalo Creek, and eventually into the Maple River 18 miles southeast."

True, it does end up in the Maple River by way of the Buffalo Creek. However, it takes a different route to get there. I will show you that with elevation and natural drain maps. But first I would like to share a little history with you. Most of our farmland starts a half mile east of the proposed site. We also have land west of the site. The main farm is 1.5 miles southeast, with two houses onsite. My nephew's new house, built last summer, is 1.5 miles straight east (they built their dream home near the farm and are expecting their first child in June). My house is 1.5 miles northeast. Pipestone was obviously more concerned about a vineyard than their neighbors who are downwind and downstream. I want you to realize today the type of people we are dealing with. (Do anything for ourselves and we don't care how it impacts the neighbors or the community.). Pipestone is quietly sneaking in and trying to build this hog farm. I asked Rodney Hogan (who owns Red Trail Vineyard) just a little over a mile northeast of the proposed site, did they come and talk to you about this proposed hog farm? Rodney said, and I quote, "Yes, they talked to me last spring (spring 2015) because they were concerned about my vineyard". So we were quite surprised when the permit application turned up in the paper on December 28, 2015.

I have a few more facts to share. Dr. Barry Kerkaert would not return my calls until Randy Melvin texted him to call me. Randy could not answer my questions, as he has never had any type of livestock on his farm. We grew up with livestock on our farm, and as most of you know, we had a farrow-to-finish operation for 30 years. When we pumped our small lagoon, our neighbors knew it. When Dr. Barry called, he answered many questions. I told him he needed to explain those things to our neighbors. Both he and Randy agreed to sit down and talk with a few of the people here. I was not OK with just that. I wanted them to come here and answer questions for everyone. When Dr. Barry finally agreed, he suggested I invite all the local Buffalo businesses too. He spoke at a public meeting on January 18, 2016 in Buffalo. The final date to get our letters of concern to the Department of Health was January 26, 2016, just over a week before we had any questions answered.

Our farm is located just to the east of this proposed site. It is on the west side of the third beach of Lake Agassiz. Because we have "beachfront" property, the elevation drops. From the proposed site at the southeast corner of the northwest quarter of section 4, 139 – 54 (Howes), you show the elevation as 1,142 feet. Page four says the bottoms of the pits are a proposed relative elevation of 1,138.8 feet. This map shows the ditch and the drop. Approaching the Ayr road, the field elevation drops to 1,130 feet. So, the bottom of the huge manure pit will be about nine feet higher than the field elevation next to the Ayr road. (Cass County Rd #3) The total drop in that half mile is 12 feet. Let's continue through the Ayr exit culvert and go east in the I-94 ditch (past our farmstead) 1.75 miles to the bottom of our pasture – slough, as we call it. Below the beach line, the elevation is 1,079 feet, for a total drop of 63 feet. This main ditch goes to the southeast. The water from this site does not go south like you say it does. Look at the color of this higher elevation. To the west, this ditch goes south, but it brings water from north and west of the site.

They are two separate ditches. Look at this small yellow ditch. The water in this ditch comes from the neighbor's (Jerry Marck's) southwest quarter and it enters the I-94 ditch 80 feet east of this culvert that takes water south into the I-94 south ditch. This spur runs north into the main southeast ditch that comes from the proposed site, and this ditch enters the I-94 ditch 133 feet east of the culvert that goes under the westbound ramp. The water under this westbound ramp travels east about 348 feet and then south under both lanes, and then goes back west 348 feet to find the south exit culvert under the eastbound ramp. Water in this country flows southeast. It's nearly impossible for the water to flow back west. These culverts are west of the outlets of the ditches, so what's the point? Jerry Marcks' ditch has some flow south under the ramp, but with 133 feet between the ramp culvert and the southeast ditch, most of the water flows to the east (downhill) through a culvert that takes it east (under Cass County Rd #3) along the north side of I-94's (westbound) ditch and along our service road. Many times, the service road to the southwest of the exit has water run over it, but it's not coming from the proposed site. That water comes from the west and northwest further upstream. I've seen this for most of my life, going on 58 years.

Because of the drop and the narrow road ditch between the westbound lanes, and the two houses (I-94 westbound lane is the old Highway 10, and they didn't expand the north ditch when I-94 went through) the water screams to the east and has sometimes caused wet basements. So, the North Dakota Department of Transportation installed three dams near the culverts to divert the water so more of it went east on the south side of I-94's eastbound lanes. Heavy rainfall still allows a lot of the water to go by our farm again. Because of the drop, water goes over the dams faster than it can get through the culverts.

Where am I going with all of this? Excessive rainfall could make their containment pond overflow. Sump pumps will dump into that pond from the drain tile under and around this pit. Manure waste will leak overtime from this 758 ft by 169 ft pit, because a concrete structure that large will crack. So, contaminated water from this containment pond will be pumped out onto the land and flow southeast past our farm and end up in the flat slough bottom that has wetlands in it. Who will be held responsible when these wetlands are contaminated by a commercial hog operation? Yes, they say there will be a dike surrounding it. Dikes can break under heavy rainfall. Some large CAFOS (Concentrated Animal Feeding Operations) like this have pumped manure over the dike into the fields just to save their dike. A major spill from the pit (which has been built essentially above ground due to the high water table) at this site should be a concern, as well as ground water contamination. Again, do you really want to issue a permit here and run the risk of contaminating wetlands? I have a National Resource Conservation Service (NRCS) maps showing that the slough bottom is very flat and the water just sits there. The water eventually ends up in Buffalo Creek, just not the way presented in the plan. To me, it looks like you have not done your homework. Plus, is there no concern for the neighbor (Jerry Marcks) who is farming the quarter of land that is directly downstream of this pond and the entire site? When this pond needs to pump a little water/excess nutrients off of the site, it will be pumped directly onto a neighbor who had no idea this hog farm proposal was even in the works. This neighbor will be significantly impacted by excess contaminated water flowing across the land that he is farming.

Rolling Green Family Farms is trying to sneak its way into North Dakota before anyone realizes it. You may feel they have done enough to sneak in under the current state laws, but I encourage you to check into all the complaints they have encountered in South Dakota. This isn't their first

rodeo. Why do you suppose they brought legal counsel (Sean Simpson) to the first meeting? By the way, again, we had to demand that they would open up this meeting to the public. If this is supposed to be such great thing for all of us neighbors, community, and the state of ND, why did they keep it so secret?

Notice this blue line. This ditch is called an intermittent stream (NRCS determines this by how much water flows through it, more than an average ditch). The highest spot in this section 29 pushes 1,200 feet, The RR tracks breaks up this stream. So starting at the tracks the stream elevation is 1,170 feet. As it goes to the SE, it goes into my CRP in sec 34 (they classify my CRP a filter strip because of the intermittent stream see yellow on map), then into our pasture in sec 35 where we have a running well depositing into a shallow dugout for the cows. It continues east through more filter strip CRP, crosses the beach line, and dumps into my other pasture stock pond in the SW 1/4 of sec 36. It continues on downhill nearby the old farmstead shallow well and then into Garsteig's Dam just a mile further downstream. Elevation near that old well in the pasture is about 1,066 feet. That's a 104 feet drop in just over four miles. This well has an 18 inch culvert going down, not sure how deep they dug it but it is a very shallow well and the water level is only down 8 feet from the surface. Again being it's off the old beach line (in the sand as we call it) it has a high water table. The bunkhouse where the man used to live is still used for storage on our farm.

As you see these two quarters outlined in red, there is a good chance manure will try and be knifed in there also. Same farmer farms these qtrs as well as sec. 29 and NE sec. 32. The potential contamination here is a very large concern.

Known fact is that land closest to the manure source gets over-fertilized. (been there, done that). Even when it is knifed in the soil there is some that lays on top and spilled on headlands. If the fall soil conditions freeze early they may try to get a permit to lay some on the surface. What else can they do when they need room in the manure pit. Even though phosphorus does attach to the soil, it can move by surface runoff. Whatever lays on top of the soil can move. Over 40% of the soil they applied for as acres to knife-in their manure is mapped Hamerly-Tonka soil. This type of soil is very limited in its ability to take-in the manure and have the soil and plants use it. In other words, 40% of the soil they plan to apply manure to is not suitable to take the manure (see USDA Web Soil Survey – Manure Management). This type of soil has a high water table and can be often saturated. This means plants will not typically be growing as well in these areas and so manure applied here will not be taken up as readily. In these conditions, nitrogen will likely denitrify and be lost to the atmosphere or potentially contaminate the water it is applied into. Because the water is not able to leach away, it sits there on the surface or top foot of the soil with the manure in it. So on these soils you are looking at more of a surface water contamination issue, because these soils are poorly drained. The water can not move down and away very fast, so the manure can also not move down and away in the soil. The poor growing conditions of these plants here will not utilize very much manure. (Good growing healthy plants do not like wet feet.). Over-applying N and P levels not only can cause contamination but also will raise the salt levels in the soil. ND has plenty of saline soil we don't need anymore. Also, numerous old farmsteads exist in these fields where manure will be applied. This is a concern, because these old wells were just bulldozed over and not properly sealed. Over-application of

manure will lead to water contamination through these unsealed, buried old wells. Lastly, the geology of this immediate area of the county (near the beach ridge) indicates there are eskers below the ground where this great amount of manure will be stored and applied. These sandy/coarse underground soil lens are significant features of the soil that make the water movement below this area prone to more rapid lateral movement. Unique soil conditions causing unknown water movement below this site and below the fields that will be applied, is very concerning.

Look close here there are four old farmsteads where extra manure could easily be put down. Just over a mile away in the NE qtr. Of sec. 6, the Von Banks still water their garden and flowers with their shallow well. Yes and by the way you do not have on file the history of this well just like many more in the area? Your list of wells in the application is very incomplete. That should be a concern to you. Also there is a shallow well in the SW qtr. Of sec. 10 in Tower township that the family still uses and less then a half mile away the plan is to apply manure there (8,000 gallons/acre). The shallow well is four foot square with a pump in it that pumps to the house and also to outside hydrants. That water has been drank in the past. These photos show the old farmsteads.

Is it true, that the ND Dept of health has not been out to look at this proposed site and surrounding areas that are a great concern for us as neighbors, the local community, and the great state of ND?

I have talked to three custom manure applicators from MN. Denny from Alexandria MN, Todd from Villard MN, and Brian from Long Prairie MN. All three prefer to pump the liquid manure rather then truck it because trucking is more expensive and also very hard on local gravel roads. The going rate can start out .013 to .022/ gallon pumped. They like to pump 8,000 to 12,000 gallons/acre. 8,000 gallons/ac is the minimum because otherwise it is too hard on the hose that gets dragged through the field behind the applicator. (Compare a nice round basketball to a half inflated football, which one rolls easier)? Another farmer I talked to, Ron from SD who has pumped a lot of liquid manure confirmed with me you can't go less than 8,000 gallons/A. These applicators get paid by the gallons pumped not the acres they go over. VRT (variable rate technology) works great in the commercial fertilizer industry, you only pay for the amount of fertilizer you are needing. Again the applicators will not cut their rate because of the hose issues, so many acres are over-applied and so the farmer in many cases is paying for the extra fertilizer that he does not need and the environment is also negatively being impacted. For example if the soil test calls for more N and doesn't need any P, you apply your 8,000 gallons to get your N needs covered but then you over-apply the soil with P and over time you can "burn" out the soil. And also salt levels will increase (saline soil). There are many scenarios you can come up with but the bottom line is the closest acres get over-applied and that can cause contamination to the soil and ground water. Knifing manure in is a good way to apply it but seepage and spillage are two concerns. From this huge pit, where the plan is to pump 8,000,000 gallons a year, the cost could be $104,000. Up to $176,000. If they have to truck a lot of it. On their plan of 1,100 A. / year that works out to be between $94 and $160/ Acre. Example: today's local fertilizer prices for 150 bu. Corn work out to be $121./A. They said at the public meeting their manure would be charged to the farmer between 60% and 70% of the local going rate of commercial fertilizer. Do

the math, yet another example how they "fudge" the numbers to make it sound good, again to "snow" the farmers and the state of ND to help sneak their way into our state before we realize what is coming. The 3,300 acres that are needed (1,100 A./ year, three year rotation) are spread over 24 qtrs of land. The first year 8 qtrs. Are within 2 to 3 miles but also need to cross BNSF railroad tracks. The second year 8 qtrs. Range from 2 to 7 miles (ave. 5 miles) and will have to cross I-94 and state highway 38. The third year 8 qtrs. Range from 4 to 10.5 miles (ave. 7.5 miles) and will have to cross state highway 38, BNSF railroad tracks, and the Maple River. This helps explain why it will cost so much to apply this manure in this area, it will be cost prohibited to use. So where and what are they going to do with all that manure? They have not looked ahead very far. They do think they will be able to apply it more locally to neighbors fields. Interesting though they have not talked to the majority of their neighbors about this. Boy do they have a surprise coming. I myself almost feel sorry for these people that are that naive. What is good for us and crap on our neighbors. If it is supposed to be so good for all of us why was it kept such a secret?

In conclusion many of us, having had small hog farms for a number of years, know the day-to-day issues and problems that can happen. So when a hog operation is enlarged to this extent (100 times larger than ours was) the issues will be exponentially larger. We are concerned with how these issues and problems will be handled and/or not handled with regard to possible contamination to the ground water and adjoining farmland. Will this become a super fund cleanup, a Rolling Green Family Farms cleanup or will our township or county have to cleanup. We are very concerned. Is the ND Dept. of Health going to monitor this?

Opening Statement: My name is Lee Fraase. My concern is the elevation drop, water runoff, and soil contamination and how it will affect our farm and the neighbors farms. Not only are we downwind but we are also downstream! My brother and I had a farrow to finish operation for over 30 years and this proposed hog farm is 100 times bigger than what ours was. This 15 million dollar site will only pay $320. In property taxes.

Southeast Drainage

The elevation at the proposed site is 1142'. Because of the water table, the bottom of the 8.6 Mgal pit is at the proposed elevation of 1139'. The elevation in the SE corner of this field is 1130'. So there is a 12' drop in this 1/2 mile and that means the field next to the county road is 9' lower than the bottom of this huge pit. Yes, they plan to build a dike around the site but dikes can break. Or worse yet the huge Enviropork farrowing facility at Larimore ND in June 2000, experienced over 20" of rain in 24 hours and in order to keep the pressure off of the dikes, they were forced to pump the manure over the dikes onto the adjacent fields and eventually running into the river. (Photo #1)

If a leak would happen most of it would be coming down I-94 ditches by our farm and down through Lake Agassiz 's second beach line and settling in the flat shore bed of Lake Agassiz. This elevation is 1079'. That's a 63' drop in these 2 1/4 miles. (Photo #2)

This map shows how the water flows SE from the proposed site (see the darker colors, means higher elevation, it does not go south (**show ditch on big wall)** a shallow containment pond is planned to catch runoff water from the site and also drain tile will be placed under and around pits to collect any dirty water which may escape from the pits and pumped into this pond. Where will this water go when the pond is full? There could be times that the pond could be being pumped out 24 -7. My first concern is how Jerry Marcks (who is the first downstream neighbor) will get to the NE corner of his quarter to farm it, plus what will this contaminated overflow water do to his land and my land further downstream. (Photo #3)

This map is more detailed on where the ditches actually go. Water runs downhill, just ask Fargo. If you look close, this small ditch comes from

Jerry Marcks SW 1/4 of, and comes into the highway ditch just east of this I-94 culvert. More interesting the main ditch from the proposed site comes into the highway ditch 133' east of this ramp culvert (which is downhill of the culvert). So all of the proposed site water moves quickly to the east and collects along the county road flowing eastbound, not southbound, like the permit application claimed (**Explain south water flow through interchange**). (Photo #4)

Air plane photos next. (Photo's #5 & #6)

As the water goes east (in between our service road and the north highway ditch) there are 4 culverts and three small dams here that help divert the water to the south highway ditch, but we still get some of this water by our two farm houses and farmyard. When I 94 went through in the fifties they would not move the houses instead they jogged the right of way. So water seepage in these basements has been a problem since then because of the narrow right of way ditch. Now being this water could be contaminated, this is even more of an issue. The water then continues east, dropping over the old Lake Agassiz beachline and settling in to the very flat Lake Agassiz shore bed. This shore bed drops less than 1' per mile as it heads south to the Buffalo Creek. (Photo #7)

This map shows the very flat Lake Agassiz shore bed in our pasture, which contains some wetlands and our stock pond. (Photo #8)

This same flat Lake Agassiz shore bed continues south with very little elevation change and more wetlands. (Photo #9)

North Intermittent Stream

Also, north of the proposed building site is an intermittent stream (NRCS determines this by constant flow of water for long periods of time) that flows southeast through my land, across my CRP filter strip, near my house, next to one open running well, and drops down across the old Lake Agassiz beach line and dumps into my stock pond. This land drops 104 feet in four miles. After this drop, this intermittent stream then continues dropping east through my pasture and

right by my shallow open well and then flows into Garsteig's dam, which is part of the Buffalo Creek. (Photo #10)

The land in pink are upstream of my land and is signed up to have manure applied to it. Spillage, seepage or just surface runoff (that's how phosphorus moves) will occur especially if applied to the soil surface after an early freeze up. You do mention setbacks, Will you be out there measuring the correct footage on these setbacks? All the applicator has to go by is that white line you drew on the water quality risk assessment maps. (Photo #11)

This map shows the path the runoff from the site and this intermittent stream come together as part of the Buffalo watershed and both go into the Maple River. (Photo #12)

See old well pictures

The shallow open well in my pasture, is from an old farmstead, but because it has not been converted to farmland it has not been bulldozed over, like most old farmsteads were. See the 18" culvert and two weeks ago the water level was 8' below the surface. (Photos #13, & 15)

There are many old farmsteads on the land that is signed up to have the manure applied on it. These old farmsteads had out-buildings which would indicate livestock was being raised, meaning shallow wells were most likely dug and used. These old farmsteads are currently being farmed over and are signed up to have large amounts of manure (8,000 gal/ac) applied over them. Were these shallow wells properly sealed when the farmstead was bulldozed over? A neighbor one and a half miles west from the proposed building site uses their well water to water their garden and flowers. (Photo #16)

There also is a neighbor's farm yard that is located a half of mile away from a field that is signed up to take manure. This neighbor continues to pump his well water into his house for certain uses and also for uses around his farmyard. The Maple River also runs through this field where manure is signed up to be applied to. This

location and one other has drain tile installed in it and both drain into the Maple River. (Photo #17)

Note the following aerial photos identifying 4 of the old farmsteads. (Photos #18, #19, #20, #21 & #22)

This map indicates the very unique geological and soil features in this area because of the glacial Lake Agassiz. They are called Eskers, they are significant sandier lens of soil beneath the surface, see here in Sec 29. Sec 29 has a lot of elevation around that 1200' (I have been told this is the highest spot in Cass county). Whatever water/nutrients that enter the soil from above in these areas could enter these soil lens below and move more rapidly downhill eastward towards the intermittent stream. It should be a concern when applying large quantities of liquid manure. (Photo #23)

After talking with three different custom manure applicators, 8,000 gal/ac is the minimum rate that they can apply. This is concerning because as Randy Coon as already mentioned, over 40% of these soils signed up to have manure applied to them are very limited in their ability to handle manure. So, even if the custom applicators agreed to cut the application rate down, more acres would be required. Some of the acres that have been signed up are at unrealistic distances from the proposed hog farm site (**one site over 10 miles away**) and will likely not even be used. It is a known fact the closest land to the site will be over applied. Pumping through hoses is the preferred way but there is a limit how far you can pump this manure, especially when you have to try and cross I-94, state highway 38, BNSF Railroad tracks and the Maple River. Trucking costs a lot more than pumping and over half the fields would need to have it trucked. To put this in perspective, to haul away a qtr. Of harvested corn, you would need around 25 semi loads. To apply a qtr. Of land with this hog manure, you would need around 125 semi loads! Tough on the township roads? So in closing over half of the acres signed up are unrealistic acres and if these acres were applied, the cost would not be the 60-70% range of commercial fertilizer like we were told. And if it is applied there is definite risk to the watersheds as outlined in my presentation. Thank you for your time and you must deny this illegal permit.

CONCERNS

Reviewing the Rolling Green Family Farms nutrient management plan has resulted in several areas of concern. Items identified in the text of this document will be summarized and presented as concerns and concerned questions. The identified items are:

1) Land easement application forms are incomplete

2) Legal descriptions and acreage errors on the Water Quality Risk Assessment Maps

3) Crop rotations were not listed making it difficult to determine nutrient needs

4) Soil test levels of Phosphorus should be used to determine manure application rates

5) Available acreages appear to be overstated --- township setbacks are not on maps and land for the facility are included as eligible acres

6) NRCS waste management soil ratings were not addressed

7) Pollution from the manure application will ultimately end up in the Maple River which feeds into the Red River

8) Hamerly-Tonka soils are rated "very limited" for application of manure and food processing wastes --- they account for 1,408.6 acres of the total listed for manure application

9) Application of liquid manure on tiled land --- what is the policy in other states

10) Who is going to monitor and enforce the nutrient management plan?

    ----over application

    -----setbacks

    ------water pollution

Nutrient Management Using Liquid Hog Manure

A large confined animal feeding operation (CAFO) produces vast amounts of animal wastes. The hog CAFO proposed for the Buffalo, ND area will have storage pits with a holding capacity of 10.2 million gallons. Estimating the gallons of liquid manure produced annually is dependent on the number of hogs, their weight, whether it is a gestating sow or a sow with a litter, and the amount of water used for cleanup, etc. For a facility the size of the one proposed in the Buffalo area an estimated 7.0 million gallons of liquid hog manure will be produced per year. Disposing of this quantity of manure is a significant problem, and using it as fertilizer for grain crops is essentially the only solution.

Using liquid hog manure as a crop fertilizer does present problems. Manure fertilizer is not a plant nutrient balanced product. In other words, the ratio of nitrogen (N) to phosphorus (P) is such that applying enough N for crop nutrient requirements will result in excess P being added to the soil. It is possible for P to reach levels high enough to cause it to move off-site and get into surface water. Accordingly, Linderman (2012) recommended North Dakota producers apply enough manure to meet the P requirements of the crop and use commercial fertilizer to bring the N to desired levels. Similar recommendations have been made for Minnesota (Schmitt and Rehm 1992) with application rates based on soil tests for P. Although the soil tests submitted as part of the Nutrient Management Plan (Appendix D) indicated a "low" phosphorus risk, environmental concerns would suggest using the University recommenctions for nutrient management. Liquid hog manure also contains potassium (K). Nutrient content for commercial and manure fertilizer are measured differently. For example, a common commercial fertilizer is 11-52-0. This fertilizer contains 11 percent N, 52 percent P, and no K. A ton (2,000 pounds) of this fertilizer has 220 pounds of N, 1,040 pounds of P, and no K. Liquid hog manure is typically expressed as pounds of N, P_2O_5, and K_2O per 1,000 gallons.

Nutrient content of liquid hog manure varies greatly with pounds of N per 1,000 gallons ranging from 15 to 50, pounds of P ranging from 8 to 20, and pounds of K ranging from 8 to 20 (Saskatchewan Soil Conservation Association 1997). Numerous studies have estimated the nutrient value of liquid hog manure. Table 1 presents the estimates for two studies from North Dakota State University and one from the University of Minnesota. The nutrient content for N, P_2O_5, and K_2O reported in the Linderman study was used for this analysis. Nitrogen in the liquid hog manure contains both inorganic and organic matter. The inorganic form of nitrogen in manure is found as ammonium nitrogen (NH_4-N) which is immediately available to plants. The relationship between the inorganic and organic content of the liquid hog manure can vary greatly, but Schmitt and Rehm (1998) estimated that 50 percent of the nitrogen would be available in the first year, 35 percent in the second and third years, and 15 percent would be lost. (All supporting documents referenced and relating to this analysis are presented in Appendix C.)

Table 1. Pounds of Nitrogen, Phosphorus, and Potassium Estimated by Selected Studies, and Values Used for this Analysis

Source	N	P_2O_5	K_2O
	----------Pounds per 1,000 Gallons----------		
Linderman (2002)	27	27	15
Weiderholt et al. (2005)	26	26	20
Schmitt and Rehm (1992)	36	27	22
Selected for Analysis	27	27	15

Obtaining land application easements, soil testing, liquid manure nutrient testing, application of the liquid manure, and a nutrient management plan are the key components of disposing of the animal wastes. A copy of the land easement contracts is presented in Appendix A. Based on the incomplete information provided on five of the six contracts, it is difficult to determine what crops are to be grown and possible crop rotations. Acres reported on the land easement agreement appear to be total cropland acres or Farm Service Agency cropland acres. Without the listing of the crops to be planted on the contracted actress, it is difficult to determine how much liquid manure can be used beyond year one.

Water quality risk assessment maps for each of the fields contracted for liquid hog manure application are presented in Appendix B. These maps show the boundaries for each parcel and indicate the total cropland acres. Setbacks are included but only include water ways and noncropland areas such as permanent wet areas, shelterbelts, and farmsteads. No setbacks are indicated for compliance with township ordnances. Subtracting the risk assessment reported with from the total cropland acres provided the setback acres (Table 2). Also, acres for the CAFO location (NW ¼-4-139-54) have not been removed from the fertilization application acres. The legal description for fields 18 & 19 are incorrect, causing further confusion. Total acres for field 16 & 17 add up to 207.4 acres. Errors and omissions in this data set complicate the calculation of how many acres are available for liquid manure application.

Appendix D presents the nutrient management plan and associated soil tests. Soil tests indicate the N, P_2O_5, and K_2O nutrient levels in the soil, and realistic yield goal nutrient requirements are presented. The realistic yield goal nutrient requirements are available for corn, soybeans, and edible beans. Soil test results for four selected fields are presented in Table 3. The soil tests indicate that the P_2O_5 levels for the four fields range from "very low" to "medium", and one field has K_2O levels that are "high" and the other three were "very high". Table 4 presents the nutrient levels needed for corn to produce yields of 140 bushels per acre or more. Similar data were available for soybeans and dry edible beans are presented in Tables 5 and 6, respectively.

Table 2. Water Quality Risk Assessment Map Acres, Setback Acres, and Listed Acres for Liquid Manure, 2015

Field Number	Map Acres	Setback Acres	Listed Acres
1 & 2	285.6	5.1	280.5
3	156.4	--	156.4
4 & 5	293.7	10.9	282.8
6	78.9	0.9	78.0
7 & 8 & 9	306.4	15.1	291.3
10	157.7	17.5	140.2
11	158.2	0.2	158.0
12	114.0	1.7	112.3
13 & 14 & 15	498.5	10.1	488.4
16 & 17	151.4	4.5	146.9
18 & 19	301.9	1.2	300.7
20	57.6	--	57.6
21	140.5	32.8	107.7
22 & 23 & 24	566.0	8.3	557.7
25	153.1	3.1	150.0
Total			3,308.5

Table 3. Soil Test Results for Four Selected Fields Contracted for liquid Hog manure Application

Field Number	N	P_2O_5[1]	K_2O[2]
	---(lbs)---	---(ppm)---	---(ppm)---
1	24	2	182
6	28	4	166
17	42	8	239
22	42	10	125

[1]Phosphorus (ppm) rankings of 0-3 are in the very low category, 4-7 are low, 8-11 are medium, 12-15 are high, and 16+ are very high (Franzen 2013).

[2]Potassium (ppm) rankings of 0-40 are very low, 41-80 are low, 81-120 are medium, 121-160 are high, and 161+ are very high (Franzen 2013).

Table 4. Required Nutrients for Corn With A 140 Bushel Per Acre or Above Realistic Yield Goal, for Four Selected Fields

Field Number	Yield Goal	N	P_2O_5	K_2O
	---bu/acre---	---lb/acre---	---lb/acre---	---lb/acre---
1	146	175	102	170
6	141	169	98	164
17	148	177	103	172
22	162	194	113	188

Table 5. Required Nutrients for Soybeans With A 37 Bushel Per Acre Realistic Yield Goal, for Four Selected Fields

Field Number	Yield Goal	N	P_2O_5	K_2O
	---bu/acre---	---lb/acre---	---lb/acre---	---lb/acre---
1	37	--	57	81
6	37	--	57	81
17	37	--	57	81
22	37	--	57	81

Table 6. Required Nutrients for Dry Edible Beans With A 1,476 Pounds Per Acre Realistic Yield Goal, for Four Selected Fields

Field Number	Yield Goal	N	P_2O_5	K_2O
	---bu/acre---	---lb/acre---	---lb/acre---	---lb/acre---
1	1,476	74	34	51
6	1,476	74	34	51
17	1,476	74	34	51
14	1,476	74	34	51

Determining the fertilizer application rates requires several calculations. For nitrogen, there could be a credit from the previous crop. Crops such as soybeans, edible beans, peas and lentils, and chick peas typically have a nitrogen credit (Franzen 2013). The nitrogen credit for these crops has been estimated to be 40 pounds of N per acre. Nitrogen required would be the N level necessary for the realistic yield goal less the existing N in the soil less the N credit. This would give the pounds of N required, but as previously stated, about half of the N in liquid hog manure is available the first year. For soil tests with P in the "very low" or "low" category, the full amount of P_2O_5 required could be applied. Application of liquid hog manure results in 80 percent of the P_2O_5 available in the first year.

An example will help illustrate the calculations. In order to obtain a 146 bushel per acre corn yield on field 1, the nutrients required would be 175 pounds per acre of N, 102 pounds per acre of P_2O_5 (because the soil test indicated "very low" parts per million) and no K_2O (because soil levels are already "very high"). Nitrogen required would be 174 pounds less the 24 pounds already in the soil less the 40 pounds soybean credit (assuming the corn is planted on a field that was soybeans the previous year). A total of 111 pounds per acre of N should be added to the soil. As previously stated 50 percent of the N in liquid hog manure is available in the first year, so the 27 pounds of N per 1,000 gallons of manure actually provides 13.5 pounds of N the first year. A total of 8,222 gallons would be needed to be applied to meet the N requirement. The 27 pounds of P_2O_5 in the liquid manure is only 80 percent available to the crop in the first year, so the product has 21.6 pounds of P_2O_5 per 1,000 gallons. A nutrient requirement of 102 pounds of P_2O_5 per acre would require 4,722 gallons to be applied. If the 8,222 gallons of manure necessary to reach the N goal were applied, 178 pounds of P_2O_5 would be added to the soil and be available in first year. This far exceeds the maximum recommended level of 102 pounds per acre. If the

manure were applied using the P soil test to determine the gallons per acre, 1,482 acres would be required to use the 7 million gallons of liquid hog manure produced per year.

If the application of the liquid manure was based on the recommended P level soil tests, the 7 million gallons of liquid manure could be disposed of in year 1, based on the acres available (Table 2). Without knowing what crops are going to be planted and the rotations, it is difficult to guarantee the same result in subsequent years. At a minimum, the manure would have to be applied to the same land every second year based on the available acres. Soils in this area are naturally high in K, so typically no K_2O would need to be applied. The liquid hog manure would add K to soils every other year with this scenario, building K levels to a point where it could contribute to soil salinity. Also, the acres may be overstated because of the plant citing acreage was included and no township setback acres are included in the nutrient management plan.

Another potential problem for the acreages is the National Conservation Resources Service Manure and Food Processing Waste soil ratings. These ratings are based on soil properties that affect absorption, plant growth, microbial activity, and erodibility. The ratings cover manure and food processing waste in solid, slurry, and liquid form. These ratings go from 0.0 to 1.0, with a 1.0 rating being classified as "very limited". The "very limited" category includes soils that have one or more features that make it unfavorable for the specified use. These limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Soil maps showing the "very limited" areas for each field contracted (by quarter section) are presented in Appendix E. For the land that has been contracted for manure application, 1,408.6 acres are classified as 1.0, or "very limited" (Table 7). These soils are classified as Hamerly-Tonka and characterized by slow water movement or ponding. Applying liquid manure to these soils could present serious environmental problems.

A map showing the locations of the land contracted for application indicates manure would have to be hauled as far as 8 miles to the northwest and 6 miles to the south. Also, applying liquid manure to tiled land is currently new to North Dakota. Much of the tilled land identified in the acreage contracts drains directly into the Maple River, which in turn ends up in the Red River. This could become an international problem if nitrogen and phosphorus leach or erode into the local waterways. It is also important to know who will be responsible for monitoring and enforcing sound environmental regulations. Based on the data currently available, it does not appear that the nutrient management plan for this CAFO is sustainable.

Table 7. Field Nutrient Easement Acres Reported, Water Quality Risk Assessment Acres, and National Resources Conservation Service Manure and Food Processing Waste Soil Type Acres Rated Very Limited

Field Number	Legal Description	Land Acres	Water Quality Acres	Very Limited Acres
1 & 2	E ½-9-139-54	284.9	285.6	171.5
3	NW ¼-4-139-54	150.0	156.4	54.5
4 & 5	N ½-36-140-55	293.0	293.7	86.4
6	W ½ SW ¼-12-139-55	78.0	78.9	43.2
7 & 8 & 9	E ½ -32-139-54	308.8	306.4	101.9
10	NE ¼ -14-139-55	157.7	157.7	59.9
11	SE ¼ -10-140-55	158.0	158.2	97.8
12	NW ¼ -14-140-55	114.0	114.0	64.8
13 & 14 & 15	11-140-45	500.0	498.5	281.6
16 & 17	NE ¼ -2-139-55	150.0	151.4	12.4
18 & 19	E ½ -4-139-54	300.7	301.9	215.6
20	S ½ -SE ¼ -11-139-55	60.0	57.6	21.9
21	NW ¼ -12-139-55	120.0	140.5	67.0
22 & 23 & 24	29-140-54	550.0	566.0	93.4
25	NE ¼ -32-140-54	155.0	153.1	36.7
Total				1,408.6

Hello, my name is Randy Coon and I farm south of Buffalo. The opinions expressed on the topic of nutrient management are solely those of the Concerned Citizens of Buffalo and do not represent any other individual, entity or institution. The large hog confined animal feeding operation (CAFO) proposed near Buffalo will produce large amounts of animal waste. Storage pits beneath the building will have a capacity of 10.2 million gallons, with an estimated 7.0 million gallons that will need to be removed annually. Disposing of this quantity of liquid manure is a significant problem, and using it as a fertilizer for grain crops is essentially the only solution.

Using liquid hog manure as a crop fertilizer does present problems. Manure is not a plant nutrient balances product. In other words, the ratio of nitrogen (N) to phosphorus (P) is such that applying enough nitrogen for crop nutrient requirements will result in excess phosphorus being added to the soil. It is possible for phosphorus to reach high enough levels to cause it to move off-site and get into surface water. North Dakota State University and the University of Minnesota researchers recommend applying enough manure to meet plant phosphorus requirement. The Olson test for phosphorus in the soil measures only the inorganic phosphorus. We strongly recommend the nutrient management plan be required to use phosphorus to set the maximum application rate, and the soil be tested using a total extraction method to determine the total phosphorus (inorganic and organic) in the soil.

Obtaining land application easements, soil testing, liquid manure nutrient testing, application of the manure, and a nutrient management plan are the key components of disposing of the animal waste. Determining the sustainability of this nutrient plan was difficult because five of the six land easement contracts were incomplete. Water quality risk assessment maps provided incorrect legal descriptions and acreages, with one quarter section showing over 200 acres. These maps show boundaries for each parcel and include setbacks which consist of waterways and noncropland acres such as permanent wet lands, shelterbelts, and farmsteads. The maps do not appear to include the Howes Township Ordinance setbacks. These setbacks are important because when the liquid manure is applied, the end-of-field turn involves lifting the applicator but leaving the pump running, dropping the

manure on top of the ground. For these reasons, it would appear that the proposed available acres are overstated.

Nutrient content of liquid manure can vary greatly. A NDSU study recommended using an analysis of 27 pounds of nitrogen, 27 pounds of phosphorus, and 15 pounds of potassium per 1,000 gallons for planning purposes. Soil tests for Field #1 (which had low soil nutrient levels) showed 24 pounds of nitrogen available, 2 ppm of P_2O_5 available, and 182 ppm of K_2O available. A realistic yield goal of 140+ bushel per acre corn would need 175 pounds of N, 102 pounds of P_2O_5, and 170 pounds of K_2O. Using phosphorus to determine the manure application with 80 percent of the P_2O_5 available, 1,000 gallons would add 21.6 pounds of P_2O_5 per acre.

Dividing the 102 pounds per acre required by the 21.6 pounds available per 1,000 gallons would give a 4,722 gallons per acre rate. If 7.0 million gallons of liquid manure were to be disposed of each year, 1,482 acres of corn would be required. Soybean yield goals require no nitrogen, so liquid manure should not be applied for that crop. A corn-soybean rotation would require applying the manure to the same ground every other year. Applying the liquid manure above the recommended rates can lead to nutrients getting into ground water and rivers. Almost all of the proposed acres drain into the Maple River, which further downstream dumps into the Red River. The Red River flows into Canada which could lead to international contamination. This illustrates the reason why it is so important to restrict application rates to match phosphorus requirements.

The proposed location for the facility is in a very unique soils area. Its proximity to the Lake Agassiz shoreline has a significant effect on the area soils. National Resource Conservation Service (NRCS) web soil survey maps provide numerous measurements for these soils, including a Sustainability and Limitations rating. This category is further subdivided into waste management-manure and food processing wastes. These rating are based on soil properties that effect adsorption, plant growth, microbial activity, and erodibility. Rating go from 0.0 to 1.0, with a 1.0 rating classified as "very limited". The "very limited" category included soils that have one or more feature that makes it unfavorable for the specified use. These limitations

generally cannot be overcome without major spoil reclamation, special design, or expensive installation procedures. These soils are classified as Hamerly-Tonka soils. The quarter section presented by Power Point is adjacent to the proposed facility. The red acres are the Hamerly-Tonka soils with the 1.0 ("very limited") rating. Of the total acres contracted for manure application, 1,408.6 are classified as Hamerly-Tonka with the "very limited" rating. If the Hamerly-Tonka soils are to be considered for manure application, we strongly recommend an environmentally responsible nutrient management plan with strict adherence to application rules and very close monitoring by the Department of Health to prevent pollution and environmental problems.

Further contributing to the potential pollution problems are the amount of tiled acres that drain into the Maple River. Another Power Point map will help explain the concerns for tiled land. The north half of section 36 of Tower Township is tiled land that has been include as land to be used for manure application. NRCS maps provide information regarding Agronomic Concerns for Pesticide and Nutrient Leaching. Hamerly-Tonka soils in this parcel are again rated at 1.0 on the 0.0 to 1.0 scale with the 1.0 being "very limited" for this use. About two-thirds of this parcel are rated as a 1.0, indicating the risk of pesticide and nutrient leaching. The waterway in the southwest corner of this land drains directly into the Maple River about one-half mile away. Applying liquid manure to this land poses a high level of environmental risk. We recommend these acres not be allowed to be use for application of liquid hog manure, or at a minimum be applied in the spring and under close supervision and monitoring by the State Health Department.

Based on the information we have been provided, it does not appear that sufficient acreage is available to dispose of the 7.0 million gallons of liquid hog manure produced annually. Acreage contracts may overstate the available acres, and drain tiled land and Hamerly-Tonka soil problems have not been addressed. Over applying liquid manure to the soils could present serious environmental problems. It does not seem that the nutrient management plan is achievable, or sustainable. Further compounding the problem of disposing of the manure is the "easement map" which will be presented later. The Concerned Citizens of Buffalo urge the North Dakota State Health

Department to stay true to their mission statement. We ask that you protect the health of the Buffalo area citizens, the air quality, the water quality, and the soils by rejecting this permit request.

Thank you.

N.D. DEPT of HEALTH
BISMARCK, ND

15 MARCH '16

I AM CURRENTLY THE OLDEST MALE LIVING IN THE CITY OF BUFFALO, ND. I CREDIT MY GOOD HEALTH AT MY AGE TO MY DOCTOR, HE TOLD ME A FEW YEARS TO WALK, WALK, WALK! SO THAT I HAVE BEEN DOING QUITE A BIT OF AND MOSTLY OUTDOORS. ESPECIALLY WHEN THE WEATHER IS FAVORABLE.

I AM SOMEWHAT APPREHENSIBLE (APPREHENSIVE) AS TO WHAT A CAFO CLOSE TO OUR CITY COULD HAVE ON THE AIR (STENCH AND UNPLEASANTNESS) AND POSSIBLY EVEN ON OUR HEALTH. PROBABLY MORESO ON SOMEONE MY AGE. I AM RAPIDLY APPROACHING 90 YEARS OLD.

I REALLY DON'T SEE MUCH GOOD OR BENEFIT OF A CAFO OPERATING SO NEARBY,

SINCERELY,

Kenneth A. Ronning
P.O. Box 166
Buffalo, ND 58011

February 21, 2016

I want to address two of my many concerns regarding the 9,000 pig operation that is to be built near Buffalo, ND:

First, I have lived in Buffalo for 36 years. Early on Don and I made the decision not to purchase a lake cabin in Minnesota but instead to spend our summer weekends right here in our yard in Buffalo, ND.

In the last 6 years we have been blessed with the addition of 3 grandchildren to our family. All nine of us spend not only summer weekends but spring, summer and autumn days and evenings outside in Buffalo, ND. Routinely our son's and their families gather on Sundays at our house and we spend hours together outside in our treasured lilac surrounded lot.

As a result of that time spent outside our grandchildren have come to enjoy an array of outdoor activities: running through the sprinkler, splashing in the pool, squirting water guns at each other, jumping on the trampoline, digging for worms or playing tractors in the dirt, driving their gator around the spacious yard and growing pumpkins in the garden. T-ball & kickball too are played providing a great source of outdoor exercise and fresh air for them.

The hammock attached to two age old trees provides much fun for them as does the bridge in the yard with a troll lurking underneath. I have numerous, 20-25, yard ornaments and animal statues which allow the kids to strategically place in the yard where ever their imaginations allow. Three watering cans are needed as each grandchild takes the task of watering Grandma's flowers seriously.

They enjoy going for fun rides around town on Papa's gulf cart or in his Wildcat. The decision of which park to play at is never an easy one to make, therefore it always ends up being "both of them". A ride in the country out to Jerry's farm a mile south of town to pick raspberries and corn is a must. If raspberries and corn aren't in season they have to go simply to see how many rabbits are running around his farm yard. Other Wildcat rides are taken to check nearby fields, explore shelter belts keeping an eye out for deer in the woods and to look for eagle nests built high atop trees. They also love the "adventure" of exploring the trail alongside the railroad tracks, checking on the families of ducks and geese along the way. It is not uncommon for the fresh air and motion and hum of the vehicles to relax Chase and Connor to the point of catching an unexpected nap on the way back home.

The facts indicate the enjoyment of our outdoor activities would come to an end if the 9,000 pig operation is built. Our life style would change drastically.

Second, since the news of this pig operation coming to our community I really think about and appreciate our city water. Now, each time I run tap water my appreciation grows. The possibility of such an operation moving fills me with wonder: I wonder how long I will enjoy a glass of refreshing cold tap water? I wonder how much contaminated water we are going to drink and use before it is realized and deemed contaminated? Will I know it is contaminated before filling the kiddie pool? I wonder now each time I run bath water or take a shower, how long I will have clear, clean water? I wonder how long it will be before we have to rely on bottled water for all our needs and how much that will cost and what hassles that will bring? I even wonder how the water

in the toilet bowl will be affected after a 9,000 pig operation is built near our town?

Please consider us and those like us who appreciate simply the greatness of fresh air and clean water. Without them much of our daily enjoyment would be taken away.

Sincerely

Sherry Peterson

MARCH 10, 2016

100 Broadway S.
Buffalo, ND 58011
701-633-2322

CYNTHIA BERGET ALLEN

NORTH DAKOTA DEPT OF HEALTH

RE: PROPOSED P16 FARM BUFFALO, ND

I HEREBY STATE THAT I AM OPPOSED TO THE ABOVE P16 FARM AND AS A RESIDENT OF BUFFALO, NORTH DAKOTA, I AM CONCERNED ABOUT HEALTH ISSUES AND ENVIRONMENTAL IMPACT THEREFORE.

SINCERELY,

Cynthia Berget Allen

TO: N D Department of Health and Water Quality

I am an older adult living in Buffalo, ND. I'm on prescription drugs for high blood pressure, blood thinner, chronic sinus, allergies (on an inhaler), dry eyes, and anxiety. I have had three TIA's, and have been diagnosed with thickening of the heart wall. At night I sleep with a C Pap machine to keep my oxygen level stable.

I have a half block of yard to mow and plant a vegetable garden and flower beds. Working outdoors is my therapy. I use a three wheeler to haul tools and cut down on walking. I also enjoy being able to hang out my laundry. After reading a bulletin from the EPA, I am concerned about having to curtail my activities because of particulates in the air. The bulletin mentions checking the news for Air Quality Index. The air quality in Fargo would not likely register the toxic air we are experiencing in Buffalo.

Since the Rolling Green CAFO owners who reap the benefits live out of state, taking the money away from our tax payers, I don't find the justice in endangering our air quality and water supply.

I sincerely hope you can sympathize with our plight and deny the proposal of Rolling Green Farms.

Janice Diemert

Janice Diemert

My name is Betty Fraase and I want to address the North Dakota Department of Health about my concerns regarding the possibility of 9,000 pigs 1-1/2 miles from my home.

I am 80 years old and have lived on my farm in Howes Township since I got married over fifty years ago. I enjoy being outdoors, either mowing my yard or working in my flower gardens. My family loves to come home to visit and we spend lots of time outside grilling.

I have very serious concerns about this pig facility so close my house and the manure application proposed for farmland directly across the road from my 640 acre farm and home. I have high blood pressure and a thyroid condition which require daily medications. I worry that the foul gases and fumes will impact my life on a daily basis making me more susceptible to anxiety and stress, and other serious illnesses.

I want to continue enjoying the life I created here on our family farm. I do not want my life negatively affected in so many ways. I beg you to deny the permit to Rolling Green Family Farms. Please protect my health.

Thank you,

Betty Fraase

Betty Fraase
Buffalo, ND

To the North Dakota Department of Health,

I, Jessica Peterson, am opposed to the passing of this proposed permit for the pig factory. The pig factory will bring significant damage to our community, family, and friends. I am a resident of Tower City. I work in Buffalo, my son goes to daycare here, and my husband and his family own a business in Buffalo. My in-laws, niece, and nephew also live in Buffalo as do many of my friends. There is significant research out there that proves there are health risks with breathing in the pathogens that can be emitted in the air from pigs. There is also significant research out there stating how most of the CAFO's produce way too much manure that the land can't handle which leads to over application of the manure/fertilizer which the crops cannot absorb. Therefore, that may lead to run off and contamination of our drinking water also.

Since children can take in 20-50% more air than adults they are more susceptible to lung disease and health effects. We have young children that go to daycare in Buffalo, we also have a preschool, and a k-3 elementary school. These kids would be exposed to all of these air pollutants, therefore, increasing their risks of health problems. These pollutants can travel anywhere from 40-100 miles from its source.

Aside from all the health risks there is also a significant economic impact that would negatively affect our community. Property values would decline and most importantly we would lose some of our lifetime residents. My husband and I have dreamt of buying a farm near Buffalo but that would be severely impacted by this pig factory. My husband also farms land around the proposed site. We are very concerned about the run off from all of the excrement's from the pigs. With 9,000 pigs, there is significant risk of there being too much nitrogen in the soil which will run off into our fields, which will harm our crops, and could contaminate our water.

Please, do not pass this proposed permit. Our livelihood depends on it. My son's health, my families health, my health, and my friend's health, all depend on it.

Sincerely,

a concerned resident

Jessica Peterson

To: North Dakota Department of Health

My name is Hal Grieve. I have lived in Buffalo North Dakota since 1962. I grew up in town, went to school and church here, started my first real job here and have hoped to retire here. The news of this factory piglet producing sow farm by Rolling Green Family Farm being built may have me rethinking about retiring in Buffalo or North Dakota for that matter. My back door will be about two miles away, as the bird flies, from this commercial pig farm.

First there is medical evidence saying the air born particulates can affect the respiratory system because of the ammonia, hydrogen and methane. The presence of the odor may raise blood pressure; create depression and PTSB because once it is here we are stuck with it no matter what the ill effects are.

Next is the vast amount of water this facility will need and then the run off from the facility and area fields that the manure is put on. This run off goes into the Maple River then the Red River and on into Lake Winnipeg. There will also be questions regarding effects on ground water under the lagoons.

Rolling Green Family Farms is anything but what its name implies. This is a corporate farm of investors who have worn out their welcome in neighboring states and came to North Dakota looking for and finding lenient zoning and farming laws. From what I understand it is nearly impossible to find out who and where these investors are really from. These are not our friends and neighbors who have devoted their lives carving a living out of the land along with raising a few animals.

As a life resident of North Dakota and one who still lives, works, and finds the beauty in enjoying the fresh air of our outdoors, I ask the Health Department to please deny, again please deny the building of the proposed hog farm near Buffalo, North Dakota.

Hal Grieve
204 4th Ave S
Buffalo, ND. 58011

Dear North Dakota Department of Health

I am writing again to express concerns over the proposed swine operation to be built just outside of Buffalo. Since first hearing about the concentrated animal feeding operation I've had time to do research of my own. To find an article or report stating this type of operation is a great opportunity for the people and communities near the operation, or had anyone living near an operation approached someone in our community stating so, it would ease my mind. Neither has happened.

I have lived in Buffalo for 41 years and before that three miles south of the proposed site for 17 years. I am an outside person, spending my time off outside working in my vegetable and flower garden, taking care of the yard, reading, walking and bike riding. Most recently I have been able to share all of this with my seven year old grandson who is with us often.

I fear my way of life as I have known it will change dramatically if the swine operation becomes reality. And, not for the better. The respiratory symptoms from exposure to the air around an operation this large can be nothing but detrimental to those within its path. While my daughter has not said as much, I fear she will not allow my grandson to stay for extended periods of time as he has his entire life. She, who is a doctor, has sent me links to many health related articles.

My mother, who lives in Buffalo, has COPD and congestive heart failure. The air quality within a short time could have a serious impact on her life. I tried to avoid mentioning the odor but feel it deserves attention as it will be a reality. It goes beyond just being a nuisance. How can it not depress someone if they are not able to enjoy life the way they once had, and planned to for the rest of their lives? Depression is real. PTSD is real. Both are medical conditions associated with the odor from these large operations.

I am not opposed to livestock operations, only to those whose existence will negatively affect so many people.

I am asking you consider all concerns; environment, health and social and deny the permit to Rolling Green Family Farm. Buffalo has many things to offer it residents and those in the surrounding area. Hopefully that continues for decades to come.

Thank you for your time.

Terryl Grieve
204 4th Ave S
Buffalo ND 58011

Buffalo, N.D
March 14, 2016

N.D. Health and Water Quality Division:

My name is Carolyn Pfeifer and I live in Buffalo, ND at 500 Pearl St. I am an elderly woman who lives alone, and I am writing to voice my concern about the out-of-state corporation which is attempting to build a huge Hog-raising facility very close to our town.

With 9000+ pigs in one small area, the amount of manure and other waste products is bound to be enormous.

Living in the Red River Valley where we are subject to periodic flooding, we are bound to have some serious problems. I would hate to see our water system threatened by the run-off from this farm.

I am also worried about the allergens from this operation which will be released into the air. Research shows that these allergens can travel several hundred miles. Since I suffer from sinus infections caused by my allergies, this really frightens me.

I beg you to consider the adverse consequences of this gigantic Hog Farm. We sincerely hope that you can put a stop to it.

Yours truly,
Carolyn Pfeifer

To Whom it May Concern at the ND Department of Health:

My husband and I are concerned with the proposed Rolling Green Family Farms CAFO to be located near our home town of Buffalo.

We both have health issues, including allergies, thyroid and migraines. We understand that the gases and fumes emitted from these hog CAFO's are detrimental to people with health issues like ours.

We have read that the ND Dept of Health has a mission statement to "*protect and enhance the health and safety of all North Dakotans and the environment in which we live*". We feel it is your duty to watch out for anything that will hurt the health, safety and well being of the taxpaying, voting people of the state of ND.

We have attached our health summaries listing our issues.

Carolyn Dostert
Alan Dostert
Buffalo, ND

Health Summary

Current Health Issues

Health Issue	Date Noted
Hypothyroidism	
Allergic rhinitis	
Dysplasia of cervix	
Hyperlipidemia	
Encounter for long-term (current) use of other medications	01/14/2009
History of colonic polyps	01/14/2009
Acute mucoid otitis media of both ears	12/23/2015

Medications

metFORMIN 1000 MG tablet
Commonly known as: GLUCOPHAGE
Instructions: Take by mouth 2 times a day with meals. use of dose
Documented by Abstract Provider

fluticasone 50 mcg/spray nasal spray
Commonly known as: FLONASE
Instructions: Use 2 sprays in each nostril daily
Approved by Michael Sand, DO
Prescribed on 4/17/2014
Prescribed quantity: 16 g
Request a renewal

levothyroxine 125 mcg tablet
Instructions: Take 1 tablet by mouth 1 time per day.
Approved by Michael Sand, DO

Prescribed on 1/21/2013
Prescribed quantity: 90 tablets

Request a renewal

ALLEGRA PO
Instructions: Take 1 tablet by mouth 1 time per day.
Documented by Abstract Provider

Allergies

Allergen	Reaction
Other: See Comments	Itching
Potato	Itching
Environmental Allergens	Other (Specify in Comments)

Immunizations

Immunization	Date
Tetanus Toxoid,not adsorbed	2/1/2006

Preventive Care

Name	Status	Last Done
Pap Smear	Overdue since 1/19/2015	1/19/2012
Dexa/heel Scan	Overdue since 2/18/2015	2/18/2013
Flu Vaccine	Overdue since 10/1/2015	
Tetanus Vaccine	Overdue since 2/1/2016	2/1/2006
Colonoscopy	Overdue since 2/3/2016	2/3/2011
Screening Mammogram	Not due until 6/16/2016	6/16/2015
Lipid Screening	Not due until 1/18/2018	1/18/2013

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Health Summary

Current Health Issues

Health Issue	Date Noted
Other forms of migraine, without mention of intractable migraine without mention of status migrainosus	11/02/2006
Routine general medical examination at a health care facility	10/08/2008
Gout	10/08/2008
Osteoarthrosis, unspecified whether generalized or localized, involving lower leg	01/19/2012

Medications

naproxen 220 mg tablet
Commonly known as: ALEVE
Instructions: Take 220 mg by mouth 2 times a day as needed.
Documented by Abstract Provider

Allergies

Allergen	Reaction
Banana	Anaphylaxis (High)
Alfalfa	Hives (High)
Food Allergies	Unknown/Not Verified

Immunizations

Immunization	Date

TDAP	11/9/2013, 10/8/2008

Preventive Care

Name	Status	Last Done
Colonoscopy	Overdue since 4/10/1962	
Lipid Screening	Overdue since 4/10/2001	
Flu Vaccine	Overdue since 10/1/2015	
Tetanus Vaccine	Not due until 11/9/2023	11/9/2013

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To: ND Department of Health and Water Quality

The concerned citizens of Buffalo, ND have done much research about CAFO's and how they affect the neighbors and community surrounding them. We have heard the statements from people that maybe this is o.k. "as long as it isn't in my back yard." We have heard that the Ag special interest groups want this CAFO to come into our community, not their communities. We are concerned about how much weight these special interest groups will have regarding the location of this CAFO. We are asking the North Dakota Department of Health to consider our health and well being, our right (as tax paying citizens of the state of ND) to live where we, our children and grandchildren will have healthy air to breath and water to drink. We believe in farming and livestock, we want to protect our local farm families health and their right to continue to have their family farming businesses grow with out the interference of an out of state entity. As we understand it, the North Dakota Department of Health exists to, has a purpose to and has a mission statement to protect the health and environment of ALL citizens of ND. Again, protecting our health and the environment we live in is your job. The concerned citizens of Buffalo, ND are asking that the testimonies given to you today be reviewed and considered and that the ND Department of Health send a clear message to everyone that the location of this CAFO and any future CAFOs in the state of ND be farther away from cities and family farms. We feel the proposed location of Rolling Green Family Farms Swine CAFO is wrong. The proposed building site and the land where the manure will be spread are TOO close to the family homes in our community and their locations will affect the health and well being of all the people who live in our community.

We have heard we are waisting our time as the swine CAFO is "a done deal" and that the ND Department of Health has already made the decision. We have also heard that the ND Department of Health will do what they have been told to do by the "powers that be" in Bismarck. These statements are terribly upsetting to us. We trust that the people we send to our capitol and the people representing us, the citizens of ND, will work for all the people, not just the ones that are members of a special interest group that has lobbyists in our capitol. We hope that you will not approve this illegal permit, just because it has been submitted, but that you will review all testimony and do your job to protect the citizens of our community and our state.

Will you, the ND Department of Health, do your job, according to your own mission statement, to protect the health and environment of the tax paying, voting citizens of our community and every citizen in the state of ND, or will you protect the business interests of special interest groups and out of state corporations?

Thank you, Carolyn Dostert

Carolyn Dostert

To: The North Dakota Department of Health

I would like to thank the members of The North Dakota Department of Health for giving us a chance to share our concerns. When I recently was made aware of the proposed pig CAFO – friends of mine from other areas of the state told me – "don't waste your time as the decision has already been made in Bismarck!" Your being here today has reassured me that the system still works.

I am Bill Marcks and I was raised on our family farm near Buffalo, North Dakota. After college I served in the US Army, worked in the Fargo Public Schools and eventually returned to my home town of Buffalo about thirty years ago. I am a past Mayor of the community and am proud to be involved in our American Legion, the City of Buffalo Historic Preservation Commission, the Buffalo Community Club and the City Park Board.

The proposed Concentrated Animal Feeding Operation to be located southeast of Buffalo could be devastating to the quality of life I enjoy now with my friends, family and neighbors in our small community of about 200. I am alarmed by the potential for serious health risks for me and everyone exposed to the daily emissions of such a large swine factory. I currently take medication for high pressure and allergies and do not want my health compromised.

Our group of Concerned Citizens in Buffalo is certainly not opposed to local family farms with animals but resistant to corporate control and potential devastation of our water and air quality, and much more. I challenge you to show us communities who feel they are better off with this type of factory farming.

It simply is not true that the employees of this hog operation will be our neighbors, friends or families. The employees will not be family farmers. This is much different from what makes North Dakota a leader in agriculture. We have been leaders because of our strong family farmers and ranchers who own their farms and understand what it means to be connected to the community where they live and work.

As part of the Concerned Citizens of Buffalo, I have done my own research to learn about the huge impact of this type of factory farming. I want a voice in my destiny, for the community I call home, and a sense of well being for my family, friends and neighbors. I strongly oppose any permit for the Rolling Green Family Farm Swine CAFO and ask the ND Department of Health to stop them from moving into our neighborhood and possibly around the state.

TO: North Dakota Department of Health

My name is Liane Rakow Stout and I was born and raised in Buffalo, ND. I am very proud of the quality of education that I received at the Buffalo Public Schools. The consolidated Maple Valley School District has continued this tradition of quality education for the 215 children from our community as well as our neighboring towns of Fingal, Oriska and Tower City. Education is an important part our communities and has given us a way of life we appreciate. We have a strong sense of caring and concern for all who live here.

Our rural life style is based on sustainable agriculture and locally owned family farms. It was a shock to our community when we were informed by a public notice in January that a proposed Concentrated Animal Feeding Operation (CAFO) for 9,000 swine was to be located several miles southeast of Buffalo. I have been involved with a group of concerned citizens who have been reviewing and researching the complex environmental impact and health risks of this type of operation. These are areas of great concern:

Water and Air Pollution: The potential of water pollution from the waste produced by 9,000 swine can contaminate waterways, including the Buffalo Creek, the Maple River and eventually the Red River. The land around the building site is one of the highest elevations in Cass County. Other states with large numbers of CAFO's have experienced 20 to 30 serious water pollution problems a year due to the manure application process to the fields. At the least the quality of daily life in our neighborhoods could be seriously reduced due to the foul-smelling air. Serious respiratory illness can result for workers, and we are especially concerned about similar health impacts, especially to our children and are senior citizens, which includes me.

Property Values and Local Economy: Residential property values often significantly go down when an industrial hog farm moves into the area. We do not understand how this would be good for any growth or sustainability in our community if nobody wants to move here or continue to live here. Once built the Concentrated Animal Feeding Operations usually have their feed trucked in; the animal's regularly trucked out and often low paid labor is used. This scenario robs our community of local economic, environmental, and social benefits, plus saddles us with the costs. We will have to pay for roads used to haul thousands of pigs and truckloads of feed, all with reduced property taxes.

On a personally issue, I have had asthma and chronic allergies my entire life. Any respiratory distress can put me in the emergency room struggling to take each breath. As scary as this for me, I am horrified by the threat to the individuals who will be exposed to the daily emissions of this type of swine factory so close to their homes.

Please carefully consider what we have to lose. I do not want a permit granted to Rolling Green Family Farms. It will cause irreparable damage to the people in the community that I call home.

Liane Rakow Stout

North Dakota Health Department

My name is Kent Beilke and I am 54 years old. I am a third generation farmer and have lived on the home farm my whole life except for the four years I went to college at NDSU. My farm is a true family farm and is two and a half miles SE of this proposed hog facility. We also have and farm land that is less than a half mile from this building site. We enjoy being outside as much as possible. We take walks as a form of exercise, enjoy swimming in our permanent pool and relaxing on one of our decks. I have multiple health concerns from this project.

I personally have high blood pressure, asthma and stress. I also have noticed in the past two months that I have edema and doctors are currently looking for the cause. I realize stress is a part of my job but this proposed hog facility has already caused me to have problems sleeping and many headaches (which I have taken more aspirin in the last couple months than I have most of my life). My wife also has multiple health issues but I will not go into them as she has written her own letter with her concerns. My mother, who is still very active, lives in Buffalo about three miles from this facility. She has to be on oxygen most of the time. She enjoys riding her golf cart and comes to our fields periodically during the farming season to bring lunches and give rides or just to see what were doing.

The emissions from the hog manure is well documented as causing health problems which includes respiratory problems especially in elderly, young and people with health problems already. Stress is a huge health issue and will certainly be a factor with people surrounding this facility not only from health concerns but also just the quality of life and everyday events we will worry not being able to do from day to day. It is known that stress can play a part in all of the health issues I have mentioned above.

I also am convinced there is more evidence of the health issues of the public from the emissions of the hog manure than there was concerning the health issues to the public from the emissions of e-cigarettes when they were banned. I understand the e-cigarette emissions is vastly more widespread in ND than hog manure emissions but that does not matter to the people living near the hogs. Please correct me if I am wrong but were not the e-cigarettes banned because of their "potential unknown risks".

I am also very concerned with the environmental problems associated with these type facilities. Knifing in the manure over top of drain tile is very concerning to me. The reason for drain tile is to remove excess water

quickly from the topsoil of the fields. I am certain under the right set of conditions the manure and bacteria could be washed into the drain tile and thus quickly flow to the drainage ditch which inevitably ends up in our streams and rivers and we all know what happens after that. Do not we want to be proactive rather than reactive. Without the drain tiled land the permit would not contain enough acres to satisfy the requirements.

What a unique opportunity we have in ND that most states envy, the fact that our health dept. has a huge part as to the granting of permits for these type facilities. They have been pushing for the their own states health departments to be able to get involved in the process because that is where one of the biggest flaws with these facilities is, they are detrimental to human health as well as the health of our environment.

I would like to ask each of you to put yourself in many of the surrounding neighbors position and ask yourself the very questions we will be asking ourselves. Will we want to live where we currently are knowing we will be exposing ourselves and our children to the unhealthy environment that surrounds these large confinement barns? Will I allow my children to stay on the family farm and raise their children, our grandchildren, near this hog farm knowing all the health issues that come with them? Will we allow our elderly parents to live out their lives where they have chosen or shall we move them somewhere away from the situation that we know is not healthy for them?

I want to thank you all for taking the time to read my concerns.
I am asking for the health department to deny the permit for this proposed hog facility!

Thanks; Kent Beilke

Kent Beilke

ND Dept. of Health

My name is Eileen Beilke and I am 56 years old. My husband and I are 3rd generation farmers living on the family farm which is located just 2 1/2 miles from the proposed hog facility and less that 1 mile from land designated for the spreading of hog manure. I personally moved to my husbands farm 22 years ago and love the quality of life on the farm. We have raised four children, one of which is still in high school and another is trying to work into the farming business. We also used to have a cattle feedlot and a small hog operation on the farm so we are not anti livestock, we are anti large factory farms.

If this hog facility is allowed to be built the quality of life will be changed for us in many ways. I am under doctors care for extreme anxiety and depression. Already my anxiety has escalated due to the tension and stress of knowing I will not be able to enjoy many of my therapeutic walks with my dogs or just sitting on my patio enjoying coffee or a fire in the evening. I also cannot imagine that anyone could find it healthy for a facility this size to be within 3 miles and a manure application site to be within 1 mile of a K thru 3rd. grade school. I try not to think about what the future will be like having 9000 hogs as my neighbors. It is hard for me just to write this letter because it brings the realism of what might be into my brain, which is what I've been trying to avoid these past couple months. How sad it would be for our established family farm to go by the way side so an out of state company can use ND land to raise hogs for out of state farmers and the only thing left for ND is the manure and a broken apart community.

One of our children will hopefully be taking over the family farm in the future and raising their own family. They have expressed to us that they do not want to raise their children in the unhealthy environment that surrounds these type hog factories. What a shame it would be for us to possibly be the last generation on our family farm so an out of state owned company can raise pigs on ND land and ship every pig to out of state farmers leaving us with every single negative effect involved.

I am asking you to reject the permit for this proposed hog facility.

Sincerely; Eileen Beilke

Eileen Beilke

March 17, 2016

Jennifer Fraase
3564 143 Avenue Southeast
Buffalo, North Dakota 58011

North Dakota Department of Health
Davison of Water Quality
918 East Divide Avenue, 4th Floor
Bismarck, North Dakota 58501-1947

To Whom It May Concern:

As a concerned land and home owner within 1.5 miles of the proposed CAFO pig operation, I would like to address my concerns about this monstrous setup. The mission of this department is to protect and enhance the health and safety of all North Dakotans and the environment in which we live. Study after study shows that these types of operations have detrimental effects on the people who live near them and for those who work in them. The United States Environmental Protection Agency's scientists have verified that large releases of ammonia and hydrogen sulfide from animal manure present a legitimate threat to our health. These health threats include: irritation of the nose, throat, and eyes and induce symptoms such as vomiting, headaches, and nausea; diarrhea, an increase in infant mortality, asthma and chronic bronchitis to name a few. Studies also show that the ammonia and methane gases and fumes cause health concerns.

What a CAFO does to the water quality is also very evident from the numerous studies that have been done around the country. Hog excrements contain more pathogens than human waste posing a risk to our water supply. This includes streams and rivers which have been polluted by existing CAFO's to say nothing of what they have done to the groundwater where they are located. This is a very real and scary threat to our water system, one that you as a state department should be looking to protect.

Within a 2 mile radius of this proposed site, there are 14 homes. Studies have shown that CAFO's have a larger impact on infants, senior citizens and those with lower immune systems. Six of these 14 homes have people living in them who fall into one of these 3 categories.

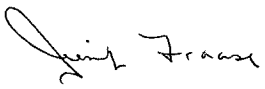
This proposed CAFO will affect my own personal health as I enjoy walking, snow shoeing and biking outdoors. I cannot even begin to imagine what it will be like to go outside to enjoy these activates smelling the odor from this pig farm and in reality figure that I will have to discontinue my exercise routine. I will not put myself at a greater risk of inhaling the particles that will be in the air from this CAFO, particles which contain known

pathogens. We all know that when you exercise, you breathe more quickly and deeply, and I will then inhale these particles into my lungs.

My health will also be affected when I am unable to open up my windows and let the fresh air in. Let the fresh air in, that's right, we will not have that benefit once this operation is up and running. That means that I will be breathing air conditioned air instead of fresh clean air. There are numerous studies showing the detrimental effects of living in these conditions.

The American Public Health Association has urged federal, state, and local governments and public health agencies to enact a freeze on the building of new CAFOs. As a department of health, you can do exactly that. As a health department, you better than anybody should know and understand the health effects, to our water and otherwise, that these CAFOs have on people, neighborhoods and communities. I am asking you to fulfill your duty as our state health department, to protect my health and that of my neighbors and my community by **denying** this industry a health permit. I strongly urge you to **deny** this permit.

Sincerely,



Jennifer Fraase

March 17, 2016

Ashley Moyer
N208 Eastowne Lane
Appleton, Wisconsin 54915

North Dakota Department of Health
Division of Water Quality
918 East Divide Avenue, 4th Floor
Bismarck, North Dakota 58501-1947

To Whom It May Concern:

Per the North Dakota Department of Health's website you state that the mission of the North Dakota Department of Health is to protect and enhance the health and safety of all North Dakotans and the environment in which we live.

To accomplish your mission, the North Dakota Department of Health is committed to improving the health status of the people of North Dakota, improving access to and delivery of quality health care, preserving and improving the quality of the environment, promoting a state of emergency readiness and response, and achieving strategic outcomes within available resources.

It is impossible for the Department of Health to have this mission and support the proposed CAFO pig operation near Buffalo, North Dakota. A University of Iowa study revealed that those living within two miles of a factory farm reported higher rates of respiratory problems, nausea and weakness, headaches and plugged ears, and irritation of eyes, nose and throat than other rural residents.[1]

A study conducted by researchers from the University of North Carolina determined that individuals living near a factory farm experienced increased occurrences of headaches, runny noses, sore throats, excessive coughing, diarrhea, and burning eyes than those living in areas without industrial agriculture operations.[2]

I grew up on a family farm 1.5 miles from this proposed pig operation and I can tell you that this is not a sparsely populated area. There are many people who call this area home including the elderly and young children. My family, friends, and those who were once my neighbors are going to have a poorer quality of life if this pig operation is allowed. Not only are they going to be at risk of developing the health issues I listed above, but they will not be able to open their windows to let fresh air in. They won't be able to enjoy the great outdoors that is North Dakota. Exercising outside will become more difficult as the air quality decreases.

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[1] Tu, K., Donham, K., Ziegenhorn, R., Reynolds, S., Thorne, P.S., Subramanian, P., Whitten, P., & Stookesberry, J. (1997). A control study of the physical and mental health of residents living near a large-scale swine operation. Journal of Agricultural Safety and Health, 3, 13-26. Retrieved August 21, 2012

[2] Wing, S., & Wolf, S. (2000). Intensive livestock operations, health, and quality of life among eastern North Carolina residents. Environmental Health Perspectives, 108, 233-238. Retrieved August 20, 2012

Waste from these factory farms will also pose a risk. The waste from these hogs will alter the soil and water quality. It will not only contaminate drinking water for the residents but this will also affect our wildlife. The backyard of my childhood home is always full of wildlife ranging from many animals including; deer, pheasants, and ducks. With this proposed farm only 1.5 miles from the woods and creek that these animals call home, their health will be affected as well.

This public health threat posed by factory farms is so great that the American Public Health Association (the world's largest association of public health professionals), issued a resolution urging state and local officials to impose a precautionary halt on the construction of new factory farms. I would encourage you to research the horrible health effects that these factory farms have on those who live nearby and work in them. The results are truly astonishing. I am asking you to abide by the mission that you claim to have and deny this permit for this CAFO. Thank you for your time and consideration.

Sincerely,

Ashley Moyer

March 10, 2016

North Dakota Health Department
600 East Boulevard Avenue
Department 301
Bismarck, ND 58501

To Whom It May Concern:

These are the items that I wish to address in regards to the large scale corporate hog operation.

1. Why are there no monthly and annual reporting requirements for inspection for this large facility?

2. What are the standards or requirements for air quality control in North Dakota?

3. What are the standards for odor control in North Dakota?

4. What are the standards in North Dakota for land application of the wastes?

To me the most tragic thing of all is the hostility of neighbors against neighbors. These are farmers who love their land and their homes. They are not people who are against agriculture or livestock. That is why my hope is that you will consider another site that would be further from these family farms and the City of Buffalo.

Thank you.

Sincerely,

Gary Milbrandt

Linda K. Milbrandt
PO Box 56
Buffalo, ND 58011

3-17-16

North Dakota Department of Health
Attn: Water Quality Division
918 East Divide
Bismarck, ND 5

To whom it may concern:

I am writing as a concerned citizen of the Buffalo, ND in regards to the environmental permit application by Rolling Green Family Farms for a proposed 9000-hog farm to be built by Buffalo, ND. I do not want this hog farm to be built by the wonderful community of Buffalo.

I believe that this proposed 9000-hog farm will be detrimental to the health of the citizens in Buffalo and will negatively affect the water quality and environment in the Buffalo area. The reasons for my disproval of the proposed 9000-hog farm are as below:

1) Water Quality – "CAFO (Concentrated Animal Feeding Operations) lagoons often leak and can cause manure and contaminants to pollute the local ground water supplies. The waste contains pathogen bacteria, including salmonella E Coli, heavy like nitrogen and phosphorous and million pounds of antibiotics". The information was retrieved from http://www.preservationnation.org and was written by Jennifer Sandy from *Forum Journal* Winter 2009/Vol. 23, No. 2. I love drinking the water here in Buffalo! I am afraid having 9000 hogs 2 miles away will ruin our water quality. I cringe at the thought of having a very rainy season or downpour of rain in a short amount of time because of the high possibility of the manure lagoon leaking into our streams and water ways. Such an event would cause the pollutants listed above to contaminate the water and would negatively affect the health of our citizens in the community.

2) Air Quality – I am concerned with the air quality may become polluted in our community if the hog farm would set up in our backyard. My concern would be with those who already have auto immune diseases, respiratory or heart conditions. My concern would be those who live near or would travel the roads in community while manure is being spread on the fields. I would be

concerned for the children in our community who would be traveling daily on the school buses to and from school, because they may become exposed to air pollutants caused from pig manure. The excerpt below was taken directly from the www.preservationnation.org website.

* "The quantity of waste from a large factory farm can equal the amount of sewage generated by a major city.[6] Factory farms also emit organic dusts, molds, bacterial endotoxins, and gases such as ammonia and hydrogen sulfide, many of which are known airway irritants or respiratory hazards.[7] This is a problem both for people living near CAFOs and for the people who work in them. Many studies have documented respiratory problems, including chronic bronchitis and non-allergic asthma, in approximately 25 percent of factory farm workers,[8] and some CAFO employees have actually died from asphyxiation after entering underground pits used to store manure.[9]"

*Cited: http://www.preservationnation.org/forum/library/public-articles/factory-farms.html?referrer=https://www.google.com/#.VurUHvkrKUk

The research shows that the water and air quality would be affected in our community and these effects have the potential to lead to health risks to the citizens in the Buffalo area.

The negative effects of CAFO's can be found all over the internet on news stories of our hog communities outraged by the negative effects of CAFO's in the United States proves that CAFO's are harmful to the environment.

I am not against hog farms. I am against corporate farming where thousands of hogs are penned up in buildings in a small area. I would rather have small hog farms spread out across the state of North Dakota then thousands of pigs concentrated to one small area. No environment can possibly handle this many hogs in one area without negative effects on the environment! This is not how animals should be raised. The negative effects are imminent with a hog farm of this size!

I am pleading with you to DENY the health environment permit to Rolling Green Family Farms. Please keep our wonderful, small community intact.

Best Regards,

Kimberly Von Bank

Kimberly Von Bank
Concerned Citizen of Buffalo, ND

Sources Cited:

http://minnesota.cbslocal.com/2015/02/16/water-air-quality-concerns-heighten-conflict-with-pig-farms/

http://www.preservationnation.org/forum/library/public-articles/factory-farms.html?referrer=https://www.google.com/#.VurUHvkrKUk

Marlene Sheldon
3477 144 Ave SE
Buffalo ND 58011-9763

To ND Health and Water Quality

I'm writing in regards to the proposed hog farm near us. We live in the southwest corner of Section 25 in Buffalo Townships.

I'm writing in concern for our water supply and quality. A 9000 plus hog farm would need alot of water. Spreading thousands of gallons of raw sewage would certainly affect our water quality. Composting dead animals will contaminate the air, cause stench and attract flies and rodents.

I'm caretaker for my husband, Bill, in our home. I don't leave him alone and seldom leave the farm more than once a week. I have allergies that affect my eyes, irritable bowel syndrome and osteporosis. It's important to have clean air for me to get outside to relieve stress and exercise for my osteporosis. In the summer I do all the outside chores, upkeep, painting, mowing, gardening flower and vegetables and caring for animals. In the winter I care for the animals and walk for excerise. One of the nicest things about summer is having the windows open.

Thank you for considering our concerns and please deny the hog farm permit.

Thank you, Marlene Sheldon

To ND Heath and Water Quality

I'm writing in regards to the proposed hog farm near us. We live in the southwest corner of section 25 in Buffalo Township.

Bill has dementia, irregular heartbeat, edema, high blood pressure, thyroid problems, kidney disease and COPD. He is homebound so it's that important to be able to have the windows open for fresh air and for him to get outside for a change of pace and stress relief.

We are also concerned about our water supply. Such a large hog farm would use a tremendous amount of water. How can thousands of gallons of untreated manure not affect our water and air quality? Composting the dead hogs would create stench, germs, flies and rodents.

Please deny the permit for the hog farm. Thank you for considering our feelings.

Bill Sheldon
by Marlene Sheldon
3477 144 Ave SE
Buffalo ND 58011-9763

ND Department of Health
Division of Water Quality

To Whom This May Concern:

We are writing in regards to the hog farm that is to be constructed near the town of Buffalo ND. We reside four miles southwest of the town of Buffalo. We have a family grain farm and my husband and I reside there with our five young children. Our kids will be the fourth generation to work our family farm.

We are concerned with the air and water quality that the farm is going to produce. That is a lot of pigs and they are going to let off lots of harmful smells and waste. We have children in the Elementary school in Buffalo which is only going to be about 3 miles from the hog farm. We are also concerned that there are going to be pipes running approximately five miles from the hog farm that the waste is going to be traveling through. That is going to get the hog farm practically in our yard when they spread the waste. My oldest son has asthma and could put a strain on this breathing. My husband worked when he was in high-school for a local hog farmer with around 1,000 pigs. He still to this day has a non-productive nagging cough that doctors think came from working around the pigs.

Our kids go fishing at many spots along the Maple River. They ride their bikes and do this all summer long. Are Pipestone farms going to make sure all the waste gets pumped on time and doesn't overflow on the land and end up in our local rivers and drinking water? It is our understanding they are going to semi-haul some of the waste too. What if the waste doesn't get tilled in the ground right away and it rains? We are very concerned about this.

We would like the North Dakota Health Department to deny the permit to Pipestone farms.

Thanks for your time,

Corey Hovel

Kristi Hovelson

Corey and Kristi Hovelson
13526 36 St SE
Buffalo, ND 58011
7016335626

48170 144th St
Big Stone City, SD
57216

Good afternoon. I am Kathy Tyler a resident of Big Stone Township, Grant County South Dakota, about two hours south of Fargo. I am a member of the Grant County Concerned Citizens and was apprised of the swine facility application via conversations with one of our county commissioners—that's a story for another time. I was invited to speak to you today about our experiences of having a 6400 sow unit in our neighborhood.

Before you get any idea that I am a city slicker complaining about odor, I grew up on a farm, live on an acreage, and own approximately 400 acres of grassland/farmland. My husband and I would be farmers/ranchers today if the stars would have aligned when my dad was retiring. We've lived at our current rural address since 1974. Up until this past summer, we have had no complaints about any of our neighbors, ever. Those neighbors include a numerous farmers—both active and retired, retired and working couples, a small organic (70 head maybe) dairy about a mile west, a 700 head dairy one mile south of us, a power plant, and an ethanol production facility.

Pipestone/Teton completed their facility in our neighborhood last spring. It is a shade over ½ mile to the southwest of our home. Within three months, the smell started. They have phase one fans coming off the pits. These fans run 24 hours per day. You may have heard from some that they visited a facility and there was no smell. There is no smell inside the barns; the pigs wouldn't survive if that air was allowed into their pen area. Please note that the air they NEED to remove is the air they are sending to us, their neighbors.

The smell we experience is like no other smell; it seems to be a heavier air and to come in waves. For example, if one is traveling along our road, you can walk into it and 1500 feet later walk out of it. It is so strong at times, that one holds one's breath until you can move away from it.

A very poignant example: Our bedroom is in the northwest corner of our home. My husband needs to be at work by 6:00 so he goes to bed fairly early. One beautiful fall evening he had gone to bed and left the windows open. When I opened our bedroom door at about 11:00 I was met with a tear-jerking odor. The nauseating smell had flowed from the facility, over a small hill, over our shelterbelt trees, and was sitting in our north yard.

We have two dairies in our neighborhood. One dairy, a small organic dairy of approximately 70 cows, is located about a mile northwest of the pig farm. When they are downwind, they smell the pigs-- while standing in their own dairy yard. The other, a larger dairy, rated at 700 cows, is southeast of the pig barn—about ¾ of a mile. That farmer has had odor in his yard..on the opposite sides of his barns.

Our neighbors and we have been keeping track of the smell on calendars since last August. What it boils down to is that if you are downwind, you will be affected by the stink coming from the barns. I've personally smelled the barns up to 3 miles away. Some days it's worse than others; it depends on cloud cover, humidity, wind speed, etc.

They will tell you that the odor will be minimal, as quoted by a Pipestone official in a recent newspaper article. They told us that also…

Their application for their facility on our county stated, in part:

"…E. All manure is stored under the buildings in concrete pits. Therefore, drainage is not a concern for potential odor production.

F. There will not be an open pens to create potential odor"

The odor is not minimal nor was it potential—it is maximum and it actual. ~~The~~ place stinks. It has ruined our neighborhood and our livelihoods. Our neighborhood has lost its nice evenings sitting on the porch with a beer or the nice walks or working in the yard or shop. Luckily we have no one in our neighborhood who is experiencing health problems, as of yet. It was a beautiful place -

I've been accused of being anti-ag, anti small farmer, etc because of my/our complaints against Pipestone/Teton, ~~I am~~ we are in no way anti-ag or anti-farm. One must remember that all farms are ag, but not all ag is farms.

I ask one thing of this committee, well two things really. Don't grant the permit for this location. But if you do grant this permit, ~~and I hope and pray you don~~'t; please require that the facility have an expert design and install biofilters or other equipment that will reduce odor and contaminated air by at least 90% on a year round basis. Research shows that this is possible. Also require that that equipment be maintained so as to consistently achieve that goal.

Thank you for your time

~~There are many others who wish to speak, so I will yield the rest of my time,~~ but am willing to answer any questions you may have as to economic advantages/disadvantages of the facility, property values, etc.

~~Thank you for your time~~

Thank you.

Kathy Tyler

Ktyler@tnics.com

As for economic impact. We are a county of numerous mega-dairies, two cheese factories, granite quarries, three banks. We have a shortage of workers. This facility wasn't needed; their feed is coming from outside our county, the construction crew was from Minnesota as were the materials, except for the concrete. The propane trucks come from Minnesota and the owners are out-of-state, or so we think. We ~~didn't~~ don't require actual names on the application.

Our county doesn't need

According to the county auditor, Teton's tax call is about $46,000 for a $11 million facility.

You will not sell any more corn, or any other grain -

In closing, I'd like to address an observation that has been made by many in our neighborhood: no one, not one person who is upset with our group, the Grant County Concerned Citizens or any other people who have complained about facilities such as this, has offered to put one of these facilities in his or her neighborhood. If a producer wishes to raise his pigs in this type of situation, go for it, but put it where it's wanted...in your neighborhood, not ours. It all boils down to location, location, location. This is not the place for a facility such as this.

Thank you, and I will welcome any and all questions.

TO: North Dakota Department of Health

My name is Craig Wendt and I am part of the Concerned Citizens of Buffalo. My wife and I and our two teenage daughters live a few miles straight south of Buffalo. I am not an area farmer. I chose to live in Buffalo because it's my hometown and I prefer the country way of life. My wife and I both work in Fargo and commute. Our daughters are currently attending Maple Valley School where I graduated in 1987.

I am horrified that this out-of-state corporation can build a hog factory 3-1/2 miles from our home and spread manure on 300 acres as close as a half mile from our family. Area farmers and landowners have signed a "Mutual Agreement to Refuse Easements". This agreement states:

"Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste or manure, or (2) to install a pipeline across or upon our land."

There are a total of 46 pages of signed documents which account for 33,083 acres. The number of acres refusing easements speaks volumes. We demand that the ND Health Department denies this illegal permit.

Hello, my name is Randy Coon and I farm south of Buffalo. The opinions expressed on the topic of nutrient management are solely those of the Concerned Citizens of Buffalo and do not represent any other individual, entity, or institution. I am here today as a private citizen and do not represent North Dakota State University or the Department of Agribusiness & Applied Economics

Using liquid hog manure as a crop fertilizer does present problems. Manure is not a plant nutrient balanced product. In other words, the ratio of nitrogen (N) to phosphorus (P) is such that applying enough nitrogen for crop nutrient requirements will result in excess phosphorus being added to the soil. It is possible for phosphorus to reach high enough levels to cause it to move off-site and get into surface water. North Dakota State University (Linderman) and the University of Minnesota (Schmitt and Rehm) researchers recommend applying enough manure to meet plant phosphorus requirement. We strongly recommend the nutrient management plan be required to use phosphorus to set the maximum application rate, and the soil be tested using a total extraction method to determine the total phosphorus in the soil.

Determining the sustainability of this nutrient plan was difficult because five of the six land easement contracts were incomplete. Water quality risk assessment maps provided incorrect legal descriptions and acreages, with one quarter section showing over 200 acres. These maps show boundaries for each parcel and include setbacks which consist of waterways and noncropland acres but do not include the Howes Township Ordinance setbacks. These setbacks are important because when turning the operator lifts the applicator but leaves the pump running, dropping the manure on top of the ground. For these reasons, the proposed available acreage is overstated.

Nutrient content of liquid manure can vary greatly. The NDSU study by Linderman recommended using an analysis of 27 pounds of nitrogen, 27 pounds of phosphorus, and 15 pounds of potassium per 1,000 gallons. Soil tests provided for Field #1 showed 24 pounds of nitrogen, 2 ppm of P_2O_5, and 182 ppm of K_2O available in the soil. To achieve a realistic corn yield goal of 140+ bushel per acre, 175 pounds of N, 102 pounds of P_2O_5, and 170 pounds

of K_2O would be required. Because 80 percent of the P_2O_5 available, 1,000 gallons of liquid manure would add 21.6 pounds of P_2O_5 per acre.

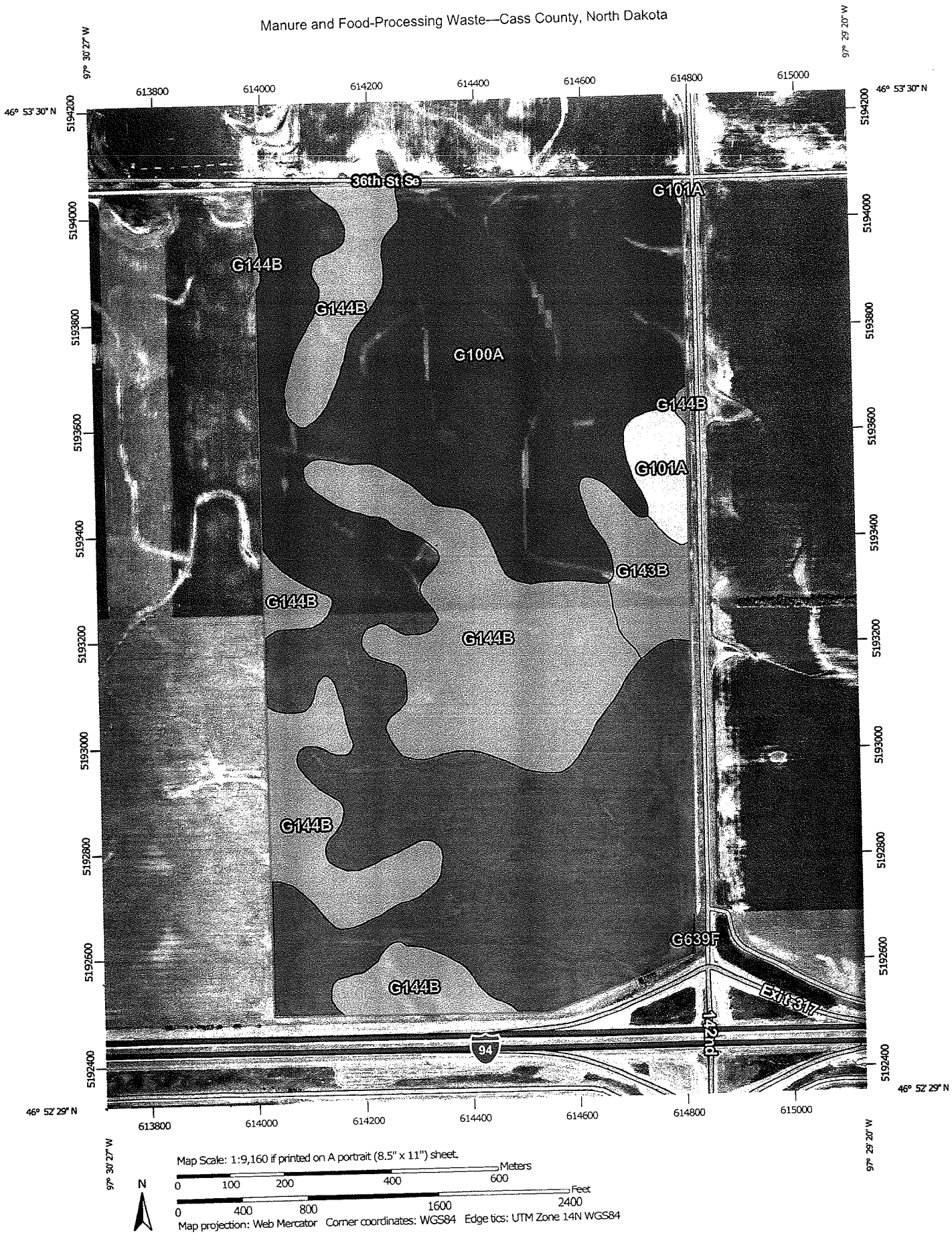
Dividing the 102 pounds per acre required by the 21.6 pounds available per 1,000 gallons would give a 4,722 gallons per acre rate. If 7.0 million gallons of liquid manure were to be disposed of each year, 1,482 acres of corn would be required. Soil tests indicate no nitrogen is need for soybeans, so liquid manure should not be applied for that crop. A corn-soybean rotation would require applying the manure to the same ground every other year. Applying the liquid manure above the recommended rates would lead to excess nutrients getting into ground water and rivers. Almost all of the proposed acres drain into the Maple River, which further downstream dumps into the Red River. The Red River flows into Canada which could lead to contamination of international waters. This illustrates the importance of restricting application rates to match phosphorus requirements.

The proposed location for the facility is in a very unique soils area. Its proximity to the Lake Agassiz shoreline has a significant effect on the area soils. National Resource Conservation Service (NRCS) web soil survey maps provide numerous measurements for these soils, including a Sustainability and Limitations rating. This category is further subdivided into waste management for manure and food processing wastes. These rating are based on soil properties that effect adsorption, plant growth, microbial activity, and erodibility. Rating go from 0.0 to 1.0, with a 1.0 rating classified as "very limited". These limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. These soils are classified as Hamerly-Tonka soils. The map presented is for the land adjacent to the proposed facility. The red colored areas are the Hamerly-Tonka soils with the 1.0 ("very limited") rating. Of the total acres contracted for manure application, 1,408.6, or over 40 percent, are classified as Hamerly-Tonka with the "very limited" rating. If the Hamerly-Tonka soils are to be considered for manure application, we strongly recommend an environmentally responsible nutrient management plan with strict adherence to application rules and very close monitoring by the Department of Health to prevent pollution and environmental problems.

Further contributing to the potential pollution problems are the amount of tiled acres that drain into the Maple River. The north half of section 36 of Tower Township is tiled land that has been designated for manure application. NRCS maps provide information regarding Agronomic Concerns for Pesticide and Nutrient Leaching. Hamerly-Tonka soils in this parcel are rated on a 0.0 to 1.0 scale, with the 1.0 being "very limited" for this use. About two-thirds of this parcel are rated as a 1.0, indicating the high risk of pesticide and nutrient leaching. The waterway in the southwest corner of this land drains directly into the Maple River about one-half mile away. Applying liquid manure to this land poses a high level of environmental risk. We recommend tiled acres not be allowed to be use for application of liquid hog manure, or at a minimum, application should be in the spring and under close supervision and monitoring by the State Health Department.

Based on the information we have been provided, there is not sufficient acreage available to dispose of the 7.0 million gallons of liquid hog manure produced annually. Acreage contracts overstate the available acres, and drain tiled land and Hamerly-Tonka soil problems have not been addressed. Over applying liquid manure to the soils could present serious environmental problems. This nutrient management plan is not achievable, or sustainable. Further compounding the problem of disposing of the manure is the "easement map" which will be presented later. The Concerned Citizens of Buffalo urge the North Dakota State Health Department to stay true to their mission statement. This illegal permit request must be denied to protect the health of the Buffalo area citizens, and everyone's air and water quality.

Thank you.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Map Scale: 1:9,160 if printed on A portrait (8.5" x 11") sheet.
Meters
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0 400 800 1600 2400
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Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Background
- Aerial Photography

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cass County, North Dakota
Survey Area Data: Version 15, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Aug 27, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Hamerly (42%)	High water table (1.00)	77.7	24.1%
			Tonka (28%)	High water table (1.00)		
			Wyard (7%)	High water table (1.00)		
			Vallers, moderately saline (7%)	High water table (1.00)		
			Parnell (5%)	High water table (1.00)		
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Very limited	Hamerly (46%)	High water table (1.00)	143.7	44.6%
			Wyard (24%)	High water table (1.00)		
			Tonka (8%)	High water table (1.00)		
			Hamerly, moderately saline (5%)	High water table (1.00)		
			Vallers (4%)	High water table (1.00)		
G143A	Barnes-Svea loams, 0 to 3 percent slopes	Somewhat limited	Barnes (39%)	High water table (0.19)	57.9	18.0%
			Svea (38%)	High water table (0.76)		
			Cresbard (3%)	High water table (0.76)		
G143B	Barnes-Svea loams, 3 to 6 percent slopes	Somewhat limited	Barnes (42%)	High water table (0.19)	8.6	2.7%
			Svea (21%)	High water table (0.76)		
			Balaton (12%)	High water table (0.76)		
			Swenoda (3%)	High water table (0.76)		
			Cresbard (3%)	High water table (0.76)		
G147C	Buse-Barnes-Darnen loams,	Not limited	Buse (28%)		23.4	7.3%
			Barnes (23%)			

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
	3 to 9 percent slopes		Langhei (7%)			
			Langhei, very stony (6%)			
G523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	Very limited	Fluvaquents, channeled, frequently flooded (40%)	High water table (1.00)	11.1	3.5%
				High perc rate (0.21)		
			Lowe, frequently flooded (28%)	High water table (1.00)		
			Lowe, moderately saline, frequently flooded (20%)	High water table (1.00)		
			Lowe, very poorly drained, frequently flooded (5%)	High water table (1.00)		
			Moritz, occasionally flooded (5%)	High water table (1.00)		
Totals for Area of Interest					322.5	100.0%

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Very limited	232.6	72.1%
Somewhat limited	66.5	20.6%
Not limited	23.4	7.3%
Totals for Area of Interest	322.5	100.0%

Description

The interpretation for Agronomic Concerns, Pesticide and Nutrient Leaching evaluates limitations of a soil that increase the hazard of contaminating aquifers, springs, and local water tables.

The soil features considered are saturated hydraulic conductivity and depth to seasonal high water table.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soil is limited by all of the soil features that affect the interpretation. Numerical ratings indicate the severity of individual limitations; the highest numerical rating identifies the most limiting soil feature(s) considered in the rating process. Less restrictive soil features have a lower numerical value than the maximum used to rate the soil. They are identified to provide the user with additional information about soil limitations for the specific use. Restrictive soil features also need to be considered in planning, design, installation, and management. "Not limited" (numerical value for the most restrictive feature = 0.00) indicates that the soil has features that are very favorable for the specified use. "Somewhat limited" (numerical value for the most restrictive feature = 0.01 to 0.99) indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning. "Very limited" (numerical value for the most restrictive feature = 1.00) indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special planning, or expensive installation procedures.

The results of this interpretation are not designed or intended to be used in a regulatory manner.

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

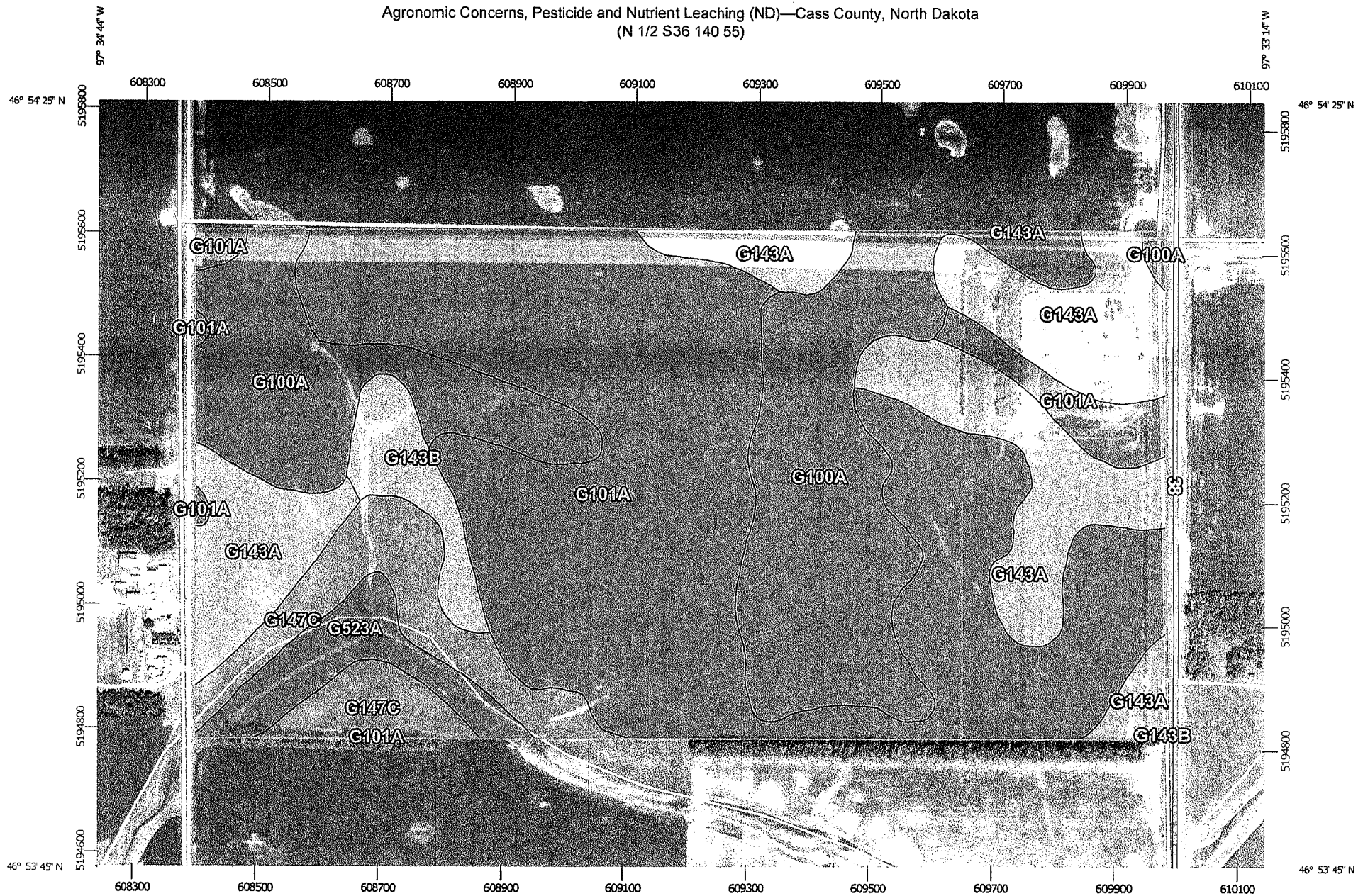
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)—Cass County, North Dakota
(N 1/2 S36 140 55)



Map Scale: 1:8,700 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 100 200 400 600

Feet: 0 400 800 1600 2400

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

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Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

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Survey Area Data: Version 15, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Aug 27, 2010

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Agronomic Concerns, Pesticide and Nutrient Leaching (ND)

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G6A	Vallers loam, 0 to 1 percent slopes	Very limited	Vallers (67%)	High water table (1.00)	6.0	1.0%
			Hamerly (13%)	High water table (1.00)		
			Vallers, moderately saline (8%)	High water table (1.00)		
			Tonka (5%)	High water table (1.00)		
			Parnell (3%)	High water table (1.00)		
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Hamerly (42%)	High water table (1.00)	111.1	17.8%
			Tonka (28%)	High water table (1.00)		
			Wyard (7%)	High water table (1.00)		
			Vallers, moderately saline (7%)	High water table (1.00)		
			Parnell (5%)	High water table (1.00)		
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Very limited	Hamerly (46%)	High water table (1.00)	38.1	6.1%
			Wyard (24%)	High water table (1.00)		
			Tonka (8%)	High water table (1.00)		
			Hamerly, moderately saline (5%)	High water table (1.00)		
			Vallers (4%)	High water table (1.00)		
G143A	Barnes-Svea loams, 0 to 3 percent slopes	Somewhat limited	Barnes (39%)	High water table (0.19)	23.6	3.8%
			Svea (38%)	High water table (0.76)		
			Cresbard (3%)	High water table (0.76)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
G143B	Barnes-Svea loams, 3 to 6 percent slopes	Somewhat limited	Barnes (42%)	High water table (0.19)	171.2	27.4%
			Svea (21%)	High water table (0.76)		
			Balaton (12%)	High water table (0.76)		
			Swenoda (3%)	High water table (0.76)		
			Cresbard (3%)	High water table (0.76)		
G143C	Barnes-Buse-Langhei loams, 6 to 9 percent slopes	Not limited	Barnes (24%)		37.2	5.9%
			Buse (23%)			
			Langhei (18%)			
			Renshaw (3%)			
G144B	Barnes-Buse loams, 3 to 6 percent slopes	Somewhat limited	Barnes (25%)	High water table (0.19)	66.2	10.6%
			Svea (14%)	High water table (0.76)		
			Balaton (10%)	High water table (0.76)		
			Swenoda (3%)	High water table (0.76)		
			Cresbard (3%)	High water table (0.76)		
			Sioux (2%)	High perc rate (0.22)		
G250A	Divide loam, 0 to 2 percent slopes	Very limited	Divide (70%)	High water table (1.00)	14.0	2.2%
			Marysland (14%)	High water table (1.00)		
			Wyrene (4%)	High water table (1.00)		
				High perc rate (0.08)		
G523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	Very limited	Fluvaquents, channeled, frequently flooded (40%)	High water table (1.00)	144.3	23.1%
				High perc rate (0.21)		
			Lowe, frequently flooded (28%)	High water table (1.00)		
			Lowe, moderately saline, frequently flooded (20%)	High water table (1.00)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
			Lowe, very poorly drained, frequently flooded (5%)	High water table (1.00)		
			Moritz, occasionally flooded (5%)	High water table (1.00)		
G546A	Lowe loam, saline, 0 to 1 percent slopes, occasionally flooded	Very limited	Lowe, moderately saline, occasionally flooded (78%)	High water table (1.00)	14.1	2.3%
			Lowe, very poorly drained, frequently flooded (8%)	High water table (1.00)		
			Lowe, occasionally flooded (5%)	High water table (1.00)		
			Harriet, occasionally flooded (4%)	High water table (1.00)		
			Moritz, saline-sodic sub, occasionally flooded (4%)	High water table (1.00)		
Totals for Area of Interest					**625.8**	**100.0%**

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Rating Value		
Rating	**Acres in AOI**	**Percent of AOI**
Very limited	327.6	52.4%
Somewhat limited	261.0	41.7%
Not limited	37.2	5.9%
Totals for Area of Interest	**625.8**	**100.0%**

Description

The interpretation for Agronomic Concerns, Pesticide and Nutrient Leaching evaluates limitations of a soil that increase the hazard of contaminating aquifers, springs, and local water tables.

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Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

North Dakota Department of Health and Water Quality

My name is Gerald Marcks, I was born in the same bedroom that I sleep in now, 77 years later. My Granddad and Dad farmed this land for 90 plus years, before I bought my Dad out. I've farmed since a sophomore in high school. I have been involved with milk cows, beef cattle and hogs in earlier years. I'm, still farming today, as I still enjoy the benefits of being my own boss and seeing what the next years bring.

The last 10-12 years I've had heart disease, two minor heart attacks, triple bypass surgery, two stents put in and have a leaky valve. I take a lot of meds for these conditions. High blood pressure, bad cholesterol, blood thinners and others. Part of my health routine is walking and staying active. I'm concerned that this hog factory will be detrimental to my well being. All my farm land lies within two and a half miles from the planned site and my farm house is a mile and a half away. With all the air pollution (hydrogen sulfide, ammonia, methane, endotoxins, carbon dioxide and particulate matter) that will be released into the area, I am very concerned for my health.

One quarter of my land is only 80 feet from the proposed hog factory. Excess runoff water from the site goes across this land and another quarter that I farm is just across a township road 1860 feet away. If this isn't enough, my neighbors will be applying manure on 1140 acres all around me - north, east and west. All 1500 acres that I farm will be impacted.

I hope you people at the ND Department of Health and Water Quality will address our concerns and deny this permit!!!!!!!

Thank you for your time,

Gerald Marcks

Gerald Marcks

FAM MED WEST FARGO SC
SANFORD WEST FARGO CLINIC
1220 Sheyenne St
West Fargo ND 58078
701-234-4445

March 8, 2016

GERALD DEAN MARCKS
PO BOX 121
BUFFALO ND 58011

TO WHOM IT MAY CONCERN:

This is to certify that Gerald Dean Marcks has been an established patient at this clinic. He has the following cardiac related chronic health conditions based on a search of his records:

Coronary artery disease
Essential hypertension
Hyperlipidemia.

Sincerely,

Matthew J McLeod, MD

Name: Gerald Dean Marcks | DOB: 8/6/1938 | MRN: E2199749 | PCP:

Health Summary

Current Health Issues

Health Issue	Date Noted
Coronary atherosclerosis	
Postsurgical aortocoronary bypass status	04/03/2007
Essential hypertension, benign	
Encounter for long-term (current) use of other medications	
Mixed hyperlipidemia	12/10/2010
Obesity	
Disorder of bursae and tendons in shoulder region	06/30/2011
Gout	02/07/2012

Medications

cyclobenzaprine 10 mg tablet
Commonly known as: FLEXERIL

Instructions: Take 1 tablet by mouth 3 times a day as needed for muscle spasm

Approved by Matthew J McLeod, MD
Prescribed on 3/15/2016
Prescribed quantity: 60 tablets

Request a renewal

metoprolol tartrate 50 mg tablet
Commonly known as: LOPRESSOR

Instructions: Take 1 and 1/2 tablets 2 times a day

Approved by Bruce Dahl, MD
Prescribed on 6/12/2015
Prescribed quantity: 270 tablets

Request a renewal

candesartan 16 mg tablet

Commonly known as: ATACAND

Instructions: Take 1 tablet by mouth 1 time per day.

Approved by Bruce Dahl, MD
Prescribed on 6/12/2015
Prescribed quantity: 90 tablets

Request a renewal

clopidogrel 75 mg tablet

Commonly known as: PLAVIX

Instructions: Take 1 tablet by mouth 1 time per day.

Approved by Bruce Dahl, MD
Prescribed on 6/12/2015
Prescribed quantity: 90 tablets

Request a renewal

allopurinol 300 mg tablet

Commonly known as: ZYLOPRIM

Instructions: Take 1 tablet by mouth every day for gout

Approved by Bruce Dahl, MD
Prescribed on 6/12/2015
Prescribed quantity: 90 tablets

Request a renewal

atorvaSTATin 20 mg tablet

Commonly known as: LIPITOR

Instructions: Take 1 tablet by mouth every day in the evening

Approved by Bruce Dahl, MD
Prescribed on 6/12/2015
Prescribed quantity: 90 tablets

Request a renewal

omega-3 fatty acids 1200 MG capsule

Commonly known as: fish oil

Instructions: Take 1,200 mg by mouth 1 time per day.

Documented by Abstract Provider

aspirin 81 mg chewable tablet

Instructions: Take 2 tablets by mouth 1 time per day.

Approved by David J Clardy, MD
Prescribed on 1/13/2014
Prescribed quantity: 180 tablets

Request a renewal

vitamin D3 (cholecalciferol) 2000 unit tablet
Instructions: Take 2,000 units by mouth 1 time per day.
Documented by Abstract Provider

Allergies

Allergen	Reaction
Lisinopril	Other (Specify in Comments)
Irbesartan	Other (Specify in Comments)

Immunizations

Immunization	Date
Influenza High Dose (65+)	10/2/2014
Influenza High Dose Vaccine (65+)	10/5/2015
Pneumococcal Polysaccharide PPSV23	9/22/2003
Td (adult) preservative free (Tenivac)	9/22/2003

Preventive Care

Name	Status	Last Done
Zostavax Vaccine	Overdue since 8/6/1998	
Pneumococcal Adult	Overdue since 9/22/2004	9/22/2003
Tetanus Vaccine	Overdue since 9/22/2013	9/22/2003
Colonoscopy	Not due until 7/14/2024	7/14/2014
Flu Vaccine	Completed on 10/5/2015	10/5/2015

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North Dakota Department of Health and Water Quality

My name is Jacqueline Marcks, Gerald Marcks is my husband and our farm home is only one and a half miles from the proposed hog factory. I've lived here since we were married 56 years ago.

I am a colon cancer survivor. I was diagnosed with Primary Biliary Cirrhosis of my liver at the Mayo Clinic in Rochester, MN. I doctored there for two years, going every 6 months, and was told that I would be a liver transplant candidate some day. I was told that doctors in Fargo would be able to treat my condition and all my records were transferred to St. Lukes, now Sanford. Two years ago I had a TIPS Procedure done, where the veins to my liver were banded and stents put in. My immune system is weak and my blood panel is askew, however, I'm maintaining now. I've been hospitalized several times in the past two years and have appointments every three month with numerous specialists for all my ailments. I am also currently in a study group with the Mayo Clinic for hereditary Primary Biliary Cirrhosis.

I am very concerned that the air quality coming from the proposed hog factory near Buffalo will be harmful to my weakened condition. I fear the air emissions of hydrogen sulfide, methane, ammonia and particulate matter that will be released from this proposed hog factory and the manure that will be spread on land next to, and all around, our land will add to my medical problems.

In closing, I ask that the ND Department of Health and Water Quality please deny this permit.

Thank you,

Jacqueline Marcks

Jacqueline Marcks

INT MED FGO SC
SANFORD BROADWAY CLINIC
801 Broadway N
Fargo ND 58122
701-234-2261

February 25, 2016

JACQUELINE LAYNE MARCKS
PO BOX 121
BUFFALO ND 58011

Regarding Jacqueline Layne Marcks:

She has chronic liver disease with multiple complications and is concerned about the ammonia, methane and hydrogen sulfide gases that may be produced by the large pig farming operation.

Sincerely,

Janelle C. Sanda, M.D.

Janelle Sanda, MD
SANFORD HEALTH BROADWAY CLINIC
701 - 234 - 2261

Janelle Sanda, MD

Name: Jacqueline Layne Marcks | DOB: 3/25/1940 | MRN: E2199751 | PCP: Laura M Nichols, MD

Health Summary

Current Health Issues

Health Issue	Date Noted
Primary biliary cirrhosis	07/24/2003
Osteoporosis	07/24/2003
Ascites	04/09/2004
Anemia	04/09/2004
Isoimmunization from other and unspecified blood-group incompatibility, unspecified as to episode of care in pregnancy	02/20/2004
Malignant neoplasm of rectum	01/11/2006
Esophageal varices	11/02/2006
Alopecia	02/13/2013
Hypothyroidism	02/13/2013
Diarrhea	04/11/2013
Red blood cell antibody positive with compatible PRBC difficult to obtain	07/09/2013
S/P TIPS (transjugular intrahepatic portosystemic shunt)	07/22/2013
Pancytopenia	07/31/2013
Depression	10/28/2013
Peripheral edema	03/04/2014
Zinc deficiency	07/17/2014
Pain of left thumb	01/13/2015
Left ankle pain	03/13/2015
Chronic pain of left ankle	04/14/2015
Acute deep vein thrombosis of left lower extremity	05/07/2015

Long term current use of anticoagulant therapy	05/15/2015
Acute hepatic encephalopathy	08/03/2015
Thrombocytopenia	08/15/2015
Thrombocytopenia	08/24/2015
Hepatic encephalopathy	09/18/2015
Neutropenia	09/21/2015

Medications

denosumab 60 mg/mL subcutaneous injection
Commonly known as: PROLIA
Instructions: Inject 1 ml (60 mg total) subcutaneously every 6 months
Approved by Niyutchai Chaithongdi, MD
Prescribed on 3/15/2016
Prescribed quantity: 1 mL
Request a renewal

neomycin sulfate 500 MG tablet
Instructions: Take 1/2 tablet by mouth 3 times a day
Approved by Sajid Jalil, MD
Prescribed on 2/23/2016
Prescribed quantity: 45 tablets
Request a renewal

levothyroxine 75 mcg tablet
Instructions: Take 1 tablet (75 mcg total) by mouth 1 time a day in the morning.
Approved by James T Upton, APRN-CNP
Prescribed on 2/16/2016
Prescribed quantity: 90 tablets
Request a renewal

omeprazole 20 mg capsule
Commonly known as: priLOSEC
Instructions: Take 1 capsule (20 mg total) by mouth 2 times a day before meals.
Approved by Doreen Gigstad-Stave, PA
Prescribed on 2/1/2016
Prescribed quantity: 180 capsules
Request a renewal

metoprolol tartrate 25 mg tablet

Commonly known as: LOPRESSOR

Instructions: Take 1/2 tablet by mouth 2 times a day

Approved by Brooke Brekke, APRN-CNP
Prescribed on 1/12/2016
Prescribed quantity: 180 tablets

Request a renewal

furosemide 40 mg tablet

Commonly known as: LASIX

Instructions: Take 60 mg by mouth 1 time per day.

Documented by Abstract Provider

XIFAXAN 550 mg tablet

Generic name: rifaximin

Instructions: Take 1 tablet by mouth 2 times a day

Approved by Sajid Jalil, MD
Prescribed on 10/5/2015
Prescribed quantity: 60 tablets

Request a renewal

calcium carbonate-vitamin D 600 mg-400 unit tablet

Commonly known as: CALTRATE 600 + D

Instructions: Take 1 tablet by mouth 1 time per day.

Documented by Abstract Provider

spironolactone 50 mg tablet

Commonly known as: ALDACTONE

Instructions: Take 3 tablets by mouth once daily

Approved by Sajid Jalil, MD
Prescribed on 9/14/2015
Prescribed quantity: 90 tablets

Request a renewal

denosumab 60 mg/mL subcutaneous injection

Commonly known as: PROLIA

Instructions: Inject 1 ml subcutaneously every 6 months.

Approved by Niyutchai Chaithongdi, MD
Prescribed on 8/26/2015
Prescribed quantity: 1 mL

Request a renewal

ursodiol 250 mg tablet
Commonly known as: URSO
Instructions: Take 250 mg by mouth 3 times a day.
Documented by Abstract Provider

vitamin D3 (cholecalciferol) 2000 unit capsule
Instructions: Take 2,000 units by mouth 1 time per day.
Documented by Abstract Provider

ENSURE COMPLETE PO
Instructions: Take 8 oz by mouth 2 times a day.
Documented by Abstract Provider

Allergies

Allergen	Reaction
Aspirin	Anaphylaxis (High)

Immunizations

Immunization	Date
Denosumab (Prolia)	3/15/2016, 8/26/2015, 2/23/2015, 8/21/2014
HEP B	7/16/1999, 2/4/1999, 1/4/1999
Hep A,peds/adol	9/28/2000, 3/6/2000
Im Medication Administration	12/18/2012
Influenza High Dose (65+)	10/5/2015, 10/2/2014, 9/23/2013, 10/4/2012
Influenza Trivalent w/preserv	9/28/2009
Influenza Vaccine	10/3/2008, 10/15/2007
Pneumococcal Conj PCV13	12/22/2014
Pneumococcal Polysaccharide PPSV23	10/15/2007, 1/4/1999
Td (adult) preservative free (Tenivac)	9/28/2009

Triamcinolone (Kenalog) 5mg/mL	11/19/2012, 11/7/2012, 8/28/2012
Zoster	11/9/2009

Preventive Care

Name	Status	Last Done
Lipid Screening	Overdue since 3/25/1980	
Colonoscopy	Not due until 6/18/2018	6/18/2013
Tetanus Vaccine	Not due until 9/28/2019	9/28/2009
Dexa/heel Scan	Not due until 8/10/2030	8/10/2015
Zostavax Vaccine	Completed on 11/9/2009	11/9/2009
Pneumococcal Adult	Completed on 12/22/2014	12/22/2014
Flu Vaccine	Completed on 10/5/2015	10/5/2015

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Tracie Zaun
304 Wilcox Ave N Buffalo ND 58011
PH: 701-361-1699 Email: tracie.zaun@corelinksolutions.com

March 12, 2016

North Dakota Department of Health
Division of Water Quality
600 E Boulevard Ave
Bismarck, ND 58505

To whom it may concern,

As you are aware, there is a lot of concern stemming from the community meeting in Buffalo, ND on January 18th regarding Rolling Green Family Farms moving in a hog farm operation. I am writing a letter of concern due to medical reasons.

I am a 40 year old female that has been dealing with a compromised immune system, I have Lupus. As you are well aware, when someone has a compromised immune system, they have a harder time fighting off viruses, bacteria and germs. I have days where I feel "normal" but I also have days that make it difficult to leave my house.

When I heard about a hog farm coming to our community, I had immediate concerns for my health and others in the community that also suffer from autoimmune diseases and other health issues. One of my biggest concerns that I have is zoonotic disease transmission especially MRSA. In some of the research that I have looked at, people who live within a mile of a hog operation are nearly 3 times more likely to carry MRSA in their noses than the general population (McKenna, 2014) and also another MRSA study conducted in Pennsylvania in 2013 (Joan A. Casey, Frank C. Curriero, Sara E. Cosgrove, Keeve E. Nachman, & Brian S. Schwartz, 2013) found that people who live near fields treated with industrially farmed hog manure are "significantly" more likely to be treated for infections, and that people who live near hog operations showed a "similar but weaker association" with MRSA infection rates. With this being said, those that have weakened immune systems are at an increased risk for developing staph infections, including MRSA.

It has also been brought to my attention that there will be application of the manure from the hog farm to fields that are adjoining land my husband and I farm. This brings concern to me also as this could increase risks to my health and others near and dear to me.

Thank you for taking the time to listen to my concerns regarding my health and those that live in the community as there are elderly folks that live in this community that could also be affected. Do not allow this illegal permit to build this facility as I do not consider this a family operation and I care about family, friends and neighbors in our community.

Sincerely,

Tracie Zaun

Stellar Healthcare

Melissa Erdmann, NP

3/15/2016

TRACIE ZAUN
304 Wilcox Ave N
Buffalo, ND 58011

To Whom It May Concern:

TRACIE ZAUN has the diagnosis Lupus.. This patient was seen in my office and is currently receiving medical care.

Thank you,

Melissa Erdmann NP

827 28th ST S Suite B. Fargo, ND 58103 Phone: 701-364-3660 Fax: 701-364-3661

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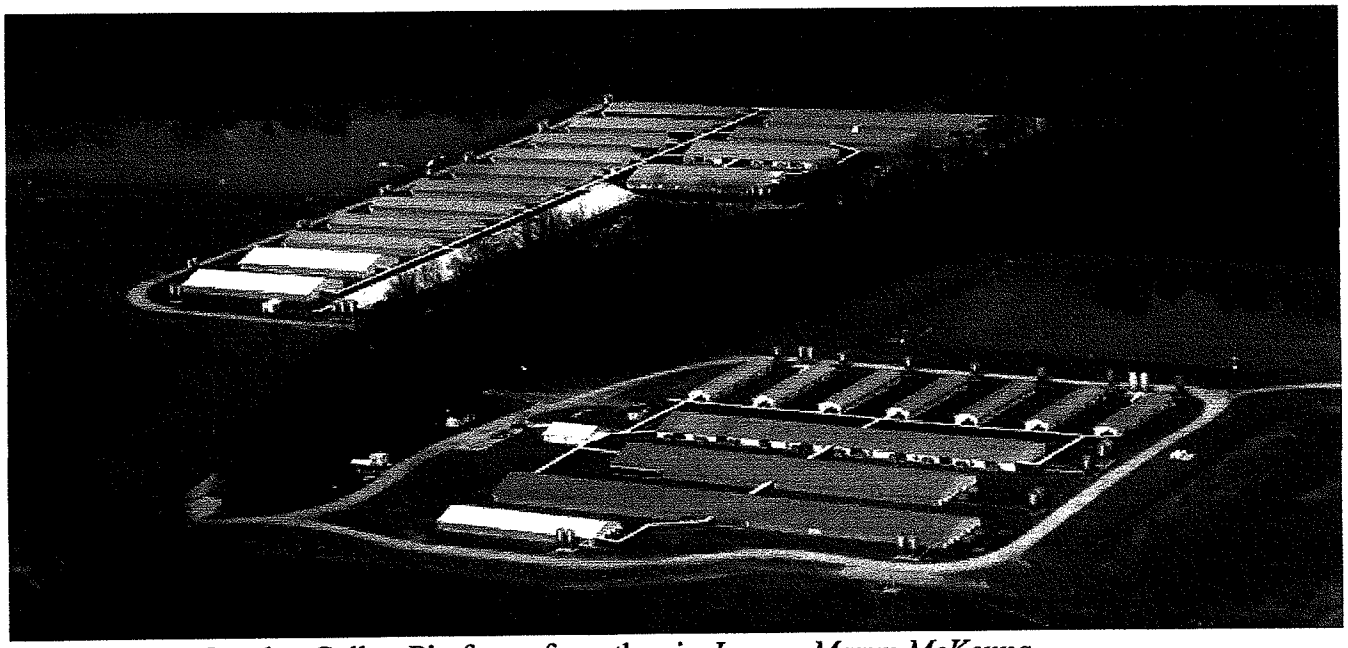
Almost Three Times the Risk of Carrying MRSA from Living Near a Mega-Farm



Click to Open Overlay GalleryPig farms from the air. *Image: Maryn McKenna*

In the long fight over antibiotic use in agriculture, one of the most contentious points is whether the resistant bacteria that inevitably arise can move off the farm to affect humans. Most of the illnesses that have been associated with farm antibiotic use — resistant foodborne illness, for example — occur so far from farms that opponents of antibiotic control find them easy to dismiss. So whenever a research team can link resistant bacteria found in humans with farms that are close to those humans, it is an important contribution to the debate.

A team from the University of Iowa, Iowa City Veterans Affairs, and Kent State University have done just that. In next month's *Infection Control and Hospital Epidemiology*, they survey 1,036 VA patients who lived in rural Iowa and were admitted to the Iowa City facility in 2010 and 2011. Overall, among those patients, 6.8 percent were carrying MRSA, drug-resistant staph, in their nostrils. But the patients' likelihood of carrying MRSA was 2.76 times higher if they lived within one mile of a farm housing 2,500 or more pigs.

They say:

The increasing populations of swine raised in densely populated CAFOs and exposed to antibiotics presents opportunities for drug-resistant pathogens to be transmitted among human populations. Our study indicates that residential proximity to large numbers of swine in CAFOs in Iowa is associated with increased risk of MRSA colonization.

Some important things to unpack here:

- MRSA (formally, methicillin-resistant *Staphylococcus aureus*) often "colonizes" people — takes up residence on the skin or in the nostrils — before it causes an infection. Studies have shown repeatedly that being colonized with MRSA increases the risk of contracting a difficult-to-treat infection.
- Because of that risk, and because MRSA spreads easily in hospitals, the VA since 2006 has required facilities to screen all incoming patients to see whether they are carrying MRSA and thus are posing a risk to other patients.
- MRSA is frequently found in the vicinity of pigs: not just MRSA ST398, the specific resistant variety that was first identified in pig farmers in the Netherlands in 2004, but the garden-variety community forms as well.
- And Iowa has a lot of pigs: 19 million, according to the US Department of Agriculture, housed in about 7,000 "CAFOs" (for confined or concentrated animal-feeding operations), which the US Environmental Protection Agency defines as a facility of at least 1,000 pigs, though most are many thousands larger.

(If you'd like to know more about MRSA, including the "livestock-associated "pig MRSA" variety, I wrote a book. OK, back to this paper.)

The authors, led by Margaret Carrel, PhD, initially identified 2,996 patient admissions in that 2-year period, and then winnowed out any patients who lived in cities as well as any whose addresses could not be confirmed and plotted using geo-coding. That left them with 1,746 samples taken from 1,036 patients, of which 119 — 6.8 percent — were positive for MRSA. That was a red flag to begin with, because MRSA colonization in the general population is less than 2 percent.

Using data from the Iowa Department of Natural Resources for the locations of very large pig-raising facilities, they then sorted the patients by the distance of their homes from pig CAFOS. Initially, patients who lived 1 mile or less from a CAFO were 1.8 times more likely to be colonized. When the team cleaned up the data — accounting for patients who came into the

hospital more than once in that 2-year period, and also adjusting for the known likelihood that elderly patients, who are likely to be in a VA facility, have higher colonization rates — they came up with a relative risk of 2.76.

This is not the first time that MRSA has been found in people who work on farms or live in the vicinity of them. Last year, a study found "pig MRSA" in workers from North Carolina hog farms, and another identified it in workers in Iowa and Illinois. Meanwhile, a third study published just in November found MRSA among people who lived in the vicinity of fields where swine manure was being applied. And last year, a group in Germany identified MRSA in people who lived near hog farms but did not have contact with animals.

None of these studies have been able to trace with precision how workers and neighbors are acquiring MRSA. The authors of the newest study say:

Although the exact mechanism by which residential proximity to large swine CAFOs increased risk of MRSA is unknown, it appears that there is potential for drug-resistant strains of *S. aureus* in animals to transmit to people living at close distances. For example, a 55-pound or greater hog can produce upward of ~~10~~ 2 *(see Update)* gallons of manure a day. Typically, in Iowa, manure is spread on surrounding fields, and MRSA can be aerosolized from this manure to human food or water sources.

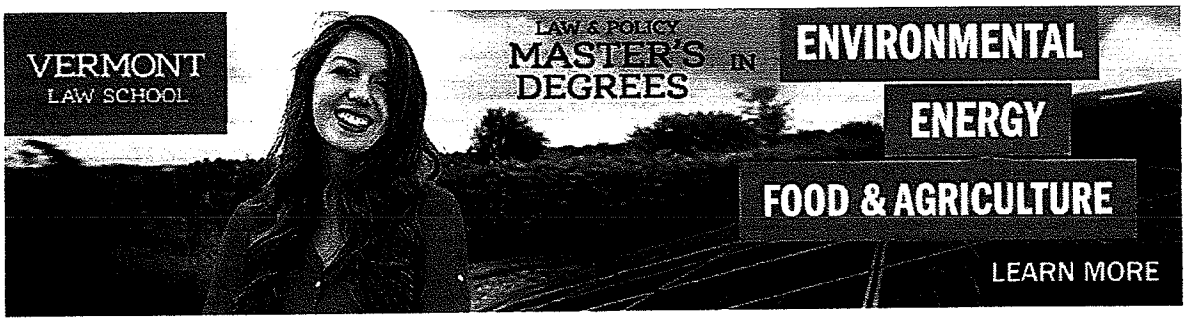
And they add:

Residential proximity to CAFOs could be risky in ways other than simply direct exposure to preexisting livestock-associated *S. aureus* strains, including via exposure to antibiotic residues via air or water, application of manure containing residues near their homes.

As last year ended, a number of food-policy writers noted that 2013 marked the first time that discussion of agricultural use of antibiotics — and the unintended consequences of that use — really emerged into mainstream discourse. Papers like this can move that process along. Throughout the decades-long discussion of farm antibiotics, the challenge has been linking the externalized costs of those antibiotics back to their use on the farm. The more those off-farm effects are elucidated, the more complete and transparent the discussion of on-farm use ought to become.

(Update: Eli Perencevich, the paper's senior author, got in touch to say that an error was edited into the paper when it was cut for length. The correct amount of manure would be 1-2 gallons a day, as noted in this paper from the Clemson University Extension by Chastain et al.)

Cite: Carrel M, Schweizer ML, Sarazin MV, Smith TC, Perencevich EN. Residential Proximity to Large Numbers of Swine in Feeding Operations Is Associated with Increased Risk of Methicillin-Resistant Staphylococcus aureus Colonization at Time of Hospital Admission in Rural Iowa Veterans. Infect Control Hosp Epidemiol 2014;35(2).



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How Superbugs Hitch a Ride From Hog Farms Into Your Community

—By **Tom Philpott** (/authors/tom-philpott) | Sat Sep. 13, 2014 6:00 AM EDT

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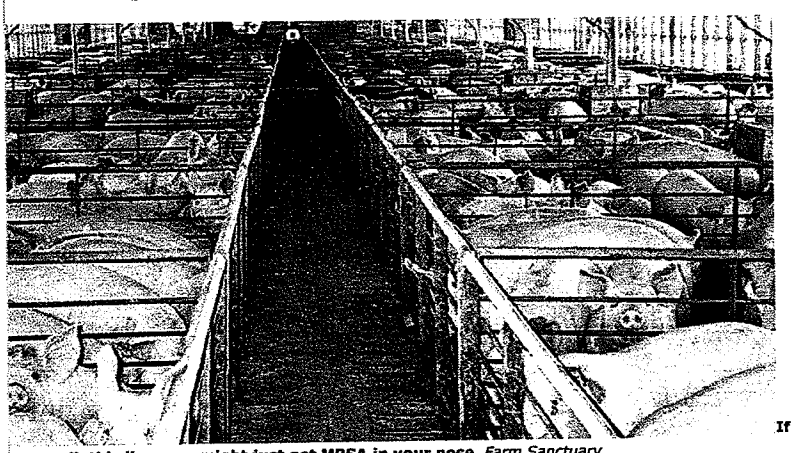

If you walk this line, you might just get MRSA in your nose. Farm Sanctuary (https://www.flickr.com/photos/farmsanctuary1/21634577736/sizes/m/in/photolist-4ibhBs-5Wg9ei-5WiDKY-aUWp9q-5WcCqk-5WfvDv-5tLYcL-5Wfpkf-5Wfqib-5hcfvT-8zHeGQ-4icpQC-4ib5tC-4icqUQ-4i6WJB-4i8hGr-5n6KJB-5n6npD-5n6m8B-5n6mfp-5n6mqk-5n6p6P-5n6mie-5n6p1M-5n6oQD-5n6pmJ-5n6oCr-5n6pte-MCcRH-5naDts-5naDm9-5n6q47-5naB2q-5naDJE-5naEtG-5n6nZB-5QYCKt-4i7m3a-4i6SCP-4icqiL-4i6D8x-4i8A4q-4ibqzQ-4iaFqG-4oNNdf-4icbnf-5n6nkv-5n6nqB-5n6kND-5n6kYF-4icb8h/) /Flickr

Factory-scale farms don't just house hundreds of genetically similar animals in tight quarters over vast cesspools collecting their waste. They also house a variety of bacteria that live within those unfortunate beasts' guts. And when you dose the animals daily with small amounts of antibiotics—a common practice—the bacteria strains in these vast germ reservoirs quite naturally develop the ability to withstand anti-bacterial treatments.

Antibiotic-resistant bacteria leave these facilities in two main ways. The obvious one is meat: As Food and Drug Administration data (http://www.fda.gov/downloads/AnimalVeterinary/SafetyHealth/AntimicrobialResistance/NationalAntimicrobialResistanceMonitoringSystem/UCM334841.pdf) shows (http://www.cidrap.umn.edu/news-perspective/2013/02/bacteria-meat-show-growing-drug-resistance-fda-says), the pork chops, chicken parts, and ground beef you find on supermarket shelves routinely carry resistant bacteria strains. But there's another, more subtle way: through the people who work on these operations.

ick.g.doubleclick.net/pcs/click?xai=AKAOjst21GRk5Srpv0sqixWRUbZsQrQvsoJ0MhTqtXN-FkYTCmW9kksDsQ88wO5_-t73erkA8sig=CgOArkOSztfdPB2vC06ZBurlfix=1&adurl=http://adserver.adtechus.com/adlink/5443/2863578/0/170/AdId%1%2BAg%2BHealth%2BTop%2BStories%2Btom-philpott%3Blink%3Dhttps://donate.doctorswithoutborders.org/surgery.cfm%3Fsource%display%26utm_campaign%3Dtn-operate)

In a new paper (http://oem.bmj.com/content/early/2014/09/05/oemed-2014-102095.full#ref-5), a team of researchers from Johns Hopkins and the University of North Carolina-Chapel Hill took nasal swabs from 22 North Carolina hog facility workers over 14 days. The results: 10 of them proved to be "persistent" carriers of a strain of bacteria associated with livestock called *Staphylococcus aureus*—that is, they carried for up to four days after their last day at work. Of those 10, 7 of the workers carried a form of *Staphylococcus aureus* that's resistant to one or more antibiotics.

The researchers report that their study is the first to test the persistence of the bacteria strains that workers pick up at livestock farms. "Researchers had believed that livestock-associated bacteria would clear from the noses of hog workers quickly—within 24 hours," the press release (http://www.jhsph.edu/news/news-releases/2014/hog-workers-carry-drug-resistant-bacteria-even-after-they-leave-the-farm.html) accompanying the report states. Apparently, not so much.

If the sample size sounds small, it is. Most hog production in North Carolina takes place within facilities owned or operated by large meat-processing companies, and they aren't eager to cooperate with independent researchers. Finding workers to participate is tricky. *"This study would not have been possible without a strong* partnership between researchers and community-based organisations that have the trust of members of communities in areas where the density of industrial hog production is high," the authors state.

The study comes on the heels of another one (http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0067641), published on *PLOS One* in 2013, which compared nasal swabs from workers on industrial-scale hog farms with those of workers on *antibiotic-free operations. Six of 34 industrial-farm workers carried multidrug-resistant* forms of livestock-associated staph, compared to none of the antibiotic-free farmworkers.

While these and other studies suggest that farmworkers are moving resistant bacteria from farms and into the world, potentially infecting others, they don't prove that MRSA (http://www.cdc.gov/mrsa/) and other potentially deadly staph strains are spreading from this source. You can carry a staph germ in your nose without becoming infected with it. The authors say (http://www.jhsph.edu/news/news-releases/2014/hog-workers-carry-drug-resistant-bacteria-even-after-they-leave-the-farm.html) they're now studying whether the workers, their families, and their surrounding communities are more prone to infections.

Meanwhile, a University of Iowa study (http://www.wired.com/2014/01/mrsa-col-cafo/) earlier this year found that people who live within a mile of a hog operation are nearly three times more likely to carry MRSA in their noses than the general population. A 2013 Johns Hopkins study (http://archinte.jamanetwork.com/article.aspx?articleid=1738717) that looked at actual MRSA infections in Pennsylvania found that people who live near fields treated with industrially farmed hog manure are "significantly" more likely to be treated for infections, and that people who live near hog operations showed a "similar but weaker association" with MRSA infection rates.

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TOM PHILPOTT (/authors/tom-philpott) *Food and Ag Correspondent*

Tom Philpott is the food and ag correspondent for *Mother Jones*. For more of his stories, click here (http://www.motherjones.com/authors/tom-philpott). To follow him on Twitter, click here (http://twitter.com/#!/tomphilpott). RSS (/RSS/AUTHORS/116126) | TWITTER (HTTP://TWITTER.COM/TOMPHILPOTT)

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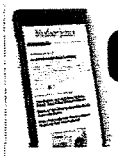

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The horrific ways we are treating farm animals these days no doubt have negative effects on our own health. For decades, scientists have found that meat, eggs and dairy increase our risk of cancer, heart disease, erectile dysfunction, diabetes, osteoporosis and bone loss, bone fracture in children, arthritis, infant apnea and crib death, type 1&2 diabetes, postpartum psychosis, circulatory disorders, food allergies, etc.

It is not only due to the antibiotics, the chemicals and the diseases the animals carry because they are kept only barely alive and all gone crazy with extremely confinement, it is also because animal protein itself is bad for us. Recent research found that animal protein is 'just as bad as smoking'. Physicians and researches have also compared our anatomy with other animals and cite plenty of evidence saying that we humans are "not designed to eat meat". No doubt a small number of our ancestors had evolved to tolerate meat and dairy, but obviously not very well. Note that our ancestors that contributed to our anatomy went way back. For instance, our ear drums are passed on from our fish ancestors.
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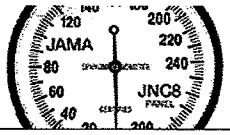

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Original Investigation | November 25, 2013

High-Density Livestock Operations, Crop Field Application of Manure, and Risk of Community-Associated Methicillin-Resistant *Staphylococcus aureus* Infection in Pennsylvania FREE

Joan A. Casey, MA[1,2]; Frank C. Curriero, PhD, MA[1,3]; Sara E. Cosgrove, MD, MS[2,4]; Keeve E. Nachman, PhD, MHS[1,5,6]; Brian S. Schwartz, MD, MS[1,2,7]

[+] Author Affiliations

JAMA Intern Med. 2013;173(21):1980-1990. doi:10.1001/jamainternmed.2013.10408. Text Size: A A A

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ABSTRACT

ABSTRACT | METHODS | RESULTS | DISCUSSION | ARTICLE INFORMATION | REFERENCES

Importance Nearly 80% of antibiotics in the United States are sold for use in livestock feeds. The manure produced by these animals contains antibiotic-resistant bacteria, resistance genes, and antibiotics and is subsequently applied to crop fields, where it may put community members at risk for antibiotic-resistant infections.

Objective To assess the association between individual exposure to swine and dairy/veal industrial agriculture and risk of methicillin-resistant *Staphylococcus aureus* (MRSA) infection.

Design, Setting, and Participants A population-based, nested case-control study of primary care patients from a single health care system in Pennsylvania from 2005 to 2010. Incident MRSA cases were identified using electronic health records, classified as community-associated MRSA or health care–associated MRSA, and frequency matched to randomly selected controls and patients with skin and soft-tissue infection. Nutrient management plans were used to create 2 exposure variables: seasonal crop field manure application and number of livestock animals at the operation. In a substudy, we collected 200 isolates from patients stratified by location of diagnosis and proximity to livestock operations.

Main Outcomes and Measures Community-associated MRSA, health care–associated MRSA, and skin and soft-tissue infection status (with no history of MRSA) compared with controls.

Results From a total population of 446 480 patients, 1539 community-associated MRSA, 1335 health care-associated MRSA, 2895 skin and soft-tissue infection cases, and 2914 controls were included. After adjustment for MRSA risk factors, the highest quartile of swine crop field exposure was significantly associated with community-associated MRSA, health care-associated MRSA, and skin and soft-tissue infection case status (adjusted odds ratios, 1.38 [95% CI, 1.13-1.69], 1.30 [95% CI, 1.05-1.61], and 1.37 [95% CI, 1.18-1.60], respectively); and there was a trend of increasing odds across quartiles for each outcome ($P \leq .01$ for trend in all comparisons). There were similar but weaker associations of swine operations with

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community-associated MRSA and skin and soft-tissue infection. Molecular testing of 200 isolates identified 31 unique *spa* types, none of which corresponded to CC398 (clonal complex 398), but some have been previously found in swine.

Conclusions and Relevance Proximity to swine manure application to crop fields and livestock operations each was associated with MRSA and skin and soft-tissue infection. These findings contribute to the growing concern about the potential public health impacts of high-density livestock production.

The US Food and Drug Administration reports that 80% of antibiotics in the United States are used in food animals, mainly to promote growth of livestock in high-density production.[1,2] In this industrial model, thousands of livestock animals are housed together and fed subtherapeutic doses of antimicrobial agents.[3] This can select for antibiotic-resistant bacteria like methicillin-resistant *Staphylococcus aureus* (MRSA).[4] About 75% of administered antibiotics are not absorbed by the animal and end up in manure.[5] In addition to antibiotics, antibiotic-resistant bacteria and resistance genes have been isolated from manure and are known to persist in the environment.[6] Application of manure to crop fields close to human dwellings may lead to increased risk of antibiotic-resistant infections.[7]

High prevalence of MRSA colonization among pig farmers was first noted in the Netherlands in 2005.[8] Transmission of MRSA among cows, calves, and humans has also been reported.[9,10] A US study reported that 45% of swine workers were colonized, which is 30 times the national average.[11,12] Few studies have assessed risk of MRSA infection. A Danish case-control study (21 cases) found that living or working on a farm was a risk factor for MRSA infection.[13] Other studies of MRSA infection have described the spread of infection within pig farming families.[14,15] To our knowledge, the impact of proximity to high-density livestock production on risk of MRSA infection has not been evaluated. Two studies assessed community livestock density and found no association with MRSA colonization.[16,17] Most studies have implicated clonal complex 398 (CC398) as the most common variant harbored by swine.[9,12-15,17,18]

In the United States, community-associated MRSA (CA-MRSA) now accounts for more than half of all noninvasive MRSA infections.[19-22] CA-MRSA often occurs as a skin and soft-tissue infection (SSTI) in *young, otherwise healthy individuals who lack common health care risk factors.*[23-25] *In contrast, health care* –associated MRSA (HA-MRSA) generally occurs in older individuals with comorbidities. Now, the epidemiology and microbiology of 2 epidemics previously considered distinct are merging.[26-28]

The possible contribution of high-density livestock production to these epidemics has been inadequately studied.[29] US data are needed to evaluate which livestock species pose risk, what aspects of the operations and manure handling are involved, and the magnitude of the risk. We conducted a population-based, nested case-control study using electronic health record (EHR) data from the Geisinger Health System, an integrated health services organization with 4 hospitals and 41 outpatient clinics. We evaluated residential proximity to swine and dairy/veal high-density livestock operations and manure-applied crop fields in relation to CA-MRSA, HA-MRSA, and SSTI (without a history of MRSA infection or colonization) case status.

METHODS

ABSTRACT | METHODS | RESULTS | DISCUSSION | ARTICLE INFORMATION | REFERENCES

Data Sources

To select cases and controls, we used EHR data from January 1, 2005, to February 9, 2010, from 446 480 patients with a Geisinger primary care provider. Geisinger's primary care patients represent the general population in the region.[30] The study area comprised the health system's primary care market and bordering counties totaling 38 counties in Pennsylvania (Figure 1); approximately 3.8 million people resided in these counties according to the 2000 US Census. The study was approved by institutional review boards at the Geisinger Health System and the Johns Hopkins Bloomberg School of Public Health.

Figure 1.

Crop Field Locations and Methicillin-Resistant *Staphylococcus aureus* (MRSA) Rates

Crop field locations and rates of MRSA per 1000 Geisinger Health System (GHS) primary care patients in townships, boroughs, and cities. Rates in communities with fewer than 50 GHS patients were not estimated. The map demonstrates that crop fields were often located in areas with a range of human population densities.

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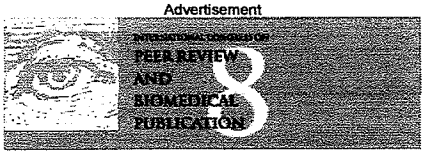

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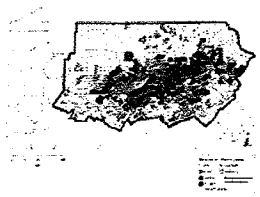

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Pennsylvania Act 38 of 2005 requires high-density livestock operations to develop and implement nutrient management plans (NMPs) for manure handling. We defined *high-density livestock operations* as agricultural operations where animal density exceeded 2 animal equivalent units (AEUs, 1000 pounds of live weight) per acre and where total AEUs exceeded 8; or operations that exceeded 300 AEUs. When livestock operations have insufficient land for manure application, manure is exported to other areas and applied to crop fields. We focused on swine and dairy/veal operations because of previously identified links with MRSA.[8-10,13-15] The NMPs provided data on livestock operation location, animal type, livestock quantity (AEUs), amount of manure applied to crop fields by season, and crop field area and location. We obtained NMPs from the Pennsylvania Department of Environmental Protection and County Conservation Districts.

Case Ascertainment and Control Selection

Incident MRSA cases were identified primarily using laboratory cultures and secondarily by diagnosis codes (eg, *International Classification of Diseases, Ninth Revision* [*ICD-9*]) that indicated MRSA infection, as previously described.[22] Cases were then classified as either CA-MRSA or HA-MRSA based on presence of health care risk factors (eg, hospitalization, surgery, dialysis, nursing home residence, indwelling device)[22,31] or diagnosis more than 2 days after hospital admission using *ICD-9* codes[21,23,32] and *Current Procedural Terminology* codes. We then randomly selected patients with SSTI but no history of MRSA using 29 *ICD-9* codes (eg, carbuncle, furuncle, abscess)[22] and controls with no history of MRSA, and we frequency matched both groups with case patients by age (0-6, 7-18, 19-45, 46-62, 62-74, ≥75 years), sex, and diagnosis or an outpatient encounter in the same year as MRSA diagnosis. The SSTI cases were evaluated as a separate case group because some SSTIs occurring during the study period were likely to have been caused by MRSA but not diagnosed as such, and high-density livestock production could cause SSTIs from other bacteria. Therefore, we selected patients with SSTIs without reference to any specific pathogen. If a control had multiple outpatient encounters during the year, a single encounter was randomly selected as the date for exposure assignment.

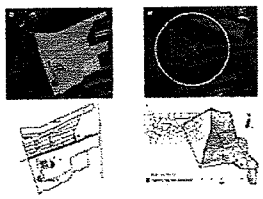
Geographic Location of Patients, Livestock Operation, and Crop Fields

We identified the latitude and longitude of patient addresses using ArcGIS, version 10 (Esri),[33] and calculated MRSA rates by community (Figure 1). The latitude and longitude of livestock operation addresses were located using Google Earth with visual confirmation of the presence of a barn at the address. Three different methods were used to locate crop fields because 131 fields (17.3%) were missing address data (Figure 2). In the absence of an address, we used the county and community of the field from the NMP to locate the crop field.

Figure 2.

Three Methods Used to Identify and Locate Crop Fields

A, Aerial photograph (top) or map (bottom) were located using Google Earth (n = 135). B, Operation addresses known and located using ArcGIS, version 10 (Esri) (n = 420). C, County and township known and addresses were located by identifying cropland, hay land, and pastureland on a land use map and randomly selecting a point within the eligible land use types (n = 131).



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Exposure Assessment

We estimated each individual's exposure to livestock operations and to manure-applied crop fields, for swine and dairy/veal, using an inverse distance-squared approach[34] in R, version 2.14.2 (R Foundation for Statistical Computing). For livestock operations, we used the equation

$$\text{Exposure for patient j} = \sum_{i=1}^{n} \frac{a_i}{d_{ij}^2}$$

where n is the number of operations, a_i is AEUs of livestock at operation I, and d_{ij}^2 is the squared distance (in meters) between operation centroid i and patient j. For crop field manure application during the season of diagnosis or visit, we used the equation

$$\text{Exposure for patient j} = \sum_{i=1}^{n} \frac{c_i}{d_{ij}^2}$$

where n is the number of crop fields, c_i is the concentration of manure (gallons per square meter) applied during the season of diagnosis or visit at field i, and d_{ij}^2 is the squared distance (in meters) between the crop field centroid i and patient j. This resulted in exposure units of gallons per quartic meter (m^4). For missing seasonal application data (40% of fields), we used the regional seasonal average. Exposure variables were modeled as quartiles because they were not normally distributed.

Genetic Typing of MRSA Isolates

In a prospective substudy that occurred from January to December 2012, we identified all primary care patients with a culture-confirmed MRSA infection. We then randomly selected isolates from patients *stratified by location of diagnosis (inpatient or outpatient) and presence or absence of a livestock operation* or crop field in their zip code of residence. We oversampled outpatient isolates from zip codes with high-density livestock production. All isolates were characterized by DNA sequence analysis of the protein A gene variable repeat region (*spa* typing).[35] The *spa* types were also assigned a Ridom StaphType, using the Ridom SpaServer database (available at http://www.spaserver.ridom.de).[36] Panton-Valentine leukocidin (*PVL*) genes were detected by polymerase chain reaction.[37]

Statistical Analysis

To compare the 4 study groups, we used *Kruskal-Wallis tests* for comparisons of means and χ^2 tests for comparisons of proportions. We used multilevel multinomial (2 MRSA groups and controls) and multilevel logistic regression (SSTI cases and controls) to assess the association between exposure and case status. We adjusted models for predictors obtained from the EHR: age, sex, race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, and other); ever-smoking status using *ICD-9* codes[22]; antibiotic order in the 2 years preceding diagnosis; and Medical Assistance for health insurance, residential community (city, borough, or township), and community socioeconomic deprivation.[33]*Medical Assistance* is a means-tested program, which we used as a surrogate indicator for low socioeconomic status.[38,39] It was identified for each encounter by 1 of 24 codes and modeled as ever received (if received for >2 encounters) vs never received. The livestock operation model was additionally adjusted for season of infection or visit. Final models were selected based on associations reported in our group's earlier article,[22] and adequate model fit was confirmed using Pearson goodness-of-fit tests and likelihood ratio tests. Semivariograms were used to determine that spatial autocorrelation did not account for the results.[40] We used a 2-sided type 1 error rate of 0.05 as the threshold for statistical significance and made no adjustments for multiple comparisons. Logistic and multinomial logistic regression analyses were completed using Stata statistical software version 11.2 (StataCorp Inc) and the GLLAMM program (www.gllamm.org).

We calculated population attributable fraction (PAF) for CA-MRSA and SSTI cases by using the adjusted odds ratios (AORs) for the third and fourth quartile of crop field swine manure exposure obtained from the final multivariable logistic regression model using the formula PAF = (AOR − 1)/AOR × (proportion of cases exposed to risk factor).[41] The PAF for the third and fourth quartiles were summed to calculate the final PAF. Confidence intervals were computed using the delta method with the postestimation command *nlcom* in Stata.

We performed several sensitivity analyses. First, we evaluated 2 other time windows for crop field manure exposures: a 1-year and a 30-day window before either the date of MRSA diagnosis or the date of a preceding SSTI diagnosis. Second, models were repeated using different methods to identify crop fields (Figure 2). Third, we evaluated effect modification by community type and season. Fourth, analysis was performed to evaluate whether distance to nearest crop field, independent of manure application, was associated with disease outcomes. Finally, we repeated analyses using only culture-confirmed MRSA cases.

RESULTS

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Patients, Farms, and Crop Fields Included in the Study

A total of 1734 CA-MRSA and 1519 HA-MRSA cases were identified between January 2005 and February 2010. Most cases (72.3%) were identified by a positive MRSA culture. We frequency matched 3336 SSTIs and 3336 controls to the cases. Of the 9925 patients, we were able to identify latitude and longitude coordinates for home addresses for 87.5%. Thirty-one patients (0.35%) were excluded because they did not reside in counties for which we collected NMPs. This resulted in a total of 1539 CA-MRSA, 1335 HA-MRSA, and 2895 SSTI cases and 2914 controls with residences in 32 counties and 574 communities defined by *minor civil divisions*, ie, census-designated divisions of a county.

We collected NMPs and identified the location of 326 high-density livestock operations, 123 swine and 203 dairy/veal operations, in 27 counties and 168 townships. Ninety-eight of the swine operations (79.7%) and 71 of the dairy/veal farms (35.0%) exported at least a portion of their manure to a total of 424 crop fields. Crop fields were located in 29 counties, 8 boroughs, and 218 townships, for an average of 3.4 crop fields per township. A reported 637 266 595 gallons of manure was applied to crop fields annually. Among those in the highest quartiles of swine livestock operation exposure and swine crop field manure exposure, the median (IQR) distance to the nearest farm or field was 4.6 km (3.1-6.7 km) and 4.0 km (2.6-7.5 km), respectively. The Pearson r correlation between the individual-level exposure assignments from the 2 models was 0.59 (both log transformed).

Demographic Characteristics of Cases and Controls

There were no differences in demographic characteristics between patients included in the study and those excluded because we could not map their home address (n = 1211), except that patients with SSTIs who were included were significantly more likely to have ever smoked than were those who were excluded (eTable 1 in the Supplement). Compared with controls, patients in the CA-MRSA group were significantly younger; they were more likely to be black, to smoke, and to receive Medical Assistance; and they lived in communities with greater socioeconomic deprivation (Table 1). White race/ethnicity (95.3% of the study population) was associated with higher levels of swine and dairy/veal crop field manure exposure (Table 2). Exposures to manure were also the lowest among those who had not received an antibiotic prescription in the 2 years prior to diagnosis or visit, those who had received Medical Assistance, and those residing in cities.

Table 1. Patient Demographic and Clinical Characteristics

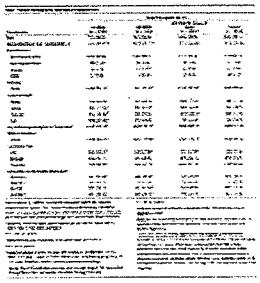

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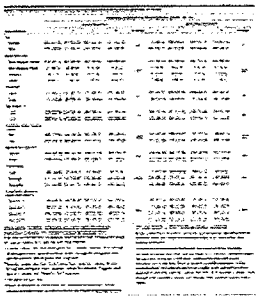
Table 2. Characteristics of CA-MRSA Group by Crop Field Manure Exposure Quartiles (n = 1539)



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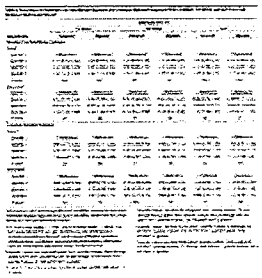
Association of Crop Field Manure Exposure With Case Status

After adjusting for potential confounding variables, we found a significantly increased odds of CA-MRSA, HA-MRSA, and SSTI with higher swine manure exposure (fourth vs first quartile AORs, 1.38 [95% CI, 1.13-1.68], 1.30 [95% CI, 1.05-1.61], and 1.37 [95% CI, 1.18-1.60], respectively; $P = .01$, $P < .001$, and $P < .001$ for trend, respectively) (Table 3). The fourth quartile (vs first quartile) of dairy/veal exposure was also associated with increased odds of CA-MRSA (AOR, 1.24 [95% CI, 1.01-1.52]). The PAFs (95% CI) for the highest 2 quartiles of swine crop field manure exposure for CA-MRSA infection and SSTI were 10.7% (5.0-16.4%) and 11.5% (7.0-16.0%), respectively.

Table 3. Association of Seasonal Crop Field Manure Exposure and Livestock Operation Exposure With CA-MRSA, HA-MRSA, and SSTI From Full Multilevel Multivariate Model[a]



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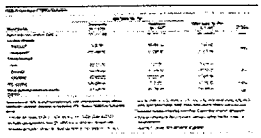
Association of High-Density Livestock Operations With Case Status

The fourth quartile vs first quartile of swine livestock operation exposure was associated with increased odds of CA-MRSA and SSTI (AORs, 1.25 [95% CI, 0.99-1.58] and 1.27 [95% CI, 1.08-1.50], respectively; $P = .04$ and $P = .002$, respectively) but not HA-MRSA (Table 3). No associations were seen with dairy/veal operations. Receipt of Medical Assistance remained independently associated with MRSA and SSTI outcomes in all adjusted analyses.

MRSA Isolate Substudy

A total of 200 isolates were randomly selected from 1128 patients with isolates (Table 4). Of these, 133 (66.5%) were common community strains (*spa* types t008, t024, t064, t206, t211); 33 (16.5%) were common health care strains (t002, t010, t062, t105); and the remainder were divided among 22 additional types. Notably, none was a *spa* type associated with CC398. A total of 27 community-onset isolates were *PVL*-negative.

Table 4. Summary of MRSA Genetics



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Sensitivity Analyses

Evaluation of the 2 other time windows for manure application revealed slightly attenuated but otherwise similar results, except in the case of annual dairy/veal exposure, where the association strengthened for both CA-MRSA and SSTI cases (fourth vs first quartile AORs, 1.41 [95% CI, 1.13-1.77] and 1.26 [95% CI 1.08-1.48], respectively; $P = .01$ and $P = .02$, respectively) (eTable 2 in the Supplement). Exclusion of crop fields without aerial photographs and/or addresses, including interaction terms for community type or season, and restricting analysis to culture-confirmed MRSA cases did not alter results. Distance to nearest crop field, independent of manure application, was not associated with MRSA or SSTI.

DISCUSSION

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High-density swine production was an independent risk factor for CA-MRSA and HA-MRSA infection and SSTI in patients without a history of MRSA. There was evidence that both a crop field manure application model that incorporated distance, swine manure volume, season of application, and field area, as well as a livestock operation model that incorporated distance and swine count, were each associated with increased risk of infection. Exposure assignments from these 2 models were moderately correlated, suggesting 2 independent sources of risk. Furthermore, while livestock operations are easily identifiable and fixed, manure-applied crop fields are not necessarily easily identifiable, are scattered, and may change from year to year. Associations with dairy/veal operations were less consistent and weaker than those for swine operations, which was not surprising, given the limited number studies on the topic. Our data also suggest that approximately 11% of CA-MRSA and SSTI cases in the study population could be attributed to crop field application of swine manure.

The association with SSTIs is notable because there were more than 50 000 such cases, compared with 4000 MRSA cases, in the region since 2001.[22] Crop field manure application may lead to SSTI either by causing MRSA infection that goes undiagnosed as such or by exposure to other bacteria that cause SSTI. We cannot attribute these infections to any single pathogen. Subanalysis of 258 SSTI cases (9%) identified from culture data as methicillin-susceptible *S aureus* (MSSA) revealed an association with swine livestock exposure (AOR, 1.70 [95% CI, 1.15-2.52]) that was stronger than for all SSTIs together. The public health burden of SSTIs[25,42] warrants future study of links to high-density livestock production. Concerning the association with HA-MRSA, this finding does not imply that livestock-associated strains are in hospitals. Rather, these older patients may have been colonized in the community with livestock strains and then had health care contact (eg, hospitalization, surgery, dialysis, indwelling device) before infection.

To our knowledge, no studies have examined the association between high-density livestock operations and MRSA infection in the community, and only 2 studies have assessed risk of colonization.[16,17] Study of colonization may not be useful when evaluating the risk of MRSA infection associated with industrial agriculture because, first, environmental exposure or direct contact may more often lead to CA-MRSA infection than does colonization[43] and second, MRSA colonization may not persist for more than 24 hours after livestock exposure.[44] Prior studies limited their ability to identify risk from high-density livestock exposure by including only patients with CC398,[13,45] by studying only people who lived or worked on farms,[9,12,46-48] and by not including crop field manure exposure.

A unique aspect of this study is the consideration of risk from manure application to crop fields. Sensitivity analyses across time (eg, annual, seasonal, and 30-day exposure) and across space (eg, restricting analysis to fields with aerial photographs or maps) did not substantively change results. Our findings are likely not an artifact of rural residents in the study population because, while manure-applied crop fields were associated with risk, residence in a township (where 98.5% of crop fields are located) and distance to nearest crop field independent of manure application were not associated with the 3 outcomes.

Previous studies have used community-level livestock density as a marker of livestock exposure.[16,17,45] We estimated exposure at the individual level, incorporating several features of these operations and fields. Operation and field sites were confirmed using Google Earth rather than physical inspection of the area, which may have led to some misclassification. Additional exposure misclassification may have occurred since the exposure assessment did not capture all smaller farms. In Pennsylvania, only large operations, *specifically concentrated animal feeding operations, or operations with greater than 2 AEUs per acre are* required to produce NMPs. The 2007 US Census of Agriculture revealed that our exposure models included 89% of swine AEUs present in the study area. Because characteristics of high-density livestock practices differ by and within states, our results may not apply in full to other areas with these operations.

A limitation of this study is that we did not measure how livestock-associated pathogens may reach individuals in a community, but several ways have been considered in prior studies. Aerosolized MRSA has been isolated from the air up to 150 m downwind and from the soil up to 300 m downwind of swine operations.[49,50] Studies have also reported that tetracycline, the most commonly used antimicrobial agent used in food-producing animals in the United States,[1] was found at concentrations sufficient to select for resistant bacteria in both swine manure and manure-fertilized soil.[51] These studies provide biologic plausibility for our findings, but more research is needed to establish sources, media, routes, and behaviors that may lead to infection. Other animals,[52] slaughterhouses,[53] and meat consumption[54] may be involved.

We did not find any *spa* types associated with clonal complex CC398. Most MRSA found on farms or in farmers has been characterized as CC398, though other types have been identified.[9,12,13,45,55,56] However, few studies have assessed MRSA infection, instead focusing on MRSA carriage, and those that do come from Europe[14,15,57,58] and/or deal exclusively with CC398 MRSA.[58-60] The most common strains on US farms are not well known. In Ohio, the closest state to Pennsylvania for which there are data, common health care strains were most often isolated from swine; CC398 was secondary.[53] We were limited in that genetic data did not come from the same time period as the main study, and isolate strains could have changed over time.

We used *ICD-9* codes to classify MRSA cases as CA or HA and to derive the predictor variables used in the analysis. The primary HA epidemiologic factors[31] are well captured by the EHR. Ever-smoking status can also be effectively obtained using *ICD-9* codes.[61] Unfortunately, the EHR did not directly capture data on individual-level socioeconomic status or occupation, so our results could have been due to these variables. To evaluate this potential confounding, we adjusted the final models for 2 surrogates for socioeconomic status: Medical Assistance at the individual level and community socioeconomic deprivation at the community level. As expected, patients with CA-MRSA were more likely to receive Medical Assistance and more likely to live in more deprived communities than controls, associations that persisted in the adjusted models.[62,63] Previous literature has suggested increased prevalence of MRSA colonization in livestock workers.[8] However, given the low prevalence of this employment (1% of population in any agricultural work, according to US Census data) even in townships and boroughs in the study area, it seems unlikely that farming occupation could account for the reported associations. Moreover, inclusion of community-level percentage of agricultural workers in the multilevel model did not change associations.

In conclusion, proximity to and size of high-density livestock production were associated MRSA infection and SSTI, and the population-attributable fraction of crop field manure application exceeded 10% for CA-MRSA and SSTI. The findings contribute to the growing concern about the potential public health impacts of high-density livestock production.

ARTICLE INFORMATION

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Study concept and design: Casey, Curriero, Nachman, Schwartz.

Acquisition of data: Casey, Schwartz.

Analysis and interpretation of data: Casey, Curriero, Cosgrove, Nachman, Schwartz.

Drafting of the manuscript: Casey.

Critical revision of the manuscript for important intellectual content: Casey, Curriero, Cosgrove, Nachman, Schwartz.

Statistical analysis: Casey, Curriero.

Obtained funding: Casey, Nachman, Schwartz.

Administrative, technical, or material support: Schwartz.

Study supervision: Cosgrove.

Conflict of Interest Disclosures: None reported.

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TIM FRUEH
14006 37TH ST. SE
BUFFALO, ND 58011

ND Dept. of Health
Div. of Water Quality
918 East Divide Ave.
Bismarck, ND 58501-1947

Feb. 11, 2016

Re: Public Notice #ND-2015-019

Public Notice #ND-2016-007

I am requesting information on the projected amounts of VOC components, Ammonia emissions, Particulate matter emissions, Endotoxin emissions, and Microorganism emissions that will be expelled into the air from this proposed operation.

I have deep concerns of the quality of air, my Family and community will have. I would like to take these projected levels to my Family doctor. Have him review them and tell me if this will be of any harm to my family in their present conditions.

I thank you for your work on this matter.

Sincerely,

Tim Frueh

March 8, 2016

To Whom It May Concern:

My name is Judith Von Bank and my husband's name is Robert. We live a little over a mile from the proposed large scale corporate hog operation.

My husband and I are very concerned about what the hydrogen sulfate and methane gas will do to our health. My husband has severe asthma and he won't be able to enjoy the outdoor activities and the lifestyle that he has enjoyed on our farm for the past seventy-seven years.

Robert needs to exercise because of his fibromyalgia, and it will be impossible to walk on our country roads. We are very concerned that our quality of life will be completely destroyed.

I wish to read and submit a letter from my husband's physician.

Sincerely,

Judith Von Bank

Judith Von Bank

Signed by Stoy, Patrick J, MD on 02/09/16 at 1453

02/09/2016

ROBERT VONBANK
3610 140TH AVE SE

BUFFALO, ND 58011

MR#: E2572904

Dear Robert:

In discussion with your wife, I have learned that there are plans to construct a large hog operation near your home. This to me raises significant concerns with regard to your severe, difficult to manage asthma. I would anticipate that the fumes that would include ammonia and methane gas generated by this kind of an operation would lead to considerable difficulties managing and dealing with your asthma and a great deal of breathing difficulties for you. I think this plan of construction is certainly not in your interest whatsoever, and if there were a way to relocate that operation at a great distance from you, it would be highly advised.

Sincerely yours,

Patrick Stoy, M.D., Pulmonology

13435482/nec
5268680

Health Summary

Current Health Issues

Health Issue	Date Noted
Fibromyalgia	12/15/2003
Lumbar spondylosis	01/27/2004
Generalized anxiety disorder	
Cervicalgia	05/30/2007
Degeneration of cervical intervertebral disc	05/30/2007
Personal history of other malignant neoplasm of skin	05/04/2009
Hiatal hernia with gastroesophageal reflux	12/17/2007
Actinic keratosis	06/23/2010
Chronic constipation	07/21/2010
Fasting hyperglycemia	01/24/2011
History of testicular mass	06/08/2011
Osteoarthritis of wrist	05/13/2011
Hypogonadism male	07/20/2011
Migraine	
Hydronephrosis	03/09/2012
Tonsil stone	03/25/2013
Osteoarthritis, multiple sites	01/20/2014
Chronic pain	08/12/2015
Hyperlipidemia	08/12/2015
Screening for prostate cancer	08/12/2015
Asthma	08/12/2015
Pain medication agreement	11/12/2015

Medications

montelukast 10 mg tablet
Commonly known as: SINGULAIR

Instructions: Take 1 tablet (10 mg total) by mouth 1 time per day

Approved by Patrick Stoy, MD
Prescribed on 2/23/2016
Prescribed quantity: 90 tablets

albuterol HFA 108 (90 BASE) MCG/ACT inhaler
Commonly known as: PROVENTIL,PROAIR,VENTOLIN

Instructions: Inhale 1-2 puffs orally every 4 to 6 hours as needed for shortness of breath shake well before using.

Approved by Patrick Stoy, MD
Prescribed on 2/23/2016
Prescribed quantity: 1 Inhaler

oxyCODONE 10 mg ER (12 hr) tablet
Commonly known as: oxyCONTIN

You should not start taking this medication until 3/4/2016.

Instructions: Take 1 tablet (10 mg total) by mouth 2 times a day earliest fill date: 3/4/16.

Approved by Rebecca A Kiecker, APRN-CNP
Prescribed on 12/31/2015
Prescribed quantity: 60 tablets

gabapentin 300 mg capsule
Commonly known as: NEURONTIN

Instructions: Take 3 capsules (900 mg total) by mouth 3 times a day.

Approved by Rebecca A Kiecker, APRN-CNP
Prescribed on 11/12/2015
Prescribed quantity: 270 capsules

Request a renewal

lubiprostone 8 mcg capsule
Commonly known as: AMITIZA

Instructions: Take 1 daily or two times a day as needed for constipation

Approved by Nina Sjoquist, APRN-CNP
Prescribed on 8/12/2015

Prescribed quantity: 180 capsules

Request a renewal

fluticasone 50 mcg/spray nasal spray
Commonly known as: FLONASE

Instructions: Spray 2 sprays into each nostril as needed for other (specify) (seasonal allergies).

Approved by Nina Sjoquist, APRN-CNP
Prescribed on 8/12/2015
Prescribed quantity: 1 Bottle

Request a renewal

polyethylene glycol powder
Commonly known as: MIRALAX

Instructions: Take 1 tablespoonful by mouth 2 times a day as needed. in 8 oz of water for constipation.

Documented by Abstract Provider

SENNA PLUS PO

Instructions: Take 4 tablets by mouth 1 time a day as needed. for bowels.

Documented by Abstract Provider

catheter Misc

Instructions: 3 times a day. 14 fr straight cath 3x daily

Documented by Abstract Provider

Allergies

Allergen	Reaction
Aspirin	Wheezing/Bronchospasm (High)
Duloxetine Hcl	Nausea and Vomiting, Diarrhea
Pregabalin	Confusion
Penicillin	Hives (High), Rash, Angioedema (High)

Immunizations

Immunization	Date
Influenza High Dose (65+)	9/23/2013
Influenza High Dose Vaccine (65+)	10/22/2015, 10/3/2012
Influenza Trivalent w/preserv	9/24/2010, 9/30/2009
Influenza Vaccine	10/15/2008, 10/16/2007
Pneumococcal Polysaccharide PPSV23	11/30/2007
Td (adult) preservative free (Tenivac)	11/23/2005
Zoster	10/12/2009

Preventive Care

Name	Status	Last Done
Pneumococcal Adult	Overdue since 11/30/2008	11/30/2007
Asthma Control Test	Overdue since 5/27/2015	5/27/2014
Asthma Action Plan & Environmental Control	Overdue since 5/27/2015	5/27/2014
Tetanus Vaccine	Overdue since 11/23/2015	11/23/2005
Colonoscopy	Not due until 5/24/2016	5/24/2013
Zostavax Vaccine	Completed on 10/12/2009	10/12/2009
Flu Vaccine	Completed on 10/22/2015	10/22/2015

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Health Summary

Current Health Issues

Health Issue	Date Noted
Allergic rhinitis	07/17/2008
Esophageal reflux	07/17/2008
Hyperlipidemia	
Hypertension	04/29/2009
Arthritis of left knee	06/08/2009
Osteopenia	07/20/2009
S/P total knee replacement	09/01/2009
Chronic kidney disease, stage III (moderate)	01/24/2011

Medications

pravastatin 20 mg tablet
Commonly known as: PRAVACHOL

Instructions: Take 1 tablet daily

Approved by Nina Sjoquist, APRN-CNP
Prescribed on 12/8/2015
Prescribed quantity: 90 tablets

Request a renewal

amLODIPine 2.5 mg tablet
Commonly known as: NORVASC

Instructions: Take 1 tablet (2.5 mg total) by mouth 1 time per day.

Approved by Nina Sjoquist, APRN-CNP
Prescribed on 10/5/2015
Prescribed quantity: 90 tablets

Request a renewal

omeprazole 20 mg capsule
Commonly known as: priLOSEC

Instructions: Take 1 capsule by mouth 1 time a day in the morning.

Approved by Nina Sjoquist, APRN-CNP
Prescribed on 8/12/2015
Prescribed quantity: 90 capsules

Request a renewal

fluticasone 50 mcg/spray nasal spray
Commonly known as: FLONASE

Instructions: Spray 2 sprays into each nostril 1 time a day as needed for other (specify) (allergies).

Approved by Nina Sjoquist, APRN-CNP
Prescribed on 8/12/2015
Prescribed quantity: 3 Bottles

Request a renewal

clobetasol propionate 0.05 % cream
Commonly known as: TEMOVATE

Instructions: Apply to affected area 2 times a day as needed for itching or rash.

Approved by Nina Sjoquist, APRN-CNP
Prescribed on 8/12/2015
Prescribed quantity: 1 Tube

Request a renewal

COQ10 PO

Instructions: Take by mouth 1 time per day.

Documented by Abstract Provider

omega-3 fatty acids 1000 mg capsule
Commonly known as: FISH OIL

Instructions: Take 1,000 mg by mouth 1 time per day.

Documented by Abstract Provider

CINNAMON PO

Instructions: Take by mouth. per patient sprinkles on breakfast food qd

Documented by Abstract Provider

psyllium 50 % Powd
Commonly known as: METAMUCIL ORANGE

Instructions: Take 1 tablespoonful by mouth 1 time a day as needed.

Documented by Abstract Provider

calcium carbonate-vitamin D 600 mg-200 unit tablet
Generic name: calcium carbonate-vitamin D
Instructions: Take 1 tablet by mouth 2 times a day.
Documented by Abstract Provider

multi-vitamin tablet
Instructions: Take 1 tablet by mouth 1 time per day.
Documented by Abstract Provider

vitamin D (cholecalciferol) 1000 UNITS Caps
Instructions: Take 2,000 units by mouth 1 time per day.
Documented by Abstract Provider

Allergies

Allergen	Reaction
Penicillin	Hives (High), Rash
Other: See Comments	Hives (High), Rash

Immunizations

Immunization	Date
H1N1 Injectable Vaccine	12/14/2009
Influenza High Dose Vaccine (65+)	10/22/2015, 9/23/2013, 10/3/2012
Influenza Trivalent w/preserv	9/24/2010, 10/7/2009
Influenza Vaccine	10/15/2008, 10/16/2007, 10/17/2003
Pneumococcal Polysaccharide PPSV23	10/16/2007
Tetanus Toxoid,not adsorbed	7/17/2008, 1/1/2007
Zoster	10/12/2009

Preventive Care

Name	Status	Last Done
Pneumococcal Adult	Overdue since 10/16/2008	10/16/2007
Screening Mammogram	Not due until 10/22/2016	10/22/2015
Colonoscopy	Not due until 11/22/2016	11/22/2006
Tetanus Vaccine	Not due until 7/17/2018	7/17/2008
Lipid Screening	Not due until 8/12/2020	8/12/2015
Dexa/heel Scan	Not due until 10/3/2027	10/3/2012
Zostavax Vaccine	Completed on 10/12/2009	10/12/2009
Flu Vaccine	Completed on 10/22/2015	10/22/2015

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TIM FRUEH
14006 37TH ST. SE
BUFFALO, ND 58011

My name is Tim Frueh
My Farm is located 1.5 miles from the proposed Swine operation in Howes township.
My family and I have lived here for 17 yrs.
I am submitting a document titled " Howes Township Feedlot Ordinance" filed with the N.D. Dept. of Health on Friday Feb. 26, 2016.
If you just review the CAFO ordinance you will see that this citing does not fit.
Take a look at the map, the inner circle is 1.5 miles for residents, and the outer circle is 3.5 miles for cities.
Here also is an overlay of wind roses that we would be dealing with. As you can see to many people would be effected.
I oppose the issuance of this illegal permit.

Sincerely,

Tim Frueh

TO: The North Dakota Department of Health

My name is Lois Smith and I have lived in Buffalo for many years. I have been the Librarian at the Margaret Fraase Public Library in Buffalo for over 10 years.

I believe in the power of education, the knowledge gained by reading and the value of the published word. I strongly recommend that the North Dakota Department of Health takes the time to read this book:

"The CAFO Reader: The Tragedy of Industrial Animal Factories"
Edited by Daniel Imhoff

. . . . This book features more than thirty essays by today's leading thinkers on food and agriculture. It provides an unprecedented overview of concentrated animal feeding operations - known as CAFO's - where increasing amounts of the world's meat, milk, eggs, and seafood are produced. The rise of the CAFO industry around the world has become one of the most pressing issues of our time.

I want to thank the Department of Health for their time to seriously consider the negative impact created by this type of factory farming. I am convinced from my research that you must not approve this permit.

To: North Dakota Department of Health
Division of Water Quality
3-17-2016
Permit Application #DNAF00853

There are two operations in the State like this one already located in Bottineau County and Nelson County. They are both farther from a town, smaller than this one, and because the counties are so sparsely populated few rural residents are affected.

The latest census indicates that Bottineau County has 6,429 residents and Nelson County has 3,126 residents. By comparison, the population of Cass County is 149,778 and if you subtract Fargo from this total there still remains 18,399 residents. Out of the 53 counties in the state, Cass County is still ranked in the top 10 highest populated counties even after taking out Fargo's population.

There are 10 homes within 2 miles of this proposed operation that will be affected with loss in property value and quality of life. Less than 3 miles, the town of Buffalo and many more rural residents will be affected.

The State of North Dakota is ranked 47th in population in the United States There is surely more appropriate sites for a hog farm of this size then here.

Due to the degree of which current residents will be affected in the value of their property and life in general, I believe it is reasonable to regard this proposed operation as a public nuisance.

If this permit is granted and the operation is built, there is no way we are putting up with the loss of quality of life while we see our property value plummet 30%-40%, without legal action.

I encourage you to deny this permit.

Roy Thompson
3517 142nd Ave. SE.
PO Box 194
Buffalo, ND 58011

We, the undersigned, have researched the impact that CAFOs such as Rolling Green Family Farms RE, LLP, and have found that such CAFOs typically have a significant negative impact on the property values of surrounding properties. If our property value is diminished as a result of the swine facility proposed by Rolling Green Family Farms RE, LLP, we will retain legal counsel and file lawsuits for nuisance and under any other pertinent legal theories to obtain damages to the loss in value to our homes and any other damages we suffer. 16 people so far

Print Name	Signature	Date
Tim Fryer		3/16/16
GERALD MARCKS	Gerald Marcks	3/16/16
Liane Rakow Stout	Liane K. Stout	3-16-16
LEE FRAASE	Lee Fraase	3-16-16
Tom Cole		3-16-16
Craig A Wardt		3-16-16

We, the undersigned, have researched the impact of CAFOs such as Rolling Green Family Farms RE, LLP, and have found that such CAFOs typically have a significant negative impact on the property values of surrounding properties. If our property value is diminished as a result of the swine facility proposed by Rolling Green Family Farms RE, LLP, we will retain legal counsel and file lawsuits for nuisance and under any other pertinent legal theories to obtain damages to the loss in value to our homes and any other damages we suffer.

Print Name	Signature	Date
LEE FISCHER		3/15/16
ALAN DOSTERT		3/15/16
Cecil F VonBank		3/15/16
Kent Baike	Kent Baike	3-15-16
Judith VonBank	Judith VonBank	3-15-16
Randal Coon		3/15/16

Print Name	Signature	Date
Roy Thompson		3-16-16
Hal Grieve		3-16-16
CAROL BEILKE		3-16-16
TRACIE ZAUN		3-16-16
Jennifer Fraase		3-17-16

(4)

CONCLUSION

On behalf of the Concerned Citizens of Buffalo, we wish to thank the North Dakota Department of Health Section Division of Water Quality for granting us this hearing to present our concerns.

Upon first learning of this proposal, we decided to approach this in an intelligent manner. We hired legal and professional experts and have information gathered from all over the country concerning CAFOs and the Applicant. Our conclusion is that this proposed CAFO will have devastating negative impact to our community, could be disastrous to our environment and that the permit is illegal.

We have produced stacks of evidence of how CAFOs will negatively impact health, water, air and general quality of life. The mission statement of the Health Department is to protect and enhance air and water quality for North Dakota citizens. How does permitting an out of state corporate business to set up and pollute in violation of the law in our back yard protect us? With North Dakota cutting budgets, who is going to monitor everything required from building permits to compliance of regulations? We respectfully submit that the Health Department has not done due diligence concerning the approval of this illegal permit. With the potential for illegal pollution that's almost guaranteed, does the ND Health Department want to sign off on the real potential of a future cleanup site? This is our home and community. All parties concerned will be held responsible.

It is our opinion that information supplied to us by the Applicant has been very misleading and untruthful. Their character assassinations of our neighbors is unwarranted and out of line. The track record of the Applicant in regards to CAFOs is less than savory. Their project designs are flawed, incomplete and inadequate. Their nutrient management plan does not have enough acres due to soil type and set-backs. The Applicant cannot possibly fulfill their illegal permit obligations as presented. If this proposal is so beneficial and will not harm our quality of life, then why has everything about this project been secretive and back door?

We have gathered significant information should we need to turn to the courts. We intend to have independent water, air and fly population monitors in place, have obtained information through open records laws and will have our properties assessed to hold the Applicant responsible for any loss in value to our property that it causes. To the Applicant this is just another investment for corporate business. To the Health Department, it's just another permit. To us, it's our home and quality of life. To us it's personal and we will proceed as such. If approved, this illegal permit and the proposed project will be challenged individually and by the Concerned Citizens of Buffalo in the courts and every other venue as required. This is our home, our community and we will not be just statistics in the way of corporate greed.

Lee Fischer
Concerned Citizens of Buffalo

March 16, 2016

Dear North Dakota Department of Health

I am very worried about the effects the large swine operation will have on me if allowed to be built just two miles from the City of Buffalo, where I live. I have congestive heart failure and COPD. I use oxygen almost continuously. I own land within one mile of where the operation would be built and often give rides to and from there during farming season. I like to be outside and enjoy the fresh air. Will I be able to do so in the future without jeopardizing my health?

I have attached a letter from my doctor stating her concerns. Reading it makes me even more concerned, and scared.

I ask you to deny the permit so my health and wellbeing, and that of my family and friends in and near Buffalo, is not sacrificed for the growth of one business.

Thank you for your time and consideration.

Carol Beilke
Po Box 186
Buffalo ND 58011

Carol Beilke

INT MED FGO SC
SANFORD BROADWAY CLINIC
801 Broadway N
Fargo ND 58122
701-234-2261

SANFORD HEALTH

March 11, 2016

CAROL MARLYS BEILKE 3 - 480
PO BOX 186
BUFFALO ND 58011-0186

To whom it may concern,

Mrs. Carol Beilke is a patient of mine followed in Internal Medicine at Sanford Health System. I have cared for Carol for many years.

She suffers from a serious lung condition requiring continuous oxygen.

I have concerns about her health in the event that a large confined animal feeding operation be located near her home.

My concerns include air contamination with dust, mold, bacterial endotoxins and volatile gas which would very likely negatively affect her breathing capacity and respiratory status.

Studies have clearly documented respiratory symptoms associated with exposure to chemical components of CAFO air emissions in particular, ammonia and hydrogen sulfide. This would be severely detrimental to my patient.

I encourage the North Dakota State Health Department to take this into close consideration and ban CAFO's near communities that will suffer from toxic air emissions.

Thank you for your time and kind consideration.

Sincerely,

Doreen Gigstad-Stave, PA

039062-00093

PMID:24043228 [PubMed - indexed for MEDLINE] PMCID:PMC4372690 Free PMC Article

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- Abstract

Apply

Send to:

J Toxicol Environ Health B Crit Rev. 2012;15(8):524-41. doi: 10.1080/10937404.2012.744288.

Respiratory health effects of large animal farming environments.

May S[1], Romberger DJ, Poole JA.

Author information

- [1]Pulmonary, Critical Care, Sleep & Allergy Division, Department of Internal Medicine, University of Nebraska Medical Center, Omaha, NE 68198, USA.

Abstract

With increases in large animal-feeding operations to meet consumer demand, adverse upper and lower respiratory health effects in exposed agriculture workers are a concern. The aim of this study was to review large animal confinement feeding operational exposures associated with respiratory disease with a focus on recent advances in the knowledge of causative factors and cellular and immunological mechanisms. A PubMed search was conducted with the keywords airway, farm, swine, dairy, horse, cattle inflammation, organic dust, endotoxin, and peptidoglycan, among items were published between 1980 and now. Articles were selected based on their relevance to environmental exposure and reference to airway diseases. Airway diseases included rhinitis, sinusitis, mucus membrane inflammation syndrome, asthma, chronic bronchitis, chronic obstructive pulmonary disease, hypersensitivity pneumonitis, and organic dust toxic syndrome. There is lower prevalence of immunoglobulin (Ig) E-mediated asthma and atopy in farmers and their children, but organic dust worsens existing asthma. Multiple etiologic factors are linked to disease, including allergens, organic dusts, endotoxins, peptidoglycans, and gases. Large animal confinement feeding operations contain a wide diversity of microbes with increasing focus on gram-positive bacteria and archaebacteria as opposed to gram-negative bacteria in mediating disease. Toll-like receptors (TLR) and nucleotide oligomerization domain (NOD)-like innate immune pathways respond to these exposures. Finally, a chronic inflammatory adaptation, tolerance-like response in chronically exposed workers occurs. Large animal confinement farming exposures produce a wide spectrum of upper and lower respiratory tract diseases due to the complex diversity of organic dust, particulates, microbial cell wall components, and gases and resultant activation of various innate immune receptor signaling pathways.

COPD

PMID: 23199220 [PubMed - indexed for MEDLINE] PMCID:PMC4001716 Free PMC Article

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Environ Health Perspect. 2013 Jan;121(1):92-6. doi: 10.1289/ehp.1205109. Epub 2012 Oct 28.

To: North Dakota Department of Health
Division of Water Quality & Division of Air Quality

RE: Permit Application #DNAF00853

My name is Sheila Thompson. I want to speak on behalf of my husband Roy and myself. We live about 1 mile from the site of this proposed operation. We built our own home, handicapped accessible, planning on it being our retirement home, and also for our grandson Jake, who is crippled.

Being outside is one of our great pleasures. Having a big garden and flowerbeds, we spend many evenings working in them, and enjoying our gazebo.

If this operation is built, the manure would be spread on every field surrounding our home. We will be endangering our health by being outside, breathing the exhaust of these hog barns. What effect will the hydrogen sulfide and high levels of ammonia have on our health, the vegetables we grow, or more importantly our kids and grandkids?

Our oldest grandson Jake is with us every weekend. He has had many brain surgeries, and has cerebral palsy. He is blind in one eye, and losing sight in the other. We are very concerned how air quality will affect him.

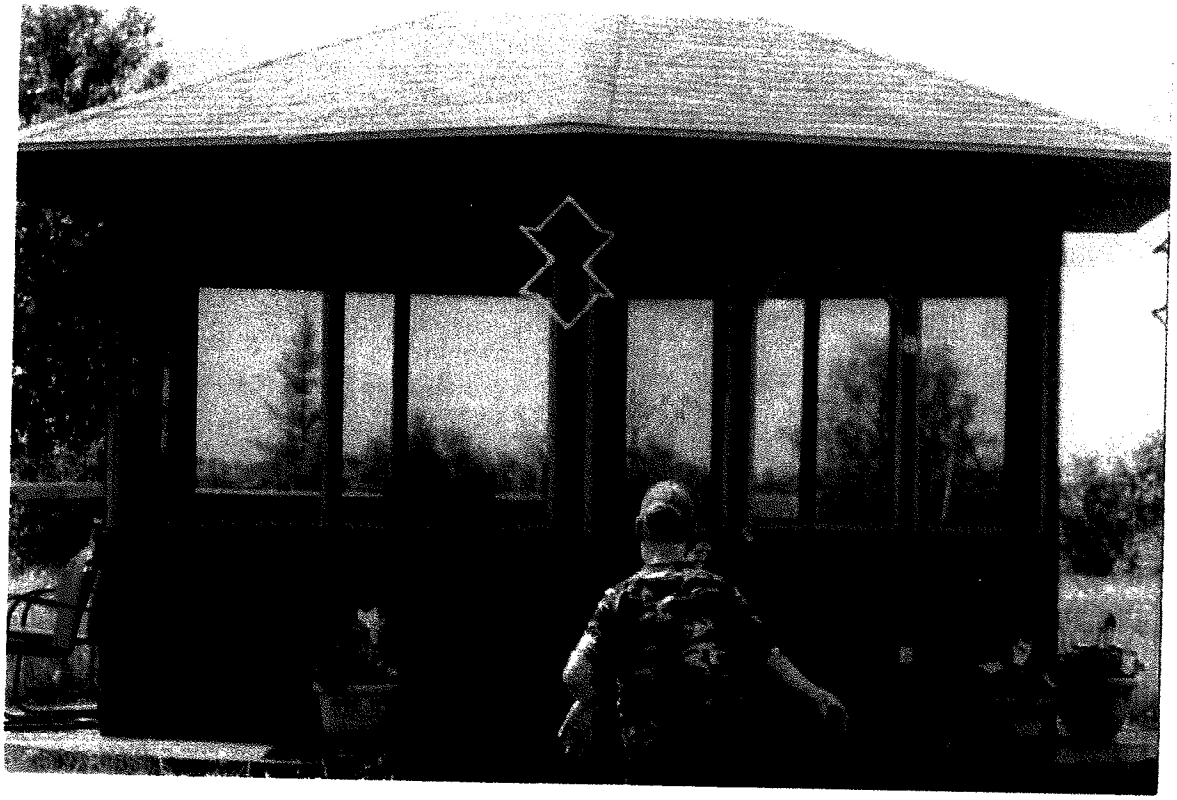
Our kids and grandkids come for visits. Our daughter Rachel, has asthma and allergies, so bad, she has to have inhalers and a portable breathing machine with her at all times. If it's too bad, she'll no longer be able to visit us.

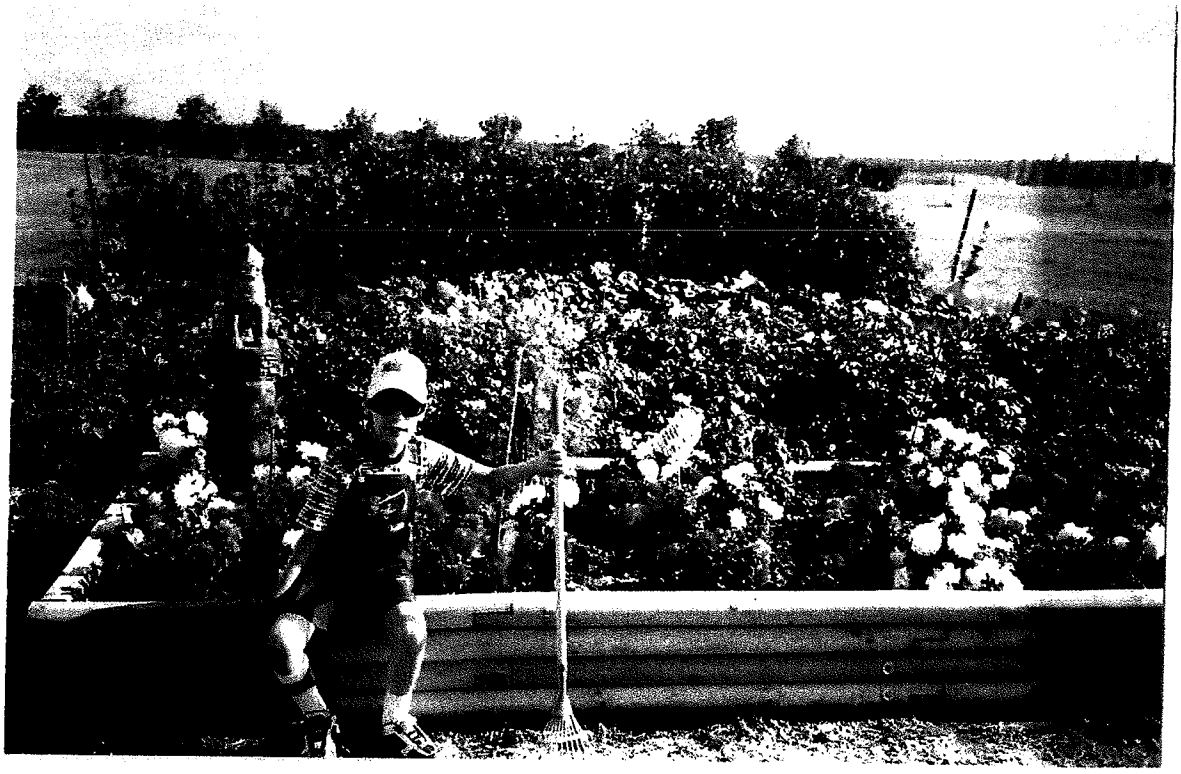
The Health Department should be concerned for all North Dakotans.

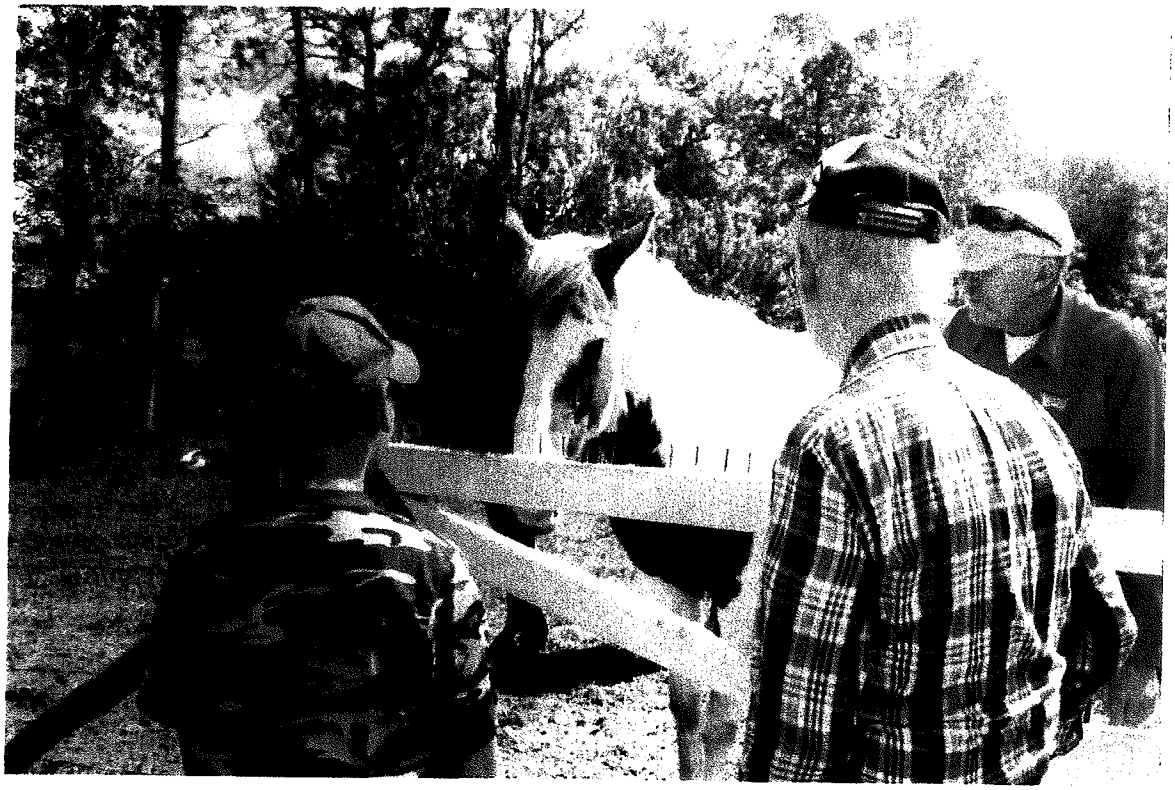
Everyone should be able to breathe clean air and have clean water.

We are asking you to please deny this permit.

Thank you







Print This Page | **Close This Window**

Name: Jacob Scott Thompson | DOB: 1/21/1998 | MRN: E2534774 | PCP: Stephen Tinguely, MD

Health Summary

Current Health Issues

Health Issue	Date Noted
Presence of ventricular shunt	11/18/2005
Partial epilepsy with impairment of consciousness	11/18/2005
Spastic hemiplegia	11/18/2005
Generalized anxiety disorder	
Disruptive behavior disorder	
Scoliosis (and kyphoscoliosis), idiopathic	03/17/2010
Short stature	04/01/2011
Abnormality of gait	05/23/2011
Unequal leg length (acquired)	05/23/2011
Other congenital varus deformity of feet	05/23/2011
Encounter for long-term (current) use of other medications	08/22/2011
ADHD (attention deficit hyperactivity disorder)	06/22/2012
Pressure ulcer of foot, stage 3	03/05/2013
Left hemiparesis	05/06/2013
Hydrocephalus	08/26/2013

Medications

risperiDONE 0.25 mg tablet
Commonly known as: RisperDAL

Instructions: Take 1 tablet by mouth ever y morning & take 1 tablet e very night atbedtime

Approved by Charlotte A Siemens, MD
Prescribed on 2/15/2016

Prescribed quantity: 60 tablets

Request a renewal

traZODone 50 mg tablet
Commonly known as: DESYREL

Instructions: Take 1 tablet by mouth ever y night at bedtime

Approved by Charlotte A Siemens, MD
Prescribed on 2/15/2016
Prescribed quantity: 30 tablets

Request a renewal

sertraline 50 mg tablet
Commonly known as: ZOLOFT

Instructions: Take 1 & 1/2 tablets by mou th once daily with food

Approved by Charlotte A Siemens, MD
Prescribed on 2/15/2016
Prescribed quantity: 45 tablets

Request a renewal

lisdexamfetamine 40 mg capsule
Commonly known as: VYVANSE

Instructions: Take 1 capsule (40 mg total) by mouth 1 time a day in the morning earliest fill date: 2/10/16.

Approved by Rachel Fleissner, MD
Prescribed on 2/10/2016
Prescribed quantity: 30 capsules

Request a renewal

hydrOXYzine pamoate 25 mg capsule
Commonly known as: VISTARIL

Instructions: Take 1 capsule by mouth every morning , at 11 am , at 4 pm , &at 7 pm

Approved by Stefanie Hanisch, MD
Prescribed on 1/28/2016
Prescribed quantity: 120 capsules

Request a renewal

Incontinence Supply Disposable Misc

Instructions: Attends dermadry extra large disposable brief, uses 5-7 per day as needed

Approved by Stephen Tinguely, MD
Prescribed on 1/19/2016
Prescribed quantity: 180 each

Request a renewal

incontinence supplies Misc

Instructions: Incontinence pads for full size bed. use 5-7 per day as needed.

Approved by Stephen Tinguely, MD
Prescribed on 1/19/2016
Prescribed quantity: 180 each

Request a renewal

loratadine 10 mg tablet
Commonly known as: CLARITIN

Instructions: Take 1 tablet by mouth once daily as needed

Approved by Stephen Tinguely, MD
Prescribed on 9/3/2015
Prescribed quantity: 30 tablets

Request a renewal

cholecalciferol 2000 units Caps capsule
Commonly known as: Vitamin D3

Instructions: Take 1 capsule by mouth once a day

Approved by Stephen Tinguely, MD
Prescribed on 6/29/2015
Prescribed quantity: 100 capsules

Request a renewal

prednisoLONE acetate 1 % ophthalmic suspension
Commonly known as: PRED FORTE

Instructions: Apply twice daily to left eye

Documented by Stefanie Hanisch, MD
Started taking on 1/19/2015

acetaminophen 325 mg tablet
Commonly known as: TYLENOL

Instructions: Take 650 mg by mouth every 4 to 6 hours as needed (rash and itching).

Documented by Abstract Provider

MINERAL OIL PO

Instructions: Take 2 teaspoonsful by mouth 1 time per day.

Documented by Abstract Provider

docusate sodium 100 mg capsule
Commonly known as: COLACE

Instructions: Take 100 mg by mouth 1 time per day.
Documented by Abstract Provider

Knee Sleeve/Kids Large Misc
Instructions: 1 device continuous.
Approved by Stephen Tinguely, MD
Prescribed on 1/30/2013
Prescribed quantity: 1 Device
Request a renewal

melatonin 3 mg tablet
Instructions: Take 3 mg by mouth every night at bedtime.
Documented by Abstract Provider

senna 8.6 MG Tabs
Commonly known as: SENOKOT
Instructions: Take 17.2 mg by mouth every night at bedtime.
Documented by Abstract Provider

citrate of magnesia 1.745 GM/30ML Soln
Instructions: Take 150 ml by mouth 1 time when needed (constipation).
Approved by Anna Marie Lindley, MD
Prescribed on 10/26/2012
Prescribed quantity: 1 Bottle
Request a renewal

pediatric multiple vitamins Chew
Instructions: Take by mouth 1 time per day.
Documented by Abstract Provider

Allergies

You have no allergies on file.

Immunizations

Immunization	Date

Immunization	Date
Ceftriaxone 1000mg	12/6/2012
Hep A,peds/adol	7/31/2008, 1/28/2008
Influenza Quadrivalent W/preserv	10/26/2015, 11/18/2014
Influenza Trivalent W/preservative 3yr+	10/2/2013
Lidocaine 1%	12/6/2012
Meningococcal B,OMV (Bexsero)	2/19/2016
Meningococcal MCV4P	2/6/2014, 9/22/2009
TDAP	9/22/2009
Varicella	1/28/2008

Preventive Care

Name	Status	Last Done
Hpv	Overdue since 1/21/2009	
Tetanus Vaccine	Not due until 9/22/2019	9/22/2009
Flu Vaccine	Completed on 10/26/2015	10/26/2015

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Name: Rachel Stangeland | DOB: 12/14/1973 | MRN: E2491620 | PCP:

Health Summary

Current Health Issues

Health Issue	Date Noted
Gastric ulcer	10/18/2005
Anxiety state	06/21/2006
Disorder of phosphorus metabolism	11/30/2006
Other hyperparathyroidism	11/30/2006
Other diseases of larynx	01/10/2007
Myalgia and myositis	12/18/2007
Vitamin D deficiency	02/07/2008
Other specified disorders resulting from impaired renal function	11/30/2006
Major depressive disorder, recurrent episode, moderate	10/01/2003
Other specified disorders of rotator cuff syndrome of shoulder and allied disorders	02/20/2009
Disorder of bursae and tendons in shoulder region	03/17/2009
Scanty or infrequent menstruation	03/31/2010
Female infertility	
Female genital symptoms	07/02/2010
Pregnancy with history of infertility	03/18/2011
Hyperemesis gravidarum with metabolic disturbance	04/28/2011
De Quervain's tenosynovitis, left	02/08/2013
Intractable chronic migraine without aura and with status migrainosus	02/26/2013
Myopia	04/08/2013
Balance problems	05/03/2013
Hydrocephalus	05/03/2013

Health Issue	Date Noted
Obstructive sleep apnea	05/16/2013
Allergic rhinitis	05/31/2013
Asthma	05/31/2013
Insomnia secondary to depression with anxiety	01/13/2015
Morbid obesity with BMI of 50.0-59.9, adult	03/28/2015

Medications

cyclobenzaprine 10 mg tablet
Commonly known as: FLEXERIL

Instructions: Take 1 tablet by mouth twice a day as needed

Approved by Angela A Dolalie Kelsch, APRN-CNP
Prescribed on 2/29/2016
Prescribed quantity: 60 tablets

Request a renewal

dihydroergotamine mesylate 1 mg/mL Soln injection solution
Commonly known as: D.H.E.45

Instructions: One muscular injection for moderate to severe migraine. max 3 doses per week.

Approved by Cynthia Knutson, MD
Prescribed on 2/5/2016
Prescribed quantity: 10 mL

Request a renewal

FLUoxetine 40 mg capsule
Commonly known as: PROzac

Instructions: Take 2 capsules (80 mg total) by mouth 1 time per day.

Approved by Harish Goyal, MD
Prescribed on 1/12/2016
Prescribed quantity: 60 capsules

Request a renewal

QUEtiapine 50 mg tablet
Commonly known as: SEROQUEL

Instructions: Take 1 tablet (50 mg total) by mouth every night at bedtime. take 1-2 tablets every 8 hours as needed for severe migraine.

Approved by Harish Goyal, MD
Prescribed on 1/12/2016
Prescribed quantity: 90 tablets

Request a renewal

gabapentin 600 mg tablet
***Commonly known as:* NEURONTIN**

Instructions: Take two tablets by mouth at bedtime.

Approved by Jeffrey M Tiongson, MD
Prescribed on 12/20/2015
Prescribed quantity: 60 tablets

gabapentin 600 mg tablet
Commonly known as: NEURONTIN

Instructions: May take one and one-half tablet (900mg) as needed every 6 hours as needed for persistent headache.

Approved by Jeffrey M Tiongson, MD
Prescribed on 12/20/2015
Prescribed quantity: 90 tablets

ondansetron 4 mg dispersible tablet
Commonly known as: ZOFRAN ODT

Instructions: Take 1 tablet (4 mg total) by mouth every 4 hours as needed for nausea.

Approved by Jeffrey M Tiongson, MD
Prescribed on 12/20/2015
Prescribed quantity: 20 tablets

sumatriptan 100 mg tablet
Commonly known as: IMITREX

Instructions: Take 1 tablet by mouth at onset of headache, may repeat in 1hour. lim it 2 tablets per day.

Approved by Cynthia Knutson, MD
Prescribed on 12/18/2015
Prescribed quantity: 18 tablets

Request a renewal

propranolol 160 mg extended release capsule
Commonly known as: INDERAL LA

Instructions: Take 1 capsule by mouth once a day

Approved by Shaveta Goyal, MD
Prescribed on 12/11/2015
Prescribed quantity: 30 capsules

Request a renewal

budesonide-formoterol 160-4.5 mcg/puff inhaler
Commonly known as: SYMBICORT

Instructions: Inhale 2 puffs orally 2 times a day. shake well before using. rinse mouth after use.

Approved by Woei Yeang Eng, MD
Prescribed on 11/17/2015
Prescribed quantity: 1 Inhaler

Request a renewal

albuterol HFA 108 (90 BASE) MCG/ACT inhaler
Commonly known as: PROVENTIL,PROAIR,VENTOLIN

Instructions: Inhale 2 puffs orally every 4 to 6 hours as needed for shortness of breath, wheezing or cough. shake well before using.

Approved by Woei Yeang Eng, MD
Prescribed on 11/17/2015
Prescribed quantity: 1 Inhaler

Request a renewal

cetirizine 10 mg tablet
Commonly known as: zyrTEC

Instructions: Take 10 mg by mouth as needed.

Documented by Abstract Provider

albuterol (2.5 mg/3mL) 0.083% inhalation solution
Commonly known as: PROVENTIL

Instructions: Inhale 1 unit-dose by nebulization every 4 hours as needed for shortness of breath, wheezing or cough.

Approved by Woei Yeang Eng, MD
Prescribed on 9/2/2015
Prescribed quantity: 90 mL

Request a renewal

buPROPion 150 mg tablet (24 hr)
Commonly known as: WELLBUTRIN XL

Instructions: Take 1 tablet by mouth 1 time per day.

Approved by Ronald Wiisanen, MD
Prescribed on 8/19/2015
Prescribed quantity: 90 tablets

Request a renewal

naltrexone 50 MG Tabs
Commonly known as: REVIA

Instructions: Take 0.5 tablets by mouth 1 time per day.

Approved by Ronald Wiisanen, MD
Prescribed on 8/19/2015
Prescribed quantity: 45 tablets

Request a renewal

modafinil 200 mg tablet
Commonly known as: PROVIGIL

Instructions: Take 1 tablet by mouth each morning and 1/2 tablet at noon on an empty stomach.

Approved by Samy S Karaz, MD
Prescribed on 7/24/2015
Prescribed quantity: 45 tablets

Request a renewal

hydrOXYzine pamoate 50 mg capsule
Commonly known as: VISTARIL

Instructions: Take 1 capsule by mouth every 6 hours as needed for anxiety.

Approved by Harish Goyal, MD
Prescribed on 3/26/2015
Prescribed quantity: 120 capsules

Request a renewal

meloxicam 7.5 mg tablet
Commonly known as: MOBIC

Instructions: Take 1 tablet by mouth twic e a day as needed

Approved by Shaveta Goyal, MD
Prescribed on 11/3/2014
Prescribed quantity: 60 tablets

Request a renewal

naproxen 220 mg tablet
Commonly known as: ALEVE

Instructions: Take 440 mg by mouth as needed.

Documented by Abstract Provider

Allergies

Allergen	Reaction
Sulfa Drugs	Nausea and Vomiting, Diarrhea
Promethazine Hcl	Wheezing/Bronchospasm (High)
Erythromycin	Nausea and Vomiting, Diarrhea

Allergen	Reaction
Codeine	Nausea and Vomiting, Diarrhea
Latex	Unknown/Not Verified

Immunizations

Immunization	Date
Ceftriaxone 1000mg	2/5/2014
H1N1 Injectable Vaccine	12/17/2009
Influenza Quadrivalent W/preserv	10/26/2015
Influenza Trivalent w/preservative 3yr+	9/26/2013
Influenza Vaccine	10/21/2010, 9/23/2009, 11/4/2008, 10/22/2007, 10/26/2006, 2/16/2006, 10/21/2003, 11/22/2002, 11/14/2001, 12/4/2000, 11/10/1999
Lidocaine 1%	2/5/2014
Pneumococcal Polysaccharide PPSV23	6/20/2008

Preventive Care

Name	Status	Last Done
Screening Mammogram	Overdue since 12/14/1991	
Pap Smear	Overdue since 4/26/2013	4/26/2010
Lipid Screening	Overdue since 12/14/2013	
Asthma Action Plan & Environmental Control	Overdue since 6/13/2015	6/13/2014
Asthma Control Test	Not due until 11/17/2016	11/17/2015
Tetanus Vaccine	Not due until 11/4/2021	11/4/2011
Flu Vaccine	Completed on 10/26/2015	10/26/2015

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My name is Antoinette Babcock and I am a resident of Buffalo. I am speaking on behalf of the Concerned Citizens who are submitting a Health Petition which has been signed by 194 people.

The petition reads as follows: We the undersigned citizens and/or property owners, who live and/or work in Buffalo or in the surrounding townships of Buffalo, Hill, Howes, Tower, and Wheatland, have been provided information from the document entitled **"Understanding Concentrated Animal Feeding Operations and their Impact on Communities"** authored by Carrie Hribar, MA, (2010) National Association of Local Boards of Health, Bowling Green, Ohio. We are alarmed by the magnitude of environmental problems associated with CAFO's which pose a direct impact on our health and welfare. We do hereby **oppose** the permit for Application No. DNAF00853 filed by Rolling Green Family Farms RE, LLP of Pipestone, MN for permission to operate a swine production facility on the SE ¼ of the NW ¼ of Section 4, Township 139 N, Range 54 W, in Cass County, North Dakota.

In addition to the Health Petition, we are also submitting a reference list of our research data and the printed documents that address health risks related to swine CAFO's, including issues regarding socioeconomic impact, water and air pollution and various diseases such as MRSA.

We also have attached 12 letters written by concerned citizens addressing their individual health issues that affect their daily life. These concerned citizens do not want the North Dakota Department of Health to grant this illegal permit.

We all rely on the North Dakota Department of Health to protect our health, safety and welfare.

As a concerned citizen of Buffalo,

We are here to express our concerns to the Dept. of Health about a proposed corporate hog operation that will be located 1.5 miles from our dream home.

We are very concerned about the effects of hydrogen sulfide, methane gas and ammonia gases and any particulate matter to our health and those of our family members. We have two grandsons with asthma, my mother who has terminal small cell lung cancer and myself with anxiety and stage four kidney failure.

We walk our country roads not just for pleasure but also for health reason. We look forward to being outside using every 10 acres of space after a long North Dakota winter.

Sincerely,
Arnetta Frueh

My name is Vicki Wendt. I am Arnetta's neighbor. Because she was not able to attend, I am submitting her letter and her documents of concern on her behalf.

Concerned Citizen of Buffalo,

I am here to express my concerns to the Dept of Health on the possibility of Rolling Green Farms, managed by Pipestone Systems of putting up a hog factory. Rolling Green Farms are looking to put up a facility of 9000 hogs on 35 acres 1.5 miles from our home, with a yield of 177,000 hogs passing through by the end of their fiscal year.

At the meeting that Pipestone held on Monday, Jan 18th, we were told that our fears are unfounded, that the air will carry slight odor or no disease because there hogs are healthy, that they will have rodents and other inhabitants including the house fly, that it's an economic boost for our Community and that hogs and there 6 million gallons of slurry will not stink.

As far as **fear** in this situation it is well founded. When we heard about this facility and the possibilities of 14 to 20 employees coming in we were excited. Our family is a self- employed plumbing contractor. We also didn't know what a CAFO was. When we looked it up we were not looking for anything but good things. We were shocked!! We looked up Pipestone System and their site was awesome. Well presented with all positive research, charts and working opportunities. Then we saw all those other articles. Those were really bad. Everyone; no matter from what state; from lay people, to mayors to Health Organizations to Farm Associations. It made the hair stand up on the back of our necks, and our anxiety was great. Now we did look up these articles on the internet, we did call some of the people who live by the facilities, some up to 5 miles away. Fear was setting in and setting in fast. Now I understand that you need to use common sense in what to believe or not believe. I also know that some people complain because their ice cream is cold. Now even if 1% of all this has some truth to it, that's too much of a risk.

Now as far as **air**, the definition of air is that it's an invisible odorless tasteless gases. Pipestone systems claim that the wind isn't going to carry dust or gases. Now we all know that the ashes from Mt. St. Helen came this far, carried by the wind. We know that the Canadian wild fires smoke smell and haze were carried here by the wind. Now we are only talking 1.5 miles away from the hog farm, but wind won't carry anything. If there is an odor in the air; that means that there is some additional gases that are mixing with the air and that is called pollution. Those gases such as methane gas, hydrogen sulfide, ammonia, carbon dioxide can cause serious respiratory

distress.
Now Pipestone and its farmers state the hogs and there by product doesn't stink, that is a totally irresponsible commit with no merit!!! That's saying that our POO doesn't stink and we all know that not to be true. We all love that fact of when the sewer backs up into our homes, right. I'll tell you, I have been the other end of those calls and they can be very distressing, which by the way I never fully repeat to my husband, mostly because those are words that I never say! Now all waste has bacteria and in that bacteria are germs that can be spread from your shoes, clothes, hair. They state that the particles live in your nose for months and we know that coughing and sneezing doesn't spread germs. Wrong! So for any one of us that has a suppressed immune system it will be seriously compromised.

Now for **flies, rodents and other inhabitants.** First Pipestone Systems state that they will have traps around for rodent capture, which is good. They do not state weather there would be any type of fencing going around the property to keep stray dogs, fox, coyotes etc. out. We have small children and house pets that will be threatened if these inhabitants are moving about. Flies! We were told that flies don't fly any further than 50 ft from their feeding source. Pipestone Systems also stated that they will not have any thing in place to control the house flies. Now research states that a house fly produces every eight days with many generations during a typical season. Each house fly is shown to "easily carry over one million bacteria on its body." They also transmit disease pathogens such as e-coli, salmonella, cholera, dysentery. The University of Kentucky's Entomologist states that "if a large number of flies develop at a site, competition among their breeding sites causes them to move." The University also states that flies can easily move up to two miles on their own. No wind involved. The University also states the 60 to 80% of the flies that they marked and released were captured within 1 mile of the release point. Most of the rest, 85 to 95 % of the total were caught within 2 miles of the release in the first 4 days from where they were turned loose. At this time NDSU's study shows that in our area we do not have house flies, with testing spots in Casselton, Harmony Township and Kindred, Normanna Township as of May 27th,2015 to July 6th, 2015.

Economic Boost and Community. Now if this was such a wonderful thing to be happening to our community, then the land sellers, applicants and Economic Development should have been working on a plan for housing for these families. There was more than enough time to not only put a plan together, but to implement it with time to spare. We should have been

gearing the school for an increase in students. We could have been working with locums for all that is needed to put this together and make these families feel welcome. So now instead of our community profiting from this, as Pipestone state "there is Valley City, Casselton and Fargo." They are not our community, they are our neighbors.

Quality of Life, that's a funny phrase because the definition means something different for each of us. So the quality of life is up to what the individual and what makes them happy. For my family it's the quality of time that we share together on the farm. We have four generations living out here with us and each moment is treasured. We have three grand babies that we wear on our chests. We make snow banks, help Papa move snow in his truck sipping hot chocolate and eating a treat that we snuck out, we ride our go carts, bicycles, climb up the tress, spend time in uncles tree house, ride the green tractor with Papa, help grandma with the garden watching those little plants grow big so we can eat the fruits of the plant, we watch the monarchs hatch and fly around us, watch the silly antics of the squirrels – don't know why they don't fall off that twig! We pick apples and test taste them. Every day we have one or two grandchild in our home, never all three without a parent. Now two of these grandchild have asthma. One is growing out of it and the other one is still doctoring. If just a fraction of the air quality is negative we are putting these children at risk of respiratory failure. Without my babies, I would be crushed. I have an anxiety disorder and at this point I have had to double my medication. I also have stage four kidney failure. If I catch any disease it will have serious effects that could be deadly. My body at this time is weakened and will not be able to fight off any harm. My mom has terminal small cell lung cancer. She has finished her chemo and radiation.

I can choose not to believe anything that I've heard from Pipestone Systems, from community members, the people that we have spoke to and believe none of my research. I can choose to believe everything that Pipestone Systems had to say, everything that community members say, the people we spoke to and believe all of my research. Or I can weigh all this information with a pro and con column using common sense. I am not against hog farming or any other farming. I love pork chops, nothing better than a tender ham and crispy bacon. What I oppose is the amount of hogs and by product in such a small area and so close to a community and farms within the proposed area.

If there is a smidgen of truth to any of this, that is too big a price to pay for our family. And we are not willing to take any risk at this time. Can this

community afford the prospect of losing 4 families and a prominent business? Thank you!

Arnette Bush

Grand Forks Herald

Barbara Bentz: Make no mistake, methane is hazardous to your health

By Barbara Bentz Today at 5:00 a.m.

FARGO—I had the chance to attend the public hearing for the federal Bureau of Land Management's methane rule. The bureau is proposing to update 30-year-old regulations in order to reduce the release of natural gas into the atmosphere from oil and gas operations on public and American Indian lands.

The proposed rule is meant to harness the energy that's lost when the methane escapes or is flared, and to decrease lost royalties and the effect methane has on global warming. The global

warming effects and immediate health risks of methane recently have made headlines as a result of the uncontained methane gas leak in California.

As a pediatrician, I am concerned about how our environment affects the health and safety of North Dakota's children and families. At the hearing in Dickinson, representatives of the oil industry presented their position; and part of the industry's concern, they said, was the need to have more evidence about health complications from methane.

This claim was part of their attempt to refute the need for the BLM's guidelines.

As I mentioned in my own presentation, when methane is sold commercially, it contains mercaptan. This is a foul-smelling chemical that makes detection of leaks obvious. It has a sulfur smell, like rotten eggs.

The chemical was put into natural gas in the aftermath of a school explosion in New London, Texas, in 1937. Some 300 students and faculty members lost their lives when the school exploded and was leveled because of the ignition of trapped natural gas.

The school was being fueled by gas directly from the nearby oil wells. After that disaster, mercaptan was introduced by the gas companies for safety and health reasons, in order to make the presence of leaks obvious.

Perhaps the people representing the oil companies in Dickinson were unaware of their own companies' concerns about safety.

These are the facts, facts the oil industry works with every day:

■ Methane is slightly soluble, so it can enter in the groundwater. Then when it seeps into basements

or leaks and is exposed to air, it becomes a vapor.

■ It also is odorless in its natural state.

■ From a respiratory point of view, very high levels of methane can displace the oxygen in the air and cause suffocation, resulting in symptoms such as headaches, dizziness, weakness, nausea, vomiting, rapid breathing, loss of coordination, loss of consciousness and possible death.

■ As an odorless, colorless and tasteless gas, its health effects as well as its explosively flammable potential may not be suspected by children or adults.

The oil companies understand methane is dangerous, but the people who represented them at the hearing wanted more evidence, more proof. I recommended that the oil companies and the Bureau of Land Management include an experienced federal public health agency such as

the Agency for Toxic Substances and Disease Registry as a partner to determine the most effective way to continuously measure methane levels in the environment before it is sold or transported.

I suggested that such a partner be added into the final methane rule, in a strong effort to protect the children, families and oil company employees of this community.

Dr. Bentz is a Sanford Health pediatrician.

Arnetta K Frueh

Continuity of Care Document, as of Feb. 26, 2016

Patient Demographics - Female, born Jul. 01, 1965

Patient Address	Communication	Language	Race / Ethnicity
14006 37th St SE BUFFALO, ND 58011	701-633-5620 (Home) 777-777-7777 (Work) 777-777-7777 (Mobile) 5bsybvrs@ictc.com	1 (Preferred)	Caucasian or White / Non-Hispanic

Note from Essentia Health

This document contains information that was shared with ARNETTA K Frueh. It may not contain the entire record from Essentia Health.

Reason for Visit

Reason
Recheck

Encounter Details

Date	Type	Department	Care Team
08/24/2011	Office Visit	32 AVE CLINIC NEPHROLOGY 3000 32nd Avenue South Fargo, ND 58103 701-364-8900	**Qarni, Ahmer, MD** 3000 32ND AVENUE SOUTH FARGO, ND 58103 701-364-8000 701-364-4628 (Fax)

Active Allergies and Adverse Reactions - as of 02/26/2016

Allergen	Noted Date	Severity	Reactions	Comments
Valine			Other	Nightmares

Current Medications - as of 02/26/2016

Prescription	Sig.	Disp.	Start Date	End Date	Status
meclizine (ANTIVERT) 25 MG tablet	Take 1 Tab by mouth as needed for Dizziness.		04/05/2012		Active
busPIRone (BUSPAR) 10 MG tablet	Take 2 Tabs by mouth three times a day.	540 Tab	01/12/2015		Active
calcitRIOL (ROCALTROL) 0.25 MCG capsule	Take 1 Cap by mouth every 48 hours.	15 Cap	08/18/2015		Active
irbesartan (AVAPRO) 300 MG tablet	TAKE 1 TABLET BY MOUTH EVERY DAY NEEDS TO BE SEEN	90 Tab	09/13/2015		Active
escitalopram (LEXAPRO) 20 MG tablet	TAKE 1 TABLET BY MOUTH EVERY DAY	30 Tab	10/14/2015		Active
ALPRAZolam (XANAX) 0.25 MG tablet	Take 1 Tab by mouth one time a day as needed for Anxiety.	30 Tab	10/21/2015		Active
simvastatin (ZOCOR) 20 MG tablet	TAKE 1 TABLET EVERY DAY AT BEDTIME	30 Tab	10/23/2015		Active
hydrochlorothiazide 25 MG tablet	TAKE 1 TABLET BY MOUTH EVERY DAY	90 Tab	10/21/2015		Active
metoprolol succinate (TOPROL-XL) 100 MG 24 hour extended-release tablet	TAKE 1 AND 1/2 TABLET BY MOUTH AT BEDTIME	135 Tab	10/31/2015		Active

Active Problems - as of 02/26/2016

Problem	Noted Date
Lipid disorder	08/28/2015
Hyperparathyroidism due to renal insufficiency (HCC)	08/28/2015
CKD (chronic kidney disease) stage 4, GFR 15-29 ml/min (HCC)	11/15/2013
Depression with anxiety	04/05/2012
IgA nephropathy	04/05/2012
Benign essential hypertension	09/17/2009

Resolved Problems - as of 02/26/2016

Problem	Noted Date	Resolved Date
Essential hypertension	08/04/2010	04/05/2012
Anxiety	07/22/2010	04/05/2012
Chronic kidney disease, stage III (moderate)	09/21/2009	11/15/2013
Unspecified hypertensive kidney disease with chronic kidney disease stage I through stage IV, or unspecified	09/21/2009	12/19/2011
Pure hypercholesterolemia	09/17/2009	08/28/2015
Dysthymic disorder	09/17/2009	04/05/2012
Chronic kidney disease, unspecified	09/17/2009	12/19/2011

Immunizations - as of 02/26/2016

Name	Dates Previously Given	Next Due
Influenza (+3 Years) Quad NPF Vial	10/29/2015	
Pneumococcal Conjugate, (Prevnar)13-valent	10/29/2015	
Tdap >7 years	08/19/2014	

Social History

Tobacco Use	Types	Packs/Day	Years Used	Date
Never Smoker				

Last Filed Vital Signs (In this Visit)

Vital Sign	Reading	Time Taken
Blood Pressure	151/85	08/24/2011 3:19 PM CDT
Pulse	72	08/24/2011 3:19 PM CDT
Temperature	-	-
Respiratory Rate	-	-
Oxygen Saturation	-	-
Weight	73 kg (161 lb 0.6 oz)	08/24/2011 3:19 PM CDT
Height	149.9 cm (4' 11")	08/24/2011 3:19 PM CDT
Body Mass Index	33.33	08/24/2011 3:19 PM CDT

Prescriptions Ordered During Visit

Prescription	Sig.	Disp.	Start Date	End Date
irbesartan-hydrochlorothiazide (AVALIDE) 300-25 MG per tablet	Take 1 Tab by mouth one time a day.	30 Tab	08/24/2011	10/24/2011

Plan of Care

Not on file

Results

Not on file

Visit Diagnoses

CKD (chronic kidney disease) stage 3, GFR 30-59 ml/min - Primary

Document Information

Primary Care Provider

Thomas Kempf (Aug. 19, 2011 - Present)
701-364-3300 (Work)
701-364-8740 (Fax)
1702 SOUTH UNIVERSITY DRIVE
FARGO, ND 58103

Document Coverage Dates

Aug. 24, 2011

Custodian Organization

Essentia Health
218-786-2964 (Work)
400 East 3rd Street
Duluth, MN 55805

Encounter Providers

Ahmer Qarni (Attending)
701-364-8000 (Work)
701-364-4628 (Fax)
3000 32ND AVENUE SOUTH
FARGO, ND 58103

Encounter Date

Aug. 24, 2011

Sandra J Cromwell

Continuity of Care Document, as of Feb. 26, 2016

Patient Demographics - Female, born Apr. 15, 1947

Patient Address	Communication	Language	Race / Ethnicity
14006 37th St SE BUFFALO, ND 58011	701-341-1683 (Home) 701-341-1683 (Mobile) crumbly@yahoo.com	1 (Preferred)	Caucasian or White / Non-Hispanic

Note from Essentia Health

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Reason for Visit

Reason
Consult

Encounter Details

Date	Type	Department	Care Team
09/21/2015	Office Visit	SOUTH UNIVERSITY PULMONARY MEDICINE 1702 SOUTH UNIVERSITY DRIVE FARGO, ND 58103 701-364-8900	**Jinnur, Praveen, MD** 1702 SOUTH UNIVERSITY DRIVE FARGO, ND 58103-4940 701-364-8900 701-364-4594 (Fax)

Active Allergies and Adverse Reactions - as of 02/26/2016

Allergen	Noted Date	Severity	Reactions	Comments
Dust Mite Extract	03/28/2014			
Pollen Extract	03/28/2014			
Seasonal	03/28/2014			

Current Medications - as of 02/26/2016

Prescription	Sig.	Disp.	Start Date	End Date	Status
meloxicam (MOBIC) 15 MG tablet	TAKE 1 TABLET BY MOUTH EVERY DAY WITH FOOD	30 Tab	07/20/2015		Active
prochlorperazine (COMPAZINE) 10 MG tablet	Take 1 Tab by mouth every six hours as needed for Nausea.	30 Tab	09/11/2015		Active
citalopram (CELEXA) 20 MG tablet	Take 1 Tab by mouth one time a day.	30 Tab	09/11/2015		Active
albuterol-ipratropium (COMBIVENT RESPIMAT) 20-100 MCG/ACT inhalation aerosol	Inhale 2 Puffs into the lungs four times a day. Dispense with spacer.	1 Inhaler	09/11/2015		Active

Active Problems - as of 02/26/2016

Problem	Noted Date
Pain with swallowing	12/14/2015
Small cell lung cancer, right (HCC)	11/06/2015
New onset of headaches	09/11/2015
Anxiety	09/01/2015
Primary osteoarthritis of both hands	09/01/2015

Resolved Problems - as of 02/26/2016

Problem	Noted Date	Resolved Date
Small cell carcinoma (HCC)	09/01/2015	11/06/2015

Immunizations - as of 02/26/2016

Name	Dates Previously Given	Next Due
Influenza (Historic Use Only)	10/03/2012, 09/25/2010, 10/10/2008	
Influenza Seasonal Inj A,B High Dose	10/29/2015	
Pneumovax 23	10/03/2012	
Tdap >7 years	10/03/2012	

Social History

Tobacco Use	Types	Packs/Day	Years Used	Date
Former Smoker		0.5	47	Quit: 07/17/2015
Smokeless Tobacco: Never Used				

Alcohol Use	Drinks/Week	oz/Week
No	0 Standard drinks or equivalent	0.0

Last Filed Vital Signs (In this Visit)

Vital Sign	Reading	Time Taken
Blood Pressure	110/73	09/21/2015 3:02 PM CDT
Pulse	102	09/21/2015 3:02 PM CDT
Temperature	-	-
Respiratory Rate	-	-
Oxygen Saturation	92%	09/21/2015 3:02 PM CDT
Weight	64.9 kg (143 lb)	09/21/2015 3:02 PM CDT
Height	157.5 cm (5' 2")	09/21/2015 3:02 PM CDT
Body Mass Index	24.69	09/21/2015 3:02 PM CDT

Functional Status

Functional Status	Response	Date of Assessment
Are you deaf or do you have serious difficulty hearing?	No	09/03/2015
Are you blind or do you have serious difficulty seeing, even when wearing glasses?	No	09/03/2015
Do you have serious difficulty walking or climbing stairs?	No	09/03/2015
Do you have difficulty dressing or bathing?	No	09/03/2015
Because of a physical, mental, or emotional condition, do you have difficulty doing errands alone such as visiting a doctor's office or shopping?	No	09/03/2015

Cognitive Status	Response	Date of Assessment
Because of a physical, mental, or emotional condition, do you have serious difficulty concentrating, remembering, or making decisions?	No	09/03/2015

Instructions

Patient Instructions - Johnson, Christina J, LPN - 09/21/2015 3:02 PM CDT

Thank you for choosing Essentia Health for your health care needs.

Here are a few suggestions that will help us in assuring your health care needs are met during your next visit:

· Please arrive 20 minutes before your appointment so that we can complete your registration and collect any other necessary information.

· Bring your medication bottles and an updated medication list with you for your visit.

Remember to always stop at the checkout desk at the end of your visit to schedule your next appointment and to pick up your After Visit Summary, which will contain your updated medication list.

Prescriptions Ordered During Visit

Prescription	Sig.	Disp.	Start Date	End Date
tiotropium (SPIRIVA HANDIHALER) 18 MCG inhalation capsule	Inhale 1 Cap into the lungs one time a day for 30 days. Remove capsule from foil blister immediately before use; place in chamber of HandiHaler Inhaler.	30 Cap	09/21/2015	10/21/2015
mometasone - formoterol (DULERA) 200-5 MCG/ACT inhalation aerosol	Inhale 2 Puffs into the lungs two times a day for 30 days.	13 g	09/21/2015	10/21/2015

Plan of Care

Upcoming Encounters

Date	Type	Specialty	Providers
03/01/2016	Appointment	Oncology	**Gupta, Mahendra, MD** 1702 SOUTH UNIVERSITY DRIVE FARGO, ND 58103 701-364-3300 701-364-6178 (Fax) **Ancillary, Sucl Infusion Lab**

Results

Not on file

Visit Diagnoses

Small cell carcinoma of lung, right (HCC) - Primary
Dyspnea
Malignant pleural effusion
Postobstructive pneumonia

Document Information

Primary Care Provider
Constance Soper (Sep. 11, 2015 - Present)
701-364-6600 (Work)
701-364-5750 (Fax)
3902 13th Avenue South
Fargo, ND 58103

Custodian Organization
Essentia Health
218-786-2964 (Work)
400 East 3rd Street
Duluth, MN 55805

Encounter Providers
Praveen Jinnur (Attending)
701-364-8900 (Work)
701-364-4594 (Fax)
1702 SOUTH UNIVERSITY DRIVE
FARGO, ND 58103-4940

Document Coverage Dates
Sep. 21, 2015

Encounter Date
Sep. 21, 2015

Sandra J Cromwell

Continuity of Care Document, as of Feb. 26, 2016

Patient Demographics - Female, born Apr. 15, 1947

Patient Address	Communication	Language	Race / Ethnicity
14006 37th St SE BUFFALO, ND 58011	701-341-1683 (Home) 701-341-1683 (Mobile) crumbly@yahoo.com	1 (Preferred)	Caucasian or White / Non-Hispanic

Note from Essentia Health

This document contains information that was shared with Sandra J Cromwell. It may not contain the entire record from Essentia Health.

Reason for Visit

Reason
Consult

Encounter Details

Date	Type	Department	Care Team
11/04/2015	Office Visit	SOUTH UNIVERSITY OTOLARYNGOLOGY 1702 South University Drive Fargo, ND 58103 701-364-8900	**Belizario, Francisco, MD** 1702 SOUTH UNIVERSITY DRIVE FARGO, ND 58103 701-364-3300 701-364-8995 (Fax)

Active Allergies and Adverse Reactions - as of 02/26/2016

Allergen	Noted Date	Severity	Reactions	Comments
Dust Mite Extract	03/28/2014			
Pollen Extract	03/28/2014			
Seasonal	03/28/2014			

Current Medications - as of 02/26/2016

Prescription	Sig.	Disp.	Start Date	End Date	Status
meloxicam (MOBIC) 15 MG tablet	TAKE 1 TABLET BY MOUTH EVERY DAY WITH FOOD	30 Tab	07/20/2015		Active
prochlorperazine (COMPAZINE) 10 MG tablet	Take 1 Tab by mouth every six hours as needed for Nausea.	30 Tab	09/11/2015		Active
citalopram (CELEXA) 20 MG tablet	Take 1 Tab by mouth one time a day.	30 Tab	09/11/2015		Active
albuterol-ipratropium (COMBIVENT RESPIMAT) 20-100 MCG/ACT inhalation aerosol	Inhale 2 Puffs into the lungs four times a day. Dispense with spacer.	1 Inhaler	09/11/2015		Active

Active Problems - as of 02/26/2016

Problem	Noted Date
Pain with swallowing	12/14/2015
Small cell lung cancer, right (HCC)	11/06/2015
New onset of headaches	09/11/2015
Anxiety	09/01/2015
Primary osteoarthritis of both hands	09/01/2015

Resolved Problems - as of 02/26/2016

Problem	Noted Date	Resolved Date
Small cell carcinoma (HCC)	09/01/2015	11/06/2015

Immunizations - as of 02/26/2016

Name	Dates Previously Given	Next Due
Influenza (Historic Use Only)	10/03/2012, 09/25/2010, 10/10/2008	
Influenza Seasonal Inj A,B High Dose	10/29/2015	
Pneumovax 23	10/03/2012	
Tdap >7 years	10/03/2012	

Social History

Tobacco Use	Types	Packs/Day	Years Used	Date
Former Smoker		0.5	47	Quit: 07/17/2015
Smokeless Tobacco: Never Used				

Alcohol Use	Drinks/Week	oz/Week
No	0 Standard drinks or equivalent	0.0

Last Filed Vital Signs (In this Visit)

Vital Sign	Reading	Time Taken
Blood Pressure	133/88	11/04/2015 8:35 AM CST
Pulse	110	11/04/2015 8:35 AM CST
Temperature	35.8 °C (96.4 °F)	11/04/2015 8:35 AM CST
Respiratory Rate	-	-
Oxygen Saturation	-	-
Weight	61.7 kg (136 lb)	11/04/2015 8:35 AM CST
Height	157.5 cm (5' 2")	11/04/2015 8:35 AM CST
Body Mass Index	24.69	11/04/2015 8:35 AM CST

Functional Status

Functional Status	Response	Date of Assessment
Are you deaf or do you have serious difficulty hearing?	No	09/03/2015
Are you blind or do you have serious difficulty seeing, even when wearing glasses?	No	09/03/2015
Do you have serious difficulty walking or climbing stairs?	No	09/03/2015
Do you have difficulty dressing or bathing?	No	09/03/2015
Because of a physical, mental, or emotional condition, do you have difficulty doing errands alone such as visiting a doctor's office or shopping?	No	09/03/2015

Cognitive Status	Response	Date of Assessment
Because of a physical, mental, or emotional condition, do you have serious difficulty concentrating, remembering, or making decisions?	No	09/03/2015

Plan of Care

Upcoming Encounters

Date	Type	Specialty	Providers
03/01/2016	Appointment	Oncology	**Gupta, Mahendra, MD** 1702 SOUTH UNIVERSITY DRIVE FARGO, ND 58103 701-364-3300 701-364-6178 (Fax) **Ancillary, Sucl Infusion Lab**

Results

Not on file

Visit Diagnoses

Dysphonia - Primary
Unilateral complete paralysis of vocal cord

Document Information

Primary Care Provider
Constance Soper (Sep. 11, 2015 - Present)
701-364-6600 (Work)
701-364-5750 (Fax)
3902 13th Avenue South
Fargo, ND 58103

Document Coverage Dates
Nov. 04, 2015

Custodian Organization
Essentia Health
218-786-2964 (Work)
400 East 3rd Street
Duluth, MN 55805

Encounter Providers
Francisco Belizario (Attending)
701-364-3300 (Work)
701-364-8995 (Fax)
1702 SOUTH UNIVERSITY DRIVE
FARGO, ND 58103

Encounter Date
Nov. 04, 2015

Sandra J Cromwell

Continuity of Care Document, as of Feb. 26, 2016

Patient Demographics - Female, born Apr. 15, 1947

Patient Address	Communication	Language	Race / Ethnicity
14006 37th St SE BUFFALO, ND 58011	701-341-1683 (Home) 701-341-1683 (Mobile) crumbly@yahoo.com	1 (Preferred)	Caucasian or White / Non-Hispanic

Note from Essentia Health

This document contains information that was shared with Sandra J Cromwell. It may not contain the entire record from Essentia Health.

Reason for Visit

Reason
Lung Cancer

Encounter Details

Date	Type	Department	Care Team
01/26/2016	Office Visit	SOUTH UNIVERSITY MEDICAL ONCOLOGY 1702 South University Drive Fargo, ND 58103 701-364-8900	**Boehlke-Fiecke, Brittani R, PA-C** 1702 SOUTH UNIVERSITY DRIVE FARGO, ND 58103-4940 701-364-3300 701-364-6178 (Fax)

Active Allergies and Adverse Reactions - as of 02/26/2016

Allergen	Noted Date	Severity	Reactions	Comments
Dust Mite Extract	03/28/2014			
Pollen Extract	03/28/2014			
Seasonal	03/28/2014			

Current Medications - as of 02/26/2016

Prescription	Sig.	Disp.	Start Date	End Date	Status
meloxicam (MOBIC) 15 MG tablet	TAKE 1 TABLET BY MOUTH EVERY DAY WITH FOOD	30 Tab	07/20/2015		Active
prochlorperazine (COMPAZINE) 10 MG tablet	Take 1 Tab by mouth every six hours as needed for Nausea.	30 Tab	09/11/2015		Active
citalopram (CELEXA) 20 MG tablet	Take 1 Tab by mouth one time a day.	30 Tab	09/11/2015		Active
albuterol-ipratropium (COMBIVENT RESPIMAT) 20-100 MCG/ACT inhalation aerosol	Inhale 2 Puffs into the lungs four times a day. Dispense with spacer.	1 Inhaler	09/11/2015		Active

Active Problems - as of 02/26/2016

Problem	Noted Date
Pain with swallowing	12/14/2015
Small cell lung cancer, right (HCC)	11/06/2015
New onset of headaches	09/11/2015
Anxiety	09/01/2015
Primary osteoarthritis of both hands	09/01/2015

Resolved Problems - as of 02/26/2016

Problem	Noted Date	Resolved Date
Small cell carcinoma (HCC)	09/01/2015	11/06/2015

Immunizations - as of 02/26/2016

Name	Dates Previously Given	Next Due
Influenza (Historic Use Only)	10/03/2012, 09/25/2010, 10/10/2008	
Influenza Seasonal Inj A,B High Dose	10/29/2015	
Pneumovax 23	10/03/2012	
Tdap >7 years	10/03/2012	

Social History

Tobacco Use	Types	Packs/Day	Years Used	Date
Former Smoker		0.5	47	Quit: 07/17/2015
Smokeless Tobacco: Never Used				

Alcohol Use	Drinks/Week	oz/Week
No	0 Standard drinks or equivalent	0.0

Last Filed Vital Signs (In this Visit)

Vital Sign	Reading	Time Taken
Blood Pressure	130/70	01/26/2016 10:17 AM CST
Pulse	81	01/26/2016 10:17 AM CST
Temperature	35.7 °C (96.2 °F)	01/26/2016 10:17 AM CST
Respiratory Rate	20	01/26/2016 10:17 AM CST
Oxygen Saturation	-	-
Weight	61.2 kg (135 lb)	01/26/2016 10:17 AM CST
Height	-	-
Body Mass Index	25.09	01/26/2016 10:17 AM CST

Functional Status

Functional Status	Response	Date of Assessment
Are you deaf or do you have serious difficulty hearing?	No	09/03/2015
Are you blind or do you have serious difficulty seeing, even when wearing glasses?	No	09/03/2015
Do you have serious difficulty walking or climbing stairs?	No	09/03/2015
Do you have difficulty dressing or bathing?	No	09/03/2015
Because of a physical, mental, or emotional condition, do you have difficulty doing errands alone such as visiting a doctor's office or shopping?	No	09/03/2015

Cognitive Status	Response	Date of Assessment
Because of a physical, mental, or emotional condition, do you have serious difficulty concentrating, remembering, or making decisions?	No	09/03/2015

Instructions

Patient Instructions - Grode, Alexandria, LPN - 01/26/2016 10:18 AM CST

Thank you for choosing Essentia Health for your health care needs.

Here are a few suggestions that will help us in assuring your health care needs are met during your next visit:

· Please arrive 20 minutes before your appointment so that we can complete your registration and collect any other necessary information.

· Bring your medication bottles and an updated medication list with you for your visit.

Remember to always stop at the checkout desk at the end of your visit to schedule your next appointment and to pick up your After Visit Summary, which will contain your updated medication list.

Plan of Care

Upcoming Encounters

Date	Type	Specialty	Providers
03/01/2016	Appointment	Oncology	**Gupta, Mahendra, MD** 1702 SOUTH UNIVERSITY DRIVE FARGO, ND 58103 701-364-3300 701-364-6178 (Fax) **Ancillary, Sucl Infusion Lab**

Results

Not on file

Visit Diagnoses

Small cell lung cancer, right (HCC) - Primary

Cough

Document Information

Primary Care Provider
Constance Soper (Sep. 11, 2015 - Present)
701-364-6600 (Work)
701-364-5750 (Fax)
3902 13th Avenue South
Fargo, ND 58103

Custodian Organization
Essentia Health
218-786-2964 (Work)
400 East 3rd Street
Duluth, MN 55805

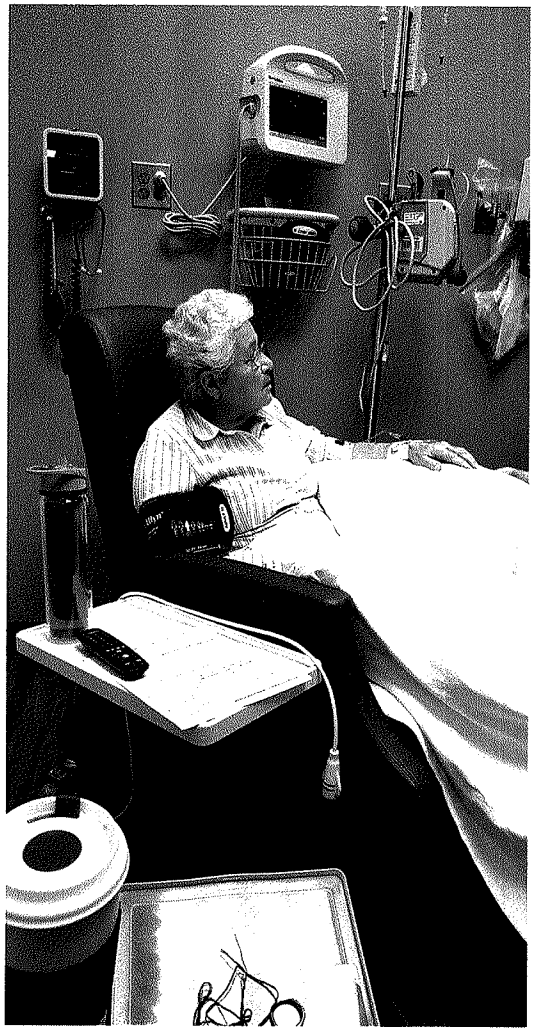
Encounter Providers
Brittani R Boehlke-Fiecke (Attending)
701-364-3300 (Work)
701-364-6178 (Fax)
1702 SOUTH UNIVERSITY DRIVE
FARGO, ND 58103-4940

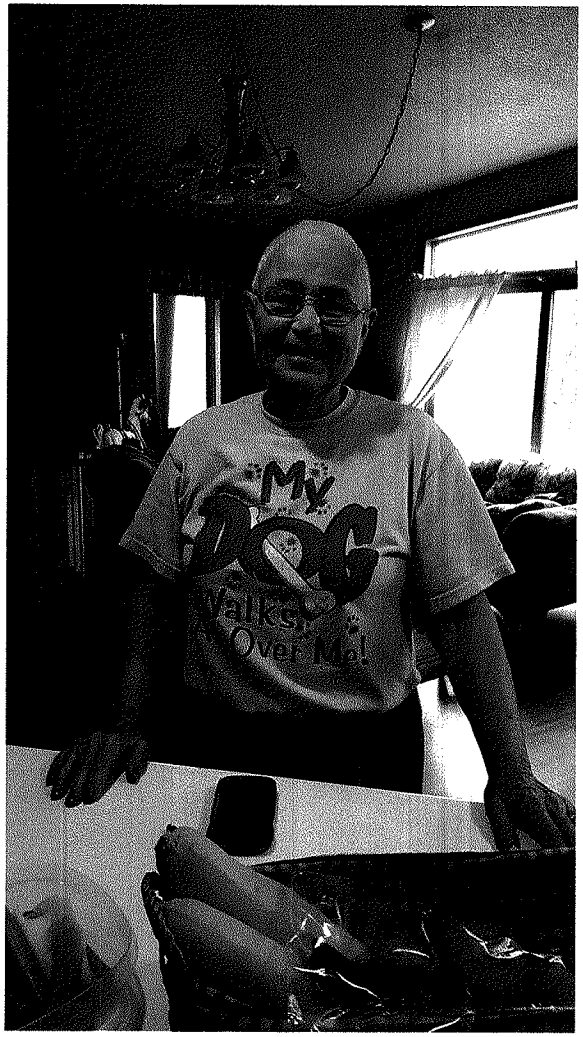
Document Coverage Dates
Jan. 26, 2016

Encounter Date
Jan. 26, 2016

This is a picture of my mom Sandra Cromwell in joying the outdoors on the farm with my husband. We find many fun activities to do outdoors after the long winters. Not much time is spent indoors This picture was taken the summer before. Date is wrong. My mom lives with us in an apt. that we made for her in the lower level of our home.

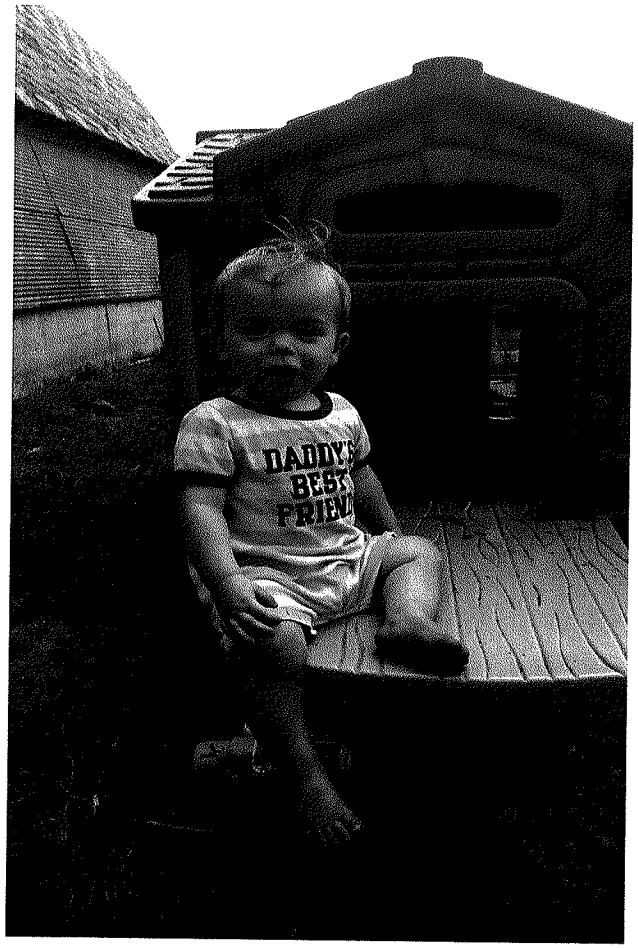
This Is my mom being loaded two days after finding out that she has small cell lung cancer. We made three more emergency trips because her oxygen was down so low before she stated her chemo treatments.





This first picture is of my mom on her first day of chemo treatments. She had treatment for three days a week, every other week for a total of nine treatments. She then had radiation every day for another six weeks after her chemo treatments. The second picture of her is seven days after her first chemo treatment. Her treatments were just to give her comfort to the end. We go back in April for scans to see if the cancer has spread. We do not know how long that we have together, but we want her to enjoy her time to the end.

This first picture is of Gavin (the littlest) with his first cousin Spencer at Grandma and Grandpas house enjoying the outdoors on their toys. The second picture is Gavin and Spencer with REAL motor toys at Grandma and Grandpas. This is last summer (2015). The date is wrong on camera, again. The children spend many days outside when they come to our home. Gavin lives in Fargo in an apt. with his mommy and doesn't get to go out much because there is no were to go, so his mommy brings out. I also watch him when mommy works weekend. Gavin can spend up to three days a week out here. Spencer is a first grader that loves being outside. I watch him after school till a parent gets home. I care for Spencer in the summer when school is out. He also lives on our property in a separate home.



This is a picture of Gavin playing in a little plastic house that we have on the farm. The second picture is of Gavin playing peek- a- boo while getting his nebulizer treatment. He isn't diagnosed with anything yet because he's to young, but is still doctoring to help keep his oxygen levels normal. The first picture was last summer and the second picture was Feb. 14th, 2016.

The date is right on the first picture for both of the pictures. The first picture is of spencer showing how many peas we picked out of the garden that he and I were growing. The second is a picture of Spencer playing in the sand box Grandpa made for him. The air is fresh, and the sand is cool and clean.

UNIVERSITY OF KENTUCKY
COLLEGE OF AGRICULTURE ● DEPARTMENT OF ENTOMOLOGY

ENTFACT-506

HOW FAR CAN HOUSE FLIES FLY?

Lee Townsend, Extension Entomologist

House flies are annoying nuisances. Even a few can make people miserable by their determined attempts to land on virtually any surface. More importantly, house flies pose a serious public health threat. They can carry a wide range of germs from filthy breeding sites to the dinner table or spread some diseases within herds or flocks. Serious conflicts can arise when significant numbers of house flies begin to disperse to nearby areas. Law suits or potential public health problems can result.

"How far can house flies fly?" becomes an important question. There is no absolute answer but house flies can easily move one to two miles. Longer distances are possible but require unique circumstances and generally will involve a small number of the insects.

Random Movement But ...

For the most part, movement of an individual house fly seems to be random. It will move relatively aimlessly from one spot to another with no indication that it is trying to reach a specific destination. However, research on house fly dispersal has identified some factors that affect movement. A general understanding of them can help to make some changes that will reduce fly movement or help to improve fly control programs.

Fly numbers. If large numbers of flies develop at a site, competition among them for larval breeding sites will force a portion of them to move. The need for effective fly management at major or potential breeding sites is obvious. This can be accomplished in large part by sanitation and water management to keep breeding sites dry. The more flies produced in an area, the more likely they are to move. It is unreasonable, however, to expect that house flies can be eliminated from an area.

Attractive sites. Moisture and food, including manure, wet feed, garbage or most any decaying organic matter provides a place for flies to feed and lay eggs. Flies moving randomly around a breeding site will tend to linger where their basic needs are met. Few will stay in dry, clean areas. A continued sanitation effort is needed in neighboring areas to keep flies from having a reason to "hang around."

Tendency to disperse. House flies seem to have an innate tendency to wander. Some will leave a breeding site even though resources that they need are plentiful. Therefore, some dispersal will occur even when fly numbers are low. The more flies produced at a site, the more that will move away and become a problem.

Environmental conditions. Optimum temperature and moisture will allow high fly production from even a minimal amount of breeding material. Winds will help with fly dispersal by allowing more flies to move longer distances than normal.

How far will they go? Studies using marked house flies, showed that 60% to 80% were captured within a mile of their release point. Most of the rest, 85% to 95% of the total, were caught within about 2 miles of the release site within the first 4 days after they were turned loose. A few flies have been shown to travel 5 to 20 miles but these tend to be "record" individuals. In general, fly control efforts for a community problem are focused within one mile of the source.

Nuisance fly control at neighboring sites

Applications of residual insecticides to fly resting places, the use of fly baits, or the use of aerosol space sprays or fogs can temporarily knockdown fly numbers. Typically, these tactics provide limited results and will not maintain flies at acceptable levels. An aggressive effort must be made to eliminate breeding sites and food or water sources that would allow fly populations to develop there, too.

Other nuisance flies

Identification of the problem flies is important. During the spring and fall, cluster flies can accumulate in windows or on the sides of buildings. Cluster flies are a group that includes several different species that move to overwintering sites in the fall and disperse again in the spring. See ENTFACT 624 for more information.

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Controlling risks of pathogen transmission by flies on organic pig farms

A review

B.G. Meerburg, H.M. Vermeer and A. Kijlstra

Abstract: *Fly prevention and control on animal production units is necessary to prevent the transmission of pathogens that could affect animal and human health and the maintenance of good hygiene. Organic farmers are often hesitant to apply insecticides for this purpose because of their farming philosophy. Organic production systems are relatively open as pigs generally have access to the outdoors. Here, we investigate the need for fly control and analyse various possibilities that organic farmers have to reduce the number of flies on their farms. We conclude that although biological control looks promising, more research should be done concerning its side effects. Currently, optimal monitoring and prevention seem to offer the best solution.*

Keywords: *organic farming; pigs; flies; pest control; animal health; Musca domestica*

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Flies can be a serious pest in animal production. They irritate livestock and workers, cause financial loss by decreasing the production of farm animals (Campell *et al*, 1977; Catangui *et al*, 1997), give a bad impression to visitors, and can even transmit contagious diseases to livestock and humans (eg Graczyk *et al*, 2001). Because of the availability of vast quantities of manure, pig units provide a perfect environment for the breeding, feeding and settling of various types of flies: for example, stable flies (*Stomoxis calcitrans*), the common housefly (*Musca domestica*) and the lesser housefly (*Fannia canicularis*). Of these species, the housefly is most frequently encountered around pig houses, and can be considered illustrative. Adult female houseflies live for between 15 and 25 days. They produce about five batches of 75–150 eggs. The increase in the fly population in spring results from a combination of increasing temperatures and rain. As a result, the fly eggs develop faster and remain for only a few days instead of months. Their rapid development, combined with the high number of eggs deposited, can result in a dramatic increase in numbers. Although fly numbers fluctuate throughout summer, there can be 10–12 generations in temperate climates. Numbers decline again in October, but the decline is less drastic than the increase during springtime.

From a biosecurity perspective, the presence of flies on farms should be prevented as much as possible, as they can transfer a large number of pathogens. However, this is rather difficult on organic pig farms within the European Union (EU) since organic farmers raise their pigs according to the regulation set up by the EU (EU regulation 2092/91), which requires the provision of organic pig feed (ingredients grown without artificial fertilizer or pesticides) and straw bedding. Also, unlike in conventional indoor housing, pigs in organic production systems are allowed outdoors and therefore the pig facilities are more open. Moreover, the provision of straw beddings for pigs can result in hygiene problems and at the least, thorough cleaning is required between batches. The consequent presence of liquid manure and especially

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straw manure is known to attract flies. Use of conventional insecticides is often not in line with organic farming principles. As a consequence, it is difficult for organic farmers to acquire the same biosecurity level as in conventional pig production systems. In this review, we specifically analyse the transmission risks of pathogens by flies to pigs and offer some suggestions to deter these pests.

Pathogen transmission

Flies have been shown to act as vectors for a number of pathogens. They are known to travel up to 20 miles (Murvosh and Taggard, 1966), although more commonly for no more than two miles. Transmission of pathogens by adult flies occurs by: (1) mechanical dislodgement from their exoskeleton (eg by hair and bristles on their legs or by cushion-like structures [pulvilli] that are used for adherence to vertical surfaces), (2) faecal deposition, and (3) the regurgitation of incompletely digested food.

They can carry protozoan parasites such as *Cryptosporidium parvum* (Graczyk *et al*, 1999), *Toxoplasma gondii* (Wallace, 1971; Graczyk *et al*, 2001) and *Sarcocystis* spp. (Markus, 1980) on their exoskeletons and pulvilli. Moreover, these animals have also been reported to transmit several types of viral pathogens to livestock, including hog cholera (Dorset *et al*, 1919), transmissible gastroenteritis virus – TGEV (Saif and Wesley, 1999) and porcine reproductive and respiratory syndrome virus – PRRSV (Otake *et al*, 2003a and b). Flies are also involved in the transmission of bacterial pathogens such as, for example, *Yersinia enterocolitica* (Fukushima *et al*, 1979), Salmonella spp. (Barber *et al*, 2002; Mian *et al*, 2002; Olsen and Hammack, 2000; Winfield and Groisman, 2003), Campylobacter spp. (Ekdahl *et al*, 2005; Szalanski *et al*, 2004), *E. coli* O157:H7 (Sasaki *et al*, 2000; Szalanski *et al*, 2004), Shigella spp. (Bidawid *et al*, 1978) and *Streptococcus suis* (Enright *et al*, 1987; Staats *et al*, 1997). *Streptococcus suis* is a pathogen that also poses a serious hazard to farmers, butchers and abattoir workers. It causes an infection characterized by septicaemia, meningitis, possibly arthritis, pharyngitis and diarrhoea (Snashall, 1996). Recently, there was a severe outbreak of *Streptococcus suis* in China: 206 cases were reported and 38 were fatal (Anonymous, 2005).

Another pathogen, *T. gondii*, can also have serious consequences in humans, such as encephalitis, mental retardation and blindness. In a previous study, Kijlstra *et al* (2004) conducted a risk analysis of infection with this protozoan parasite on organic pig production facilities. Even though it was shown that the chance of introduction of *T. gondii* by flies was estimated to be low, the authors consider fly control to be necessary to prevent transmission of *T. gondii* (Kijlstra *et al*, 2004).

Flies play a more important role with regard to Campylobacter spp. (one of the most important zoonotic bacteria). A study by Rosef and Kapperud (1983) has already postulated the hypothesis that flies might form a link between animals and human food in the transmission of Campylobacter. Moreover, flies have been shown to play a vital role in the epidemiology of avian campylobacteriosis (Hald *et al*, 2004; Shane *et al*, 1985; Szalanski *et al*, 2004). Nichols (2005) looked for possible seasonal drivers behind Campylobacter infections in humans. In this study, only vector transmission by flies appeared to provide a convincing explanation for the observed seasonal trends in human Campylobacter infections (Nichols, 2005).

Table 1. Means of transmission of various pathogens by flies present on-farm.

Means of transmission	Pathogen
Mechanical (exoskeleton)	*T. gondii*, *C. parvum*, *C. jejuni*, Shigella spp. PRRS virus, TGEV
Faecal	PRRS virus, *E. coli* O157
Digestion	*Y. enterocolitica*, *E. coli* O157

The porcine reproductive and respiratory syndrome (PRRS) virus, a member of the Arterivirus group, is an economically significant pathogen leading to a drop in pig reproduction and increased perinatal mortality of piglets. Moreover, the virus causes increased susceptibility to secondary infections of the respiratory and reproductive systems. The studies of Otake *et al* (2003a and b) demonstrate that the PRRS virus can survive for up to six hours in houseflies on their exoskeleton, but 12 hours in their intestinal viscera, after they have fed on an infected pig. In a previous study, Golding *et al* (2001) had observed that the flight velocity of *Musca* sp. was 0.3 m s^{-1} (about 1 km/h). Thus, if we assumed that flies flew in a straight line during those 12 hours, they could theoretically contribute to horizontal transmission of PRRSV among pigs at a distance of 12 kilometres from an infected commercial pig farm. The means of transmission of various pathogens by flies are summarized in Table 1.

Flies can also be responsible for human–human transmission of diseases. *Musca sorbens* Wiedemann (Diptera: Muscidae) breeds on human faeces and can transmit *Chlamydia trachomatis* to cause human trachoma (Emerson *et al*, 2001). Moreover, *Musca domestica* can acquire *Helicobacter pylori* from human excrement and transmit it to human food by regurgitation or depositing faeces. Contaminated food, if swallowed by a susceptible individual, will be a source of *H. pylori* in the gastric mucosa, thus re-establishing human infection.

Control of houseflies on organic farms

Guaranteeing animal health and food safety industry-wide and at farm level thus requires the control of pathogens such as those transmitted by flies. In conventional pig production systems, efforts to control insect pests often focus on the use of insecticides. In organic pig farming, however, the use of chemical control of insect pests is generally not condoned – although it is allowed by the regulations – as it does not fit with organic farming philosophy and it is difficult to achieve in practice because premises usually have access to the outdoors.

Limited use of insecticides, however, may ultimately be advantageous, as it will prevent the development of resistance to insecticide among insect pests (Liu and Yue, 2000) and thus increase their long-term effectiveness. Insecticide resistance is a global problem: control failures

with cyfluthrin, one of the relatively new chemicals used (Scott *et al*, 2000), have, for example, been reported from New York, and it is debatable whether we will be able to create an unending supply of new insecticides to replace current compounds (Scott *et al*, 2000).

The most important aspect of pest control is year-round farm hygiene, which will prevent fly infestations from happening. Rubbish should be removed regularly and stored in closed containers. Manure should be removed daily from pig pens and areas around feeding stations, and feed storage should be cleaned frequently. Manure piles should be covered: the rise in temperature will render them as breeding sites. Farmers should aim to keep solid manure as dry as possible to prevent hatching.

The use of electrocuting insect traps (EITs), popular devices that contain a visual attractant and a high-voltage metal grid, is not suitable for farm environments and ought not to be considered as an alternative to insecticides. A study by Urban and Broce (2000) has shown that when insects are disintegrated by high voltages, they can release a number of bacteria (including *E. coli*) and viruses. The spread of pathogens carried on the surface of the fly exoskeleton was the largest risk, but internally contaminated flies can also release some micro-organisms (Urban and Broce, 2000). Non-electrocuting glueboard flytraps would seem to provide a better option.

Another solution in managing pests is the exploitation of natural enemies of flies, ie biological control. This may be done by protecting or improving the habitat of these natural enemies. Several options exist. A previous study in the UK (Renn, 1998) demonstrated that entomopathogenic nematodes could be used successfully to control housefly infestations in intensive pig units. During a field trial, he compared the application of two species of nematodes, *Steinernema feltiae* and *Heterorhabditis megidis*, with the application of a water-soluble carbamate insecticide, methomyl, and concluded that there were significantly fewer houseflies in pig houses baited with the nematodes. These nematodes occur naturally in soil and possess a durable, motile infective stage that can actively seek out and infect a broad range of insects, but they do not infect birds or mammals. Within their bodies, they carry insect-pathogenic gram-negative bacteria – *Xenorhabdus* in the case of *Steinernematids*, and *Photorhabdus* in the case of *Heterorhabditids* (Forst *et al*, 1997). When a host (eg a maggot of the housefly) has been located, the nematodes penetrate the insect body cavity, usually via natural body openings (mouth, anus, spiracles) or areas of thin cuticle. When bacteria are released from the nematode gut, they multiply rapidly and kill the insect (Sicard *et al*, 2004). The nematodes feed upon the bacteria and liquefying host, and mature into adults (Forst *et al*, 1997). This is an obligate symbiotic relationship, as the bacterium needs the nematode to carry it into the body cavity of the insect, while the nematode needs the bacterium to create conditions in the insect suitable for its growth and reproduction, and as a food source (Sicard *et al*, 2004). The bacteria are safe to vertebrates and have never been detected living freely in the soil: they only occur together with these nematodes and infected insects. Their environmental persistence is limited (Morgan *et al*, 1997).

Another use of a natural enemy that might be used for biological control of houseflies on farms may be the release of parasitoid wasps such as *Spalangia cameroni* (Hymenoptera, Pteromalidae) and *Muscidifurax raptor* (Rondani) (Geden, 2001; King, 1997; Meyer *et al*, 1990; Skovgård and Jespersen, 1999; Skovgård and Nachman, 2004). These parasitoids attack pupae of houseflies and stable flies by laying single or multiple eggs. When the parasite eggs hatch, the maggot feeds on the host pupa, thereby killing it. The wasp then completes its development, emerges as an adult and continues the process by looking for more hosts. These small wasps only attack flies; they neither sting nor bite other insects, animals or humans. In Skovgård and Nachman's (2004) study, it was shown that weekly releases of adult *S. cameroni* on a dairy cattle farm and two pig facilities restricted the population of houseflies and stable flies to acceptable levels. However, there have also been studies in which attempts to control houseflies by releasing pupal parasitoids failed (Maini and Bellini, 1990; Mourier, 1972; Stage and Petersen, 1981; Skovgård, 2002).

A third option is the use of a microbial insecticide such as *Bacillus thuringiensis*. This bacterium grows in manure, and functions as a larvicide. It prolongs the larval stage, and affects the lifespan and fertility of adults emerging from treated larvae. High doses cause mortality among young larvae. According to a previous study, it is safe, effective and easy to produce (Carlberg, 1986). Furthermore, fly resistance to *B. thuringiensis* has been shown to develop very slowly, and it is, therefore, suitable for fly control.

Discussion and conclusion

There is no need to question the necessity for fly control as flies can cause financial losses and nuisance and can spread a number of hazardous pathogens. Although the risk of pathogen transmission by a single specimen is probably limited, this is compensated by the large populations commonly found due to the rapid reproduction of flies.

Whilst some chemical control methods are allowed by organic regulation, most organic farmers will be reluctant to use them, for reasons already discussed. Biological control looks promising as it has two advantages over chemical control: (1) it fits in with the organic farming philosophy, and (2) at the same time, it forms an option for reducing the resistance of flies to insecticides. However, there are also several constraints. The first constraint is that from a food safety perspective it is not known whether the application of biological methods such as parasitoid wasps, nematodes or microbes fit in with a Hazard Analysis on Critical Control Points (HACCP) approach. Although many studies have been performed into the mechanisms behind biological control and potential effects are often said to be minimal, it is still largely unknown whether these methods pose threats to farm animal health or food safety. Moreover, from experiences in greenhouses (Van Lenteren and Woets, 1988), we know that biological control can potentially disturb the ecological balance. The natural enemy should therefore not attack non-pest organisms of importance where it is introduced or have other non-target effects (Louda *et al*, 2003). As these knowledge gaps exist, more

research into these aspects is required before all the effects of biological control can be assessed.

The second constraint is efficacy: effective natural enemies should have a pest kill rate equal to or greater than the potential maximum rate of population increase of houseflies. Ideally, they should be able to search out and destroy the flies before these have crossed economic threshold densities.

Another constraint of biological control is economic viability. Unlike in a relatively closed system such as a greenhouse, application of biological control in organic pig farming will have a lower efficiency, as adult wasps can easily migrate elsewhere or microbes will be removed when the pens are cleaned. Continuous application of new parasitoids or sprinkling of bacterial preparations will thus be essential and will have financial consequences. Application of conventional insecticides will probably be less expensive. Physical control methods such as use of non-electrocuting glueboard flytraps can be useful, but operating/labour costs are high as the glueboards need to be replaced regularly. Moreover, the attracting lamps need to be replaced approximately once a year, which is expensive.

Because of the constraints of chemical, biological and physical methods for fly control, prevention by reduction or elimination of fly breeding sites always seems to provide the best solution and requires a good farm hygiene policy. Furthermore, fly populations should be monitored by a standardized, quantitative method in order to make appropriate fly control management decisions. The spot card technique (Stafford, 1988) in which white file cards are placed near the livestock houses and/or near manure heaps is the easiest monitoring technique (Hogsette *et al*, 1993; Jacobs *et al*, 1992). These spot cards (3 × 5 inches) can be fastened to support posts, ceilings or other areas where flies tend to land. After placement, cards should be left for a period of seven days and then replaced with new cards. The number of 'fly specks' on the exposed side of each card should be counted and recorded. Generally, 100 or more spots per card indicates the need for fly control measures (Stafford, 1988). The use of spot cards is a simple, cost-effective and widely adopted method for assessing fly populations. With the outcome of this monitoring, a farmer can objectively visualize whether his or her prevention strategy is sufficient or whether fly control should be applied.

Good monitoring combined with prevention seems to offer the most viable solution for organic farmers to keep the transmission risks of pathogens by flies to their pigs at a minimum. If their prevention efforts are insufficient, use of non-electrocuting glueboard traps seem to be a good option. Although promising, more studies into the mechanisms behind biological control, its efficiency and side effects are necessary before farmers can truly make an informed choice between chemical control and biological control.

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Adverse Health Effects Of Hog Production

A Literature Review

Ammonia emissions from hog farms pose a serious public health threat.

- Ammonia emissions from hog farms react with other gases in the air to form fine particle pollution, a public health threat linked to decreased lung function, cardiovascular ailments and most seriously, premature death.[1]
- Recent analysis by NC State University (NCSU) researchers shows that fine particulate pollution is higher in Raleigh (and likely for all of the Triangle area) when air masses cross the high density hog counties on the way to Raleigh.[2] This analysis also found fine particulate levels in a rural town (Kenansville) in a high density hog county were very high relative to what would be expected.
- The 2003 National Academy of Sciences[3] report identified atmospheric ammonia nitrogen emissions as the most significant public health threat from Animal Feeding Operations[4] on a regional scale.
- Reducing ammonia emissions from Animal Feeding Operations makes sense not only for the obvious public health benefits, but also for economic reasons. The Benefit Cost Analysis conducted by Research Triangle Institute for the NCSU hog waste management evaluations found that a 50% reduction in ammonia emissions from hog farms in eastern NC will provide an estimated $190 million a year in benefits from avoided health impacts.[5]

Air emissions from lagoons, sprayfields and hog houses have been linked to neurological and respiratory problems.

- Subjects in a controlled exposure chamber who were exposed to air from hog operations for one hour reported headaches, eye irritation and nausea.[6]
- Unpleasant odors have been found to be a nuisance and emotional stressor on neighbors,[7] and are known to contain irritants that can cause damage to mucosal linings in the nose, throat and respiratory tract.[8]
- The 2003 National Academy of Sciences report identified odor as the most significant concern for local communities among the suite of air emission problems from Animal Feeding Operations.
- Researchers from the UNC School of Public Health and Duke University found that neighbors exposed to odors from hog operations showed evidence of reduced immune system function.[9]
- Evidence is also emerging that indicates that the health of citizens living near hog operations is negatively affected.[10] Research in Iowa and North Carolina showed that neighbors living within three miles of hog operations experience elevated levels of respiratory complaints relative to those living near other animal production operations or crop production.[11,12]
- Abhorrent odors can be exacerbated by the smell and sight of rotting flesh from hog carcasses that are often stored in "dead boxes" close to neighbors' property lines. "Dead trucks" that transport hog carcasses to rendering facilities also emit odor

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Hydrogen Sulfide Emissions

- Hydrogen sulfide (H_2S) is a colorless gas with a strong odor of rotten eggs that is detectable at concentrations as low as 0.5 ppb (0.0007 mg/m^3). Acute exposures to H_2S at 2 – 10 ppm have been associated with respiratory and cardiovascular effects, and people with asthma appear to be more sensitive to H_2S reporting headaches following 30 minute exposures to 2 ppm.[13] The EPA also reports that acute occupational exposures have been associated with a variety of central nervous system (CNS) transitory symptoms, such as dizziness, nausea, headache, and at higher exposure concentrations, serious conditions such as "abrupt physical collapse" and pulmonary edema.[14]
- The 2003 National Academy of Sciences report, noting hydrogen sulfide's risks to public health, recommended that the EPA and USDA should develop process-based mathematical models for atmospheric emissions of hydrogen sulfide, along with ammonia and methane, to identify management changes that decrease emissions.
- Of particular concern is the susceptibility of children to neurological effects associated with H_2S exposure.[15]
- The EPA Office of Air Quality Planning and Standards is in the process of re-evaluating H_2S toxicity to determine if it requires specific regulation.[16] The neurotoxicity has been cited as one of the principle reasons for increased scrutiny.
- In light of these efforts by the EPA Office of Air Quality Planning and Standards, it would seem reasonable and practical to continue to collect emissions data, and use this information in the evaluation of potential health impacts that can be used to inform the decision-making process by the Office of Air Quality Planning and Standards. It is premature to cease collecting this information at a time when an analysis of the exposure conditions is warranted.

Hog waste contains disease-causing pathogens & increases antibiotic resistance.

- Hogs and humans share many of the same disease organisms. Large quantities of antibiotics, many closely related to those used to treat humans, are used by pork and other livestock and poultry producers.[17]
- Environment Defense reported in 2005[18] that North Carolina's animal production industry, which is largely comprised of hog and poultry production, is estimated to use three million pounds of antibiotics annually. This is approximately the same amount of antibiotics that is estimated to be used *nationally* to treat humans.
- The vast majority of antibiotics are administered not to treat disease but rather to promote growth or to compensate for the crowded, stressful and often unhygienic conditions in industrial-scale livestock operations. An expanding body of evidence[19,20] links this frequent exposure of antibiotics to the development of antibiotic-resistant pathogens, contributing to the problem of reduced antibiotic effectiveness in humans, a growing health concern in the United States.
- There are also concerns about the exposure of workers or neighbors to antibiotics in the dust generated in the hog confinement facilities, which are vented to the outdoors.[21,22]

Evidence indicates adverse impacts on workers' and children's health.

- An enormous amount of research exists to document the serious negative impacts to swine confinement house workers.[23] Effects include respiratory symptoms, reductions in pulmonary function and increased bronchial responsiveness.
- Researchers in Iowa found a high prevalence of asthma in children living on hog farms, especially farms that added antibiotics to feed.[24,25]
- A North Carolina study of 58,169 children found a 23% higher prevalence of asthma symptoms among students attending schools where staff noticed livestock odors indoors twice a month or more.[26]

Manure land application rates at hog Animal Feeding Operations result in high levels of pollutants in groundwater and pose risks for drinking water wells.

- Ground water nitrate levels beneath animal waste sprayfields are typically found to range from 10 to 50 parts per million (ppm).[27] The drinking water standard for nitrate is 10 ppm. Even wells drilled to clean aquifers below surface contaminated groundwater aquifers are at risk because well casing construction flaws can allow leaks of highly contaminated groundwater into drinking water wells.
- Results from a free well-testing program for people living adjacent to hog farms in North Carolina in 1996 found more that 10% of the wells tested failed to meet drinking water standards for nitrate. Three wells had nitrate concentrations in the 70 – 100 ppm range. The NC Department of Health and Human Services found that the results of the well testing program "*...illustrate a potentially serious groundwater problem to the people utilizing wells near Industrial Livestock Operations in five counties in eastern North Carolina.*"[28]

Community health experts are recommending safeguards to protect the health of rural residents.

- Based on the 2003 American Public Health Association's review of evidence of the health and economic impacts of concentrated animal feeding operations (CAFOs)[29] [30] and "evidence, albeit less certain, indicating impacts on children and CAFO neighbors from exposure to large concentrations of manure and their subsequent emissions of dust, toxins, microbes, antibiotics and pollutants in the air and water," the Association resolved that it would:

> *[U]rge federal, state, and local governments, and public health agencies to impose a moratorium on new Concentrated Animal Feed Operations until additional scientific data on the attendant risks to public health have been collected and uncertainties resolved.*

Community health experts are recommending safeguards to protect the health of rural residents. (continued)

- The American Public Health Association's recommendations were recently endorsed by a collection of American and European environmental scientists brought together in a symposium and workshop organized by the University of Iowa's Environmental Health Science Research Center and sponsored by the National Institutes of Environmental Health Sciences. The endorsement emerged from an expert community health workgroup assembled at the workshop in 2004, the results of which were recently published.[31] The workgroup found that "*...sufficient research exists to support action to protect rural residents from the negative community health effects of CAFOs....*" Furthermore, the expert workgroup recommended that permitting of CAFOs should include: consideration of total animal density in a watershed; environmental impact statements; public meetings and local decision making; regulation with standards applied to general industry with similar levels of emissions and type of waste handling; and bonding for manure-storage basins for performance and remediation.

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Mysterious Poop Foam Causes Explosions on Hog Farms

—By Tom Philpott

| Wed May 15, 2013 5:00 AM EDT

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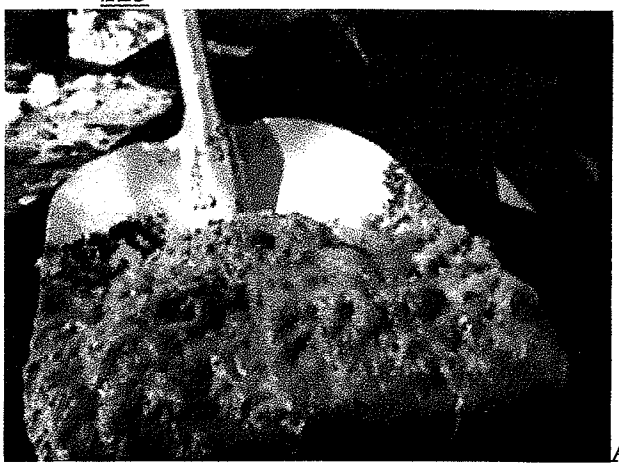

A sample of the manure foam that caused an explosion that lifted a hog barn two feet off the ground and blew a man 20 feet away from where he had been standing (see video below). Screenshot from the video embedded below.

When you hear about foam in the context of food, you might think of the culinary innovations of the Spanish chef Ferran Adrià, who's famous for dishes like apple caviar with banana foam.

But this post is about a much less appetizing kind of foam. You see, starting in about 2009, in the pits that capture manure under factory-scale hog farms, a gray, bubbly substance began appearing at the surface of the fecal soup. The problem is menacing: As manure breaks down, it emits toxic gases like hydrogen sulfide and flammable ones like methane, and trapping these noxious fumes under a layer of foam can lead to sudden, disastrous releases and even explosions. According to a 2012 report from the University of Minnesota, by September 2011, the foam had "caused about a half-dozen explosions in the upper Midwest…one explosion destroyed a barn on a farm in northern Iowa, killing 1,500 pigs and severely burning the worker involved."

And the foam grows to a thickness of up to four feet—check out these images, from a University of Minnesota document published by the Iowa Pork Producers, showing a vile-looking substance seeping up from between the slats that form the floor of a hog barn. Those slats are designed to allow hog waste to drop down into the below-ground pits; it is alarming to see it bubbling back up in the form of a substance the consistency of beaten egg whites.

And here's the catch: Scientists can't explain the phenomenon.

Check out this amazing 2011 video presentation on the matter by University of Minnesota researcher David Schmidt. He opens by describing a 2009 explosion that lifted a hog barn a "couple of feet off the ground" and blew the farm operator himself 20 feet from the building. (Thankfully, he wasn't injured, and there were no animals in it.) And check out the footage, starting about 3:19 in, of the foam itself, which must be seen to be believed. At one point , a shovel dips into the mire and scoops up as sample—which jiggles and pulsates, alive, apparently, with microbial activity. Schmidt also does a great job of explaining just how manure foam can cause explosions.

David Schmidt: Foaming Manure Pits ***from*** *Iowa State University Extension* ***on*** *Vimeo*

I wrote about the phenomenon about a year ago. But these days, there's not much in the agriculture trade press about it. Which led me to wonder: Has the mysterious foam subsided—or congealed into yet another fact of factory farming that

isn't even notable anymore, like, you know, raising hundreds of pigs over pits that concentrate their waste, or dosing them them daily with low levels of antibiotics, leading to rampant antibiotic-resistant bacteria?

I decided to do a bit of digging for an update. Via email, Angela Kent, an associate professor in the department of natural resources and environmental sciences at the University of Illinois, informed me that "manure foaming" is "still a very serious problem among pork producers in the Midwest." Scientists have still not been able to finger the cause of it, but "we are in the midst of a large multi-institution investigation focused on finding the cause of this very serious problem."

So: still happening, and still no explanation.

Surveys show that around 25 percent of operations in the hog-intensive regions of Minnesota, Illinois, and Iowa are experiencing foam—and "the number may be higher, because some operators might not know that they have it."

I then got Larry Jacobson, a professor and extension engineer at the University of Minnesota who has been working on the issue, on the phone. He confirmed that the problem persists—just about a month ago, he said, workers were welding metal fixtures in an empty hog facility and a fire broke out, likely because a spark managed to penetrate foam enough to free trapped methane and ignite it. (No one was injured.)

Jacobson said that surveys show that around 25 percent of operations in the hog-intensive regions of Minnesota, Illinois, and Iowa are experiencing foam—and "the number may be higher, because some operators might not know that they have it."

He added that the practice of feeding hogs distillers grains, the mush leftover from the corn ethanol process, might be one of the triggers. Distillers grains entered hog rations in a major way around the same time that the foam started emerging, and manure from hogs fed distillers grains contains heightened levels of undigested fiber and volatile fatty acids—both of which are emerging as preconditions of foam formation, he said. But he added that distillers grains aren't likely the sole cause, because on some operations, the foam will emerge in some buildings but not others, even when all the hogs are getting the same feed mix.

But if the causes of manure foam remain a mystery, a solution seems to be emerging, Jacobson told me: Dump a bit of monensin, an antibiotic widely used to make cows grow faster, directly into the foam-ridden pit. At rather low levels—Jacobson told me that about 25 pounds of the stuff will treat a typical 500,000 gallon pit—the stuff effectively breaks up the foam, likely by altering the mix of microbes present. No other treatment has been shown to work consistently, he said.

Thankfully, monensin isn't used in human medicine. Still, it's striking to consider that the meat industry's ravenous appetite for antibiotics has now extended to having to treat hog shit with them.

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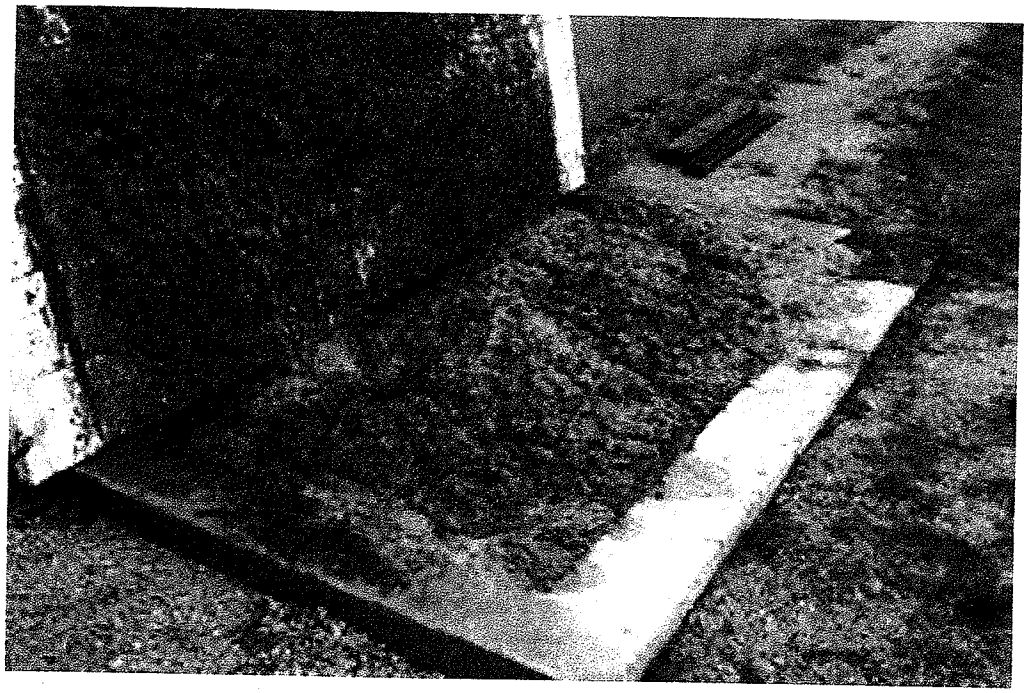
Manure Foaming



Foaming Manure - Source: Schimdt, UMN.

Foam in manure pits can be a danger both to animals and workers around the pits. **Manure foaming** occurs primarily in hog facilities, most commonly in the midwestern United States and Canada. The causes of manure foaming remain a mystery. Manure foaming is not predictable, and no known solutions work in every situation. It is therefore important to understand the risks posed by foaming manure and ways to reduce those risks.

Foam is defined as a mass of bubbles of gas on the surface of a liquid. Rather than being crusty or fluffy, foaming manure has a thick, mucous consistency. In manure pits, the bubbles do not burst but rather cling together.

One theory suggests that a specific microbial population causes foaming in manure pits. Another theory suggests that filamentous microorganisms (bacteria, fungi, or algae) are the cause. Neither theory has been confirmed, and research into the causes of manure foaming continues. Possible triggers include a high content of manure solids resulting from water conservation practices; cool weather patterns; reduced antibiotic use; feeding or diet adjustments; changes in DDGS; changes in corn,

including genetic modifications; moldy and/or lightweight corn; and changes in the type or quantity of fat fed to the animals.

Dangers of Foaming Manure

Foam in manure pits may be linked to suffocation of hogs and incidents of fire and explosion. Methane (CH_4) and hydrogen sulfide (H_2S) are gases produced during the anaerobic breakdown of manure. Methane is a highly flammable gas that can lead to asphyxiation at high levels. The foam in manure pits captures methane, resulting in concentrations of methane in the foam that can be as high as 60% to 70% (600,000 to 700,000 ppm), which is higher than the concentration at which explosions can occur. When the foam bubbles are disturbed or broken, the captured methane is released at an explosive concentration of 5% to 20% (50,000 to 200,000 ppm). If there is an ignition source near an explosive concentration of methane, an explosion or a flash fire could occur.

Hydrogen sulfide is a colorless gas that smells like rotten eggs at low levels but can overcome a person's sense of smell at levels of 100 ppm or higher. Hydrogen sulfide is heavier than air and can collect in the floor or lower areas of the pit. Exposure to hydrogen sulfide can cause eye and nose irritation, headache, nausea, and death.

In addition to the danger of explosion or fire, **foaming manure** poses an asphyxiation risk for both people and hogs when foam rises through the slats in a barn. Anyone working within the building or in the immediate area should be informed about the dangers of foaming manure, including the hazards of methane and hydrogen sulfide. No smoking should be permitted in or near the building.

Methods of Treatment

There are no proven ways to prevent manure foaming; at present, the focus remains on treating the symptoms. Below are some treatments that have yielded mixed results:

- Water – Spraying water, running sprinklers, or using soaker systems can break the bubbles in foam, releasing the methane in a relatively safe manner. If you are using water to break down foam, remember to follow recommended ventilation practices.
- Antifoam agents – There are several antifoam agents on the market. Although some have had limited success in reducing foam, none have proven effective on a consistent basis.
- Microbial enhancements – Microbial enhancements, typically in the form of feed or manure additives, have been effective on an inconsistent basis.
- Microbial control – Microbial control refers to changes in pH or oxygen levels or the use of antibiotics.

Due to the unpredictable nature of **manure foaming**, you should complete an audit of manure pits at least once a month. The purpose of the audit is to monitor pits for changes in manure consistency, increases in foam, and other such indicators of a potential problem. Based on information gathered in the audit, you can make necessary management decisions about using a treatment or changing the pumping

schedule.

Emergency Action Plans

Develop an emergency action plan and review it annually with employees. It is especially important that anyone on-site during pit pumping receive training about the action plan. The emergency action plan should include a list of clean-up and containment practices in the event of an overflow, breach, leak, fire, or emergency land application. Due to the potential risk of fire or explosion, include in the action plan an evacuation route for employees. In addition, make sure that all employees know the location of fire extinguishers, hose cabinets, fire blankets, and other types of safety equipment. As a farm or ranch manager, make sure that you have necessary safety equipment and that it is in proper working order.

During pit pumping, remember to keep on hand the contact information of first responders, including the fire department, hospital, and police. When calling 911, give your name, location, contact information, and details about the emergency.

Precautions during Agitation and Pumping

When **foaming manure** is present, the risk of explosion necessitates additional precautions during pit agitation and pumping. It is strongly recommended that you pump manure pits when the barn is empty. People should remain outside of the building during agitation and pumping. After checking that everyone is out of the facility, add a physical barrier such as yellow caution tape or place warning signs to ensure that no one enters the facility during the process.

Any ignition sources should be turned off and locked out. Possible ignition sources include welders, heaters, motors, and other equipment, such as a feeding system, that uses electricity. (Because of the importance of ventilation, discussed in the next section, ventilation systems that use electricity may operate during agitation and pumping.)

Do not agitate the manure until the top of the manure surface is at least two feet below the floor slats. Agitate the manure below the surface of the liquid manure and stop the process if you can no longer agitate below the surface level. Agitate intermittently to reduce the risk of sudden gas release.

When possible, cover pump-out ports unless they are needed for agitation or manure load-out, and cover the pump-out around the agitation with a tarp. After pumping is complete, remember to secure manure pit covers.

Ventilation during Agitation and Pumping

Proper ventilation is one of the most important safety measures during agitation and pumping of manure pits. Regularly check your ventilation system to ensure that it is in proper working condition. Use a ventilation rate of 20 to 30 cfm per animal to dilute the methane concentration below 5%. Ventilation inlets, curtains, and pivot doors should be open during the ventilation process. For naturally ventilated barns, make sure that inlets and outlets are open. Circulation fans used in the summer do not provide the

necessary air exchange needed during agitation or pumping, so plan these processes for days when wind is present to increase the amount of fresh air circulating through the building.

Ventilation for Curtain-Sided Barns

Ventilation procedures for curtain-sided barns differ slightly depending on weather conditions. When the weather is warm with winds over 5 mph, run exhaust fans while the curtains are open. On a calm day, the sidewall curtains should remain closed with the fans running. If, however, you are running more than half of the fans, the curtains should remain open during the pumping process. During colder weather, keep the curtains closed while running the exhaust fans.

If you are using a stir fan, use a horizontally directed fan rather than a fan directed downward, to reduce pockets of gas concentrations and to ensure that contaminated gas does not blow back onto hogs. Ventilate for approximately one to two hours after pumping and prior to entering the barn.

Ventilation for Tunnel-Ventilated Barns

During warm or hot weather, run all of the pit fans and a minimum of two tunnel fans. The procedure is slightly different for cold or moderate weather, but you should nevertheless run all of the pit fans and the 36 in. fan and open the tunnel curtain approximately 6 to 12 in. to provide air movement through the entire length of the barn. Remember to reduce the static pressure of the inlet velocity at the tunnel curtain from the regular setting of 800 fpm to 1,000 fpm to a lower setting of 300 fpm to 400 fpm. During both cold and hot weather, partially close mechanized/motorized ceiling inlets to allow air to enter from the tunnel curtain. Ventilate for approximately one to two hours after pumping and prior to entering the barn.

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Resources

Click here to watch an informative video by Dr. David Schmidt from Iowa State University Extension about foaming manure pits.

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ENVIRONMENTAL HEALTH

Understanding Concentrated Animal Feeding Operations and Their Impact on Communities

NATIONAL

Understanding Concentrated Animal Feeding Operations and Their Impact on Communities

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Foreword

The National Association of Local Boards of Health (NALBOH) is pleased to provide Understanding Concentrated Animal Feeding Operations and Their Impact on Communities to assist local boards of health who have concerns about concentrated animal feeding operations (CAFOs) or large industrial animal farms in their communities. The Environmental Health Services Branch of the Centers for Disease Control and Prevention (CDC), National Center for Environmental Health (NCEH) encouraged the development of this product and provided technical oversight and Ànancial support. This publication was supported by Cooperative Agreement Number 5U38HM000512. Its contents are solely the responsibility of the authors and do not necessarily represent the ofÀcial views of the CDC.

The mission of NALBOH is to strengthen boards of health, enabling them to promote and protect the health of their communities, through education, technical assistance, and advocacy. Boards of health are responsible for fulÀlling three public health core functions: assessment, policy development, and assurance. For a health agency, this includes overseeing and ensuring that there are sufÀcient resources, effective policies and procedures, partnerships with other organizations and agencies, and regular evaluation of an agency's services.

NALBOH is conÀdent that Understanding Concentrated Animal Feeding Operations and Their Impact on Communities will help local board of health members understand their role in developing ways to mitigate potential problems associated with CAFOs. We trust that the information provided in this guide will enable board of health members to develop and sustain monitoring programs, investigate developing policy related to CAFOs, and create partnerships with other local and state agencies and ofÀcials to improve the health and well-being of communities everywhere.

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Introduction

Livestock farming has undergone a signiÀcant transformation in the past few decades. Production has shifted from smaller, family-owned farms to large farms that often have corporate contracts. Most meat and dairy products now are produced on large farms with single species buildings or open-air pens (MacDonald & McBride, 2009). Modern farms have also become much more efÀcient. Since 1960, milk production has doubled, meat production has tripled, and egg production has quadrupled (Pew Commission on Industrial Animal Farm Production, 2009). Improvements to animal breeding, mechanical innovations, and the introduction of specially formulated feeds and animal pharmaceuticals have all increased the efÀciency and productivity of animal agriculture. It also takes much less time to raise a fully grown animal. For example, in 1920, a chicken took approximately 16 weeks to reach 2.2 lbs., whereas now they can reach 5 lbs. in 7 weeks (Pew, 2009).

New technologies have allowed farmers to reduce costs, which mean bigger proÀts on less land and capital. The current agricultural system rewards larger farms with lower costs, which results in greater proÀt and more incentive to increase farm size.

AFO vs. CAFO

A CAFO is a speciÀc type of large-scale industrial agricultural facility that raises animals, usually at high-density, for the consumption of meat, eggs, or milk. To be considered a CAFO, a farm must Àrst be categorized as an animal feeding operation (AFO). An AFO is a lot or facility where animals are kept conÀned and fed or maintained for 45 or more days per year, and crops, vegetation, or forage growth are not sustained over a normal growing period (Environmental Protection Agency [EPA], 2009). CAFOs are classiÀed by the type and number of animals they contain, and the way they discharge waste into the water supply. CAFOs are AFOs that contain at least a certain number of animals, or have a number of animals that fall within a range and have waste materials that come into contact with the water supply. This contact can either be through a pipe that carries manure or wastewater to surface water, or by animal contact with surface water that runs through their conÀned area. (See Appendix A)

History

AFOs were Àrst identiÀed as potential pollutants in the 1972 Clean Water Act. Section 502 identiÀed "feedlots" as "point sources" for pollution along with other industries, such as fertilizer manufacturing. Consequently, a permit program entitled the National Pollutant Discharge Elimination System (NPDES) was created which set efÁuent limitation guidelines and standards (ELGs) for CAFOs. CAFOs have since been regulated by NPDES or a state equivalent since the mid-1970s. The deÀnitions of what was considered an AFO or CAFO were created by the EPA for the NPDES process in 1976. These regulations remained in effect for more than 25 years, but increases and changes to farm size and production methods required an update to the permit system.

The regulations guiding CAFO permits and operations were revised in 2003. New inclusions in the 2003 regulations were that all CAFOs had to apply for a NPDES permit even if they only discharged in the event of a large storm. Large poultry operations were included in the regulations, regardless of their waste disposal system, and all CAFOs that held a NPDES permit were required to develop and implement a nutrient management plan. These plans had CAFOs identify ways to treat or process waste in a way that maintained nutrient levels at the appropriate amount.

The 2003 CAFO rule was subsequently challenged in court. A Second Circuit Court of Appeals decision required alteration to the CAFO permitting system. In Water Keeper et al. vs. the EPA, the court directed the EPA to remove the requirement for all CAFOs to apply for NPDES. Instead, the court required that nutrient management plans be submitted with the permit application, reviewed by ofÀcials and the public, and the terms of the plan be incorporated into the permit.

As a result of this court decision, the CAFO rule was again updated. The current Ànal CAFO rule, which was revised in 2008, requires that only CAFOs which discharge or propose to discharge waste apply for permits. The EPA has also provided clariÀcation in the discussion surrounding the rule on how CAFOs should assess whether they discharge or propose to discharge. There is also the opportunity to receive a no discharge certiÀcation for CAFOs that do not discharge or propose to discharge. This certiÀcation demonstrates that the CAFO is not required to acquire a permit. And while CAFOs were required to create nutrient management plans under the 2003 rule, these plans were now included with permit applications, and had a built-in time period for public review and comment.

BeneÀts of CAFOs

When properly managed, located, and monitored, CAFOs can provide a low-cost source of meat, milk, and eggs, due to efÀcient feeding and housing of animals, increased facility size, and animal specialization. When CAFOs are proposed in a local area, it is usually argued that they will enhance the local economy and increase employment. The effects of using local materials, feed, and livestock are argued to ripple throughout the economy, and increased tax expenditures will lead to increase funds for schools and infrastructure.

Environmental Health Effects

The most pressing public health issue associated with CAFOs stems from the amount of manure they produce. CAFO manure contains a variety of potential contaminants. It can contain plant nutrients such as nitrogen and phosphorus, pathogens such as E. coli, growth hormones, antibiotics, chemicals used as additives to the manure or to clean equipment, animal blood, silage leachate from corn feed, or copper sulfate used in footbaths for cows.

Depending on the type and number of animals in the farm, manure production can range between 2,800 tons and 1.6 million tons a year (Government Accountability OfÀce [GAO], 2008). Large farms can produce more waste than some U.S. cities—a feeding operation with 800,000 pigs could produce over 1.6 million tons of waste a year. That amount is one and a half times more than the annual sanitary waste produced by the city of Philadelphia, Pennsylvania (GAO, 2008). Annually, it is estimated that livestock animals in the U.S. produce each year somewhere between 3 and 20 times more manure than people in the U.S. produce, or as much as 1.2–1.37 billion tons of waste (EPA, 2005). Though sewage treatment plants are required for human waste, no such treatment facility exists for livestock waste.

While manure is valuable to the farming industry, in quantities this large it becomes problematic. Many farms no longer grow their own feed, so they cannot use all the manure they produce as fertilizer. CAFOs must Ànd a way to manage the amount of manure produced by their animals. Ground application of untreated manure is one of the most common disposal methods due to its low cost. It has limitations, however, such as the inability to apply manure while the ground is frozen. There are also limits as to how many nutrients from manure a land area can handle. Over application of livestock wastes can overload

Table 1 Typical pollutants found in air surrounding CAFOs.

CAFO Emissions	Source	Traits	Health Risks
Ammonia	Formed when microbes decompose undigested organic nitrogen compounds in manure	Colorless, sharp pungent odor	Respiratory irritant, chemical burns to the respiratory tract, skin, and eyes, severe cough, chronic lung disease
Hydrogen SulÀde	Anaerobic bacterial decomposition of protein and other sulfur containing organic matter	Odor of rotten eggs	InÁammation of the moist membranes of eye and respiratory tract, olfactory neuron loss, death
Methane	Microbial degradation of organic matter under anaerobic conditions	Colorless, odorless, highly Áammable	No health risks. Is a greenhouse gas and contributes to climate change.
Particulate Matter	Feed, bedding materials, dry manure, unpaved soil surfaces, animal dander, poultry feathers	Comprised of fecal matter, feed materials, pollen, bacteria, fungi, skin cells, silicates	Chronic bronchitis, chronic respiratory symptoms, declines in lung function, organic dust toxic syndrome

they experience odors from CAFOs inside the schools. Schools that were closer to CAFOs were often attended by students of lower socioeconomic status (Mirabelli, Wing, Marshall, & Wilcosky, 2006).

There is consistent evidence suggesting that factory farms increase asthma in neighboring communities, as indicated by children having higher rates of asthma (Sigurdarson & Kline, 2006; Mirabelli et al., 2006). CAFOs emit particulate matter and suspended dust, which is linked to asthma and bronchitis. Smaller particles can actually be absorbed by the body and can have systemic effects, including cardiac arrest. If people are exposed to particulate matter over a long time, it can lead to decreased lung function (Michigan Department of Environmental Quality [MDEQ] Toxics Steering Group [TSG], 2006). CAFOs also emit ammonia, which is rapidly absorbed by the upper airways in the body. This can cause severe coughing and mucous build-up, and if severe enough, scarring of the airways. Particulate matter may lead to more severe health consequences for those exposed by their occupation. Farm workers can develop acute and chronic bronchitis, chronic obstructive airways disease, and interstitial lung disease. Repeated exposure to CAFO emissions can increase the likelihood of respiratory diseases. Occupational asthma, acute and chronic bronchitis, and organic dust toxic syndrome can be as high as 30% in factory farm workers

they can cause severe diarrhea. Healthy people who are exposed to pathogens can generally recover quickly, but those who have weakened immune systems are at increased risk for severe illness or death. Those at higher risk include infants or young children, pregnant women, the elderly, and those who are immunosuppressed, HIV positive, or have had chemotherapy. This risk group now roughly compromises 20% of the U.S. population.

Table 2 Select pathogens found in animal manure.

Pathogen	Disease	Symptoms
Bacillus anthracis	Anthrax	Skin sores, headache, fever, chills, nausea, vomiting
Escherichia coli	Colibacilosis, Coliform mastitis-metris	Diarrhea, abdominal gas
Leptospira pomona	Leptospirosis	Abdominal pain, muscle pain, vomiting, fever
Listeria monocytogenes	Listerosis	Fever, fatigue, nausea, vomiting, diarrhea
Salmonella species	Salmonellosis	Abdominal pain, diarrhea, nausea, chills, fever, headache
Clostirdum tetani	Tetanus	Violent muscle spasms, lockjaw, difÀculty breathing
Histoplasma capsulatum	Histoplasmosis	Fever, chills, muscle ache, cough rash, joint pain and stiffness
Microsporum and Trichophyton	Ringworm	Itching, rash
Giardia lamblia	Giardiasis	Diarrhea, abdominal pain, abdominal gas, nausea, vomiting, fever
Cryptosporidium species	Cryptosporidosis	Diarrhea, dehydration, weakness, abdominal cramping

Sources of infection from pathogens include fecal-oral transmission, inhalation, drinking water, or incidental water consumption during recreational water activities. The potential for transfer of pathogens among animals is higher in conÀnement, as there are more animals in a smaller amount of space. Healthy or asymptomatic animals may carry microbial agents that can infect humans, who can then spread that infection throughout a community, before the infection is discovered among animals.

When water is contaminated by pathogens, it can lead to widespread outbreaks of illness. Salmonellosis, cryptosporidiosis, and giardiasis can cause nausea, vomiting, fever, diarrhea, muscle pain, and death, among other symptoms. E.coli is another serious pathogen, and can be life-threatening for the young, elderly, and immunocompromised. It can cause bloody diarrhea and kidney failure. Since many CAFO use sub-therapeutic antibiotics with their animals, there is also the possibility that disease-resistant bacteria can emerge in areas surrounding CAFOs. Bacteria that cannot be treated by antibiotics can have very serious effects on human health, potentially even causing death (Pew Charitable Trusts, n.d.).

There is also the possibility of novel (or new) viruses developing. These viruses generate through mutation or recombinant events that can result in more efficient human-to-human transmission. There has been some speculation that the novel H1N1 virus outbreak in 2009 originated in swine CAFOs in Mexico. However, that claim has never been substantiated. CAFOs are not required to test for novel viruses, since they are not on the list of mandatory reportable illness to the World Organization for Animal Health.

Antibiotics

Antibiotics are commonly administered in animal feed in the United States. Antibiotics are included at low levels in animal feed to reduce the chance for infection and to eliminate the need for animals to expend energy fighting off bacteria, with the assumption that saved energy will be translated into growth. The main purposes of using non-therapeutic doses of antimicrobials in animal feed is so that animals will grow faster, produce more meat, and avoid illnesses. Supporters of antibiotic use say that it allows animals to digest their food more efficiently, get the most benefit from it, and grow into strong and healthy animals.

The trend of using antibiotics in feed has increased with the greater numbers of animals held in confinement. The more animals that are kept in close quarters, the more likely it is that infection or bacteria can spread among the animals. Seventy percent of all antibiotics and related drugs used in the U.S. each year are given to beef cattle, hogs, and chickens as feed additives. Nearly half of the antibiotics used are nearly identical to ones given to humans (Kaufman, 2000).

There is strong evidence that the use of antibiotics in animal feed is contributing to an increase in antibiotic-resistant microbes and causing antibiotics to be less effective for humans (Kaufman, 2000). Resistant strains of pathogenic bacteria in animals, which can be transferred to humans thought the handling or eating of meat, have increased recently. This is a serious threat to human health because fewer options exist to help people overcome disease when infected with antibiotic-resistant pathogens. The antibiotics often are not fully metabolized by animals, and can be present in their manure. If manure pollutes a water supply, antibiotics can also leech into groundwater or surface water.

Because of this concern for human health, there is a growing movement to eliminate the non-therapeutic use of antibiotics with animals. In 2001, the American Medical Association approved a resolution to ban all low-level use of antibiotics. The USDA has developed guidelines to limit low-level use, and some major meat buyers (such as McDonald's) have stopped using meat that was given antibiotics that are also used for humans. The World Health Organization is also widely opposed to the use of antibiotics, calling for a cease of their low-level use in 2003. Some U.S. legislators are seeking to ban the routine use of antibiotics with livestock, and there has been legislation proposed to solidify a ban. The Preservation of Antibiotics for Medical Treatment Act (PAMTA), which was introduced in 2009, has the support of over 350 health,

consumer, and environmental groups (H.R. 1549/S. 619). The act, if passed, would ban seven classes of antibiotics important to human health from being used in animals, and would restrict other antibiotics to therapeutic and some preventive uses.

Other Effects – Property Values

Most landowners fear that when CAFOs move into their community their property values will drop signiÀcantly. There is evidence that CAFOs do affect property values. The reasons for this are many: the fear of loss of amenities, the risk of air or water pollution, and the increased possibility of nuisances related to odors or insects. CAFOs are typically viewed as a negative externality that can't be solved or cured. There may be stigma that is attached to living by a CAFO.

The most certain fact regarding CAFOs and property values are that the closer a property is to a CAFO, the more likely it will be that the value of the property will drop. The exact impact of CAFOs Áuctuates depending on location and local speciÀcs. Studies have found differing results of rates of property value decrease. One study shows that property value declines can range from a decrease of 6.6% within a 3-mile radius of a CAFO to an 88% decrease within 1/10 of a mile from a CAFO (Dakota Rural Action, 2006). Another study found that property value decreases are negligible beyond 2 miles away from a CAFO (Purdue Extension, 2008). A third study found that negative effects are largest for properties that are downwind and closest to livestock (Herriges, Secchi, & Babcock, 2005). The size and type of the feeding operation can affect property value as well. Decreases in property values can also cause property tax rates to drop, which can place stress on local government budgets.

Considerations for Boards of Health

Right-to-Farm Laws

With all of the potential environmental and public health effects from CAFOs, community members and health ofÀcials often resort to taking legal action against these industrial animal farms. However, there are some protections for farms in place that can make lawsuits hard to navigate. Right-to-farm laws were created to address conÁicts between farmers and non-farming neighbors. They seek to override common laws of nuisance, which forbid people to use their property in ways that are harmful to others, and protect farmers from unreasonable controls on farming.

All 50 states have some form of right-to-farm laws, but most only offer legal protections to farms if they meet certain speciÀcations. Generally, they must be in compliance with all environmental regulations, be properly run, and be present in a region Àrst before suburban developments, often a year before the plaintiff moves to that area. These right-to-farm laws were originally created in the late 1970s and early 1980s to protect family farms from suburban sprawl, at a time when large industrial farms were not the norm. As industrial farms grew in size and number, the agribusiness industry lobbied for and achieved the passage of stricter laws in the 1990s, many of which are now being challenged in court by homeowners and small family farmers. Opponents to these laws argue that they deprive them of their use of property and therefore violate the Fifth Amendment to the Constitution.

Some state courts have overturned their strict right-to-farm laws, such as Iowa, Michigan, Minnesota, and Kansas. Others such as Vermont have rewritten their laws. Vermont's updated right-to-farm bill

protects established farm practices as long as there is not a substantial adverse effect on health, safety, or welfare.

Boards of health need to be aware of what legal protection their state offers farms. Right-to-farm laws can hinder nuisance complaints brought about by community members. State laws can prevent local government or health ofÀcials from regulating industrial farms.

Board of Health Involvement with CAFOs

Boards of health are responsible for fulÀlling the three public health core functions: assessment, policy development, and assurance. Boards of health can fulÀll these functions through addressing problems stemming from CAFOs in their communities. SpeciÀc public health services that can tackled regarding CAFOs include monitoring health status, investigating health problems, developing policies, enforcing regulations, informing and educating people about CAFOs, and mobilizing community partnerships to spread awareness about environmental health issues related to CAFOs.

Assessment: Board of health members should ensure that there is an effective method in place for collecting and tracking public complaints about CAFOs and large animal farms. Since environmental health specialists at local health departments are often responsible for investigating complaints, the board of health must take measures to ensure that they are properly trained and educated about CAFOs. It is possible that the board of health may be responsible or choose to do some investigations itself. Schmalzried and Fallon (2008) advocate that local health districts adopt a proactive approach for addressing public concerns about CAFOs, stating that health districts can offer some services that may help ease public frustration with CAFOs. A Áy trapping program can establish a baseline for the average number of Áies present prior to the start-up of CAFOs or large animal farms, which can then establish if a Áy nuisance exists in the area. Testing for water quality and quantity can provide evidence if CAFOs are suspected of affecting private water supplies. Boards of health can also monitor exposure incidences that occur in emergency rooms to determine if migrant or farm workers are developing any adverse health conditions as a result of their work environments. Establishing these programs beneÀt both members of the community and provide information to future animal farm operators, and local boards of health should recommend them if they've been receiving complaints about CAFOs.

Policy Development: Boards of health in many states can adopt health-based regulations about CAFOs, however, they may be met with some resistance. Humbolt County, Iowa, adopted four health-based ordinances concerning CAFOs that became models for regulations in other states, but the Iowa Supreme Court ruled the ordinances were irreconcilable with state laws. Boards of health that choose to regulate CAFOs can also be subject to pressure from outside forces, including possible lawsuits or withdrawal of funding. Boards of health should also consider working with other local ofÀcials to institute regulations on CAFOs, such as zoning ordinances.

Assurance: Boards of health can execute the assurance function by advocating for or educating about better environmental practices with CAFOs. Board members may receive complaints from the public about CAFOs, and boards can hold public meetings to receive complaints and hear public testimony about farms. If boards of health are not capable of regulating industrial farms in their communities, they can still try to collaborate with other local agencies that have jurisdiction. Board of health members can educate other local agencies and public ofÀcials about CAFOs and spread awareness about the environmental and health hazards. They can request a public hearing with the permitting agency of the

CAFO to express their concerns about the potential health effects. They can also work with agricultural and farm representatives to teach better environmental practices and pollution reduction techniques.

In many states, boards of health are empowered to adopt more stringent rules than the state law if it is necessary to protect public health. Board of health members should examine their state laws before they take any action regarding CAFOs to determine the most appropriate course of action. Any process should include an investigative period to gather evidence, public hearings, and a time for public review of draft policies.

Board of Health Case Studies

Tewksbury Board of Health, Massachusetts

Locals have complained about Krochmal Farms, a pig farm, for many years, but complaints have increased recently. The addition of a hog finishing facility to the farm coincided with the time that community member complaints grew. Most complaints are centered on the odor coming from the farm. The complaints were originally just logged when phone calls were received; however, the health department added a data tracking system as the number of complaints increased. After a complaint is received, the sanitarian or health director does a site visit to investigate.

The health director in Tewksbury filed an order of prohibition against the farm, which is allowed under Massachusetts law 111, section 143, for anything that threatens public health. The order of prohibition was appealed and the matter was taken to the board of health for a grievance hearing. The board of health hearing included months of testimony about the pig farm. The board of health is also doing a site assignment, which determines if a location is appropriate for treating, storing, or disposing of waste, including agricultural waste. The site assignment process includes both the Department of Environmental Protection (DEP) and the local board of health. The board of health holds a public hearing process, while the DEP reviews the site assignment application. The board of health grants the site assignment only if it is concurrently approved by the DEP.

The health director in Tewksbury points out that the only laws the board of health is able to regulate the farm under are nuisance laws. There have been efforts by the community to do a home rule petition to address the air quality and pest management complaints. The home rule petition is currently working its way through the Massachusetts state house. The status of the petition is unknown.

The board of health has tried to work directly with the pig farm to manage complaints. The farm contains manure composting facilities and the health district has requested advance notice to warn the community before manure is treated or applied to the soil. The farm has adopted a new manure management system. This system uses Rapp technology to control odors and reduce ammonia and hydrogen sulfide levels. However, questions still remain as to whether this addition will fully solve the odor issue. Typically, systems using Rapp technology include an oil cap that floats on manure holding pools and helps seal odors inside. These techniques have been researched and proven to reduce odors. However, the Tewksbury farm did not install the oil cap, and it is unknown whether the exclusion of the cap will hinder the technology's ability to reduce odors.

The complaints about the farm primarily concern the odor that emanates from the farm. The complaints do include mention of health side effects, including nausea and burning eyes. The health director has also heard concerns about potential environmental effects from the pig manure. Community members are

worried the manure runoff is entering and contaminating Sutton Brook, since there has been Áooding in that area. There has been no conÀrmation of this occurring. The board of health is aware that the farm has a nutrient management plan, but they are not allowed to request and Àrnd out what is incorporated in that plan.

The Tewksbury piggery is technically not classiÀed as a CAFO, though it is believed to be the largest pig farm in the commonwealth of Massachusetts. The area around it has become densely populated and the community members state that they just want to live peacefully with the farm. The board of health has submitted multiple grant applications to study the health effects associated with the farm. After the site assignment process is complete, the board of health will decide how it will regulate the farm. At the beginning of 2010, the board of health was still working on drafting regulations for the pig farms.

Wood County Board of Health, Ohio

Wood County, Ohio, contains two existing large dairy farms, both of which were proposed in 2001 to be expanded to over 1500 cows each. It is also the site for three other proposed dairy farms. There is a large community effort that supports restricting the operation and expansion of these farms, mainly represented by the community group Wood County Citizens Opposed to Factory Farms. The Wood County Board of Health became involved in investigating these dairy farms through this community group and other local ofÀcials. The Trustees of Liberty Township requested assistance from the Wood County Board of Health in supporting a moratorium on factory farm operations until local regulations were in effect. The trustees believed that manure runoff from the farms could contaminate local waterways, lower the ground water table, increase the presence of insect vectors, and devalue local properties.

The Wood County Health Director, in cooperation with the board of health, contacted nearby counties to determine what actions they had taken against farms in their communities. While the health director and board of health investigated action in the form of a nuisance regulation against the farms, they were advised that nuisance lawsuits Àled against farms in Ohio were held to a tough standard, and they would be forced to demonstrate with scientiÀc proof that the farms have a substantial adverse effect on health. They found that no other board of health in Ohio had opted to regulate farming operations and relied on the enforcement of existing state laws.

The board of health held a public forum to hear public opinion regarding the industrial farms. Ultimately, the Wood County Board of Health took actions other than regulations to help protect the health and environment of its community. They helped community members protect the safety of their water wells by offering free and low cost water well testing and inspections. They tested area ditch and water ways for fecal coliform bacteria, phosphorous, and nitrates to monitor the impact of farm runoff. They also purchased Áy traps to monitor and count Áy types to determine if the farms have caused an increase in insect vectors. Board of health members also met with state ofÀcials from the Ohio EPA in an effort to facilitate cooperation regarding the factory farms. While the Wood County Board of Health and Health Department chose not to institute any local regulations, they continue to monitor the situation and respond to community complaints.

Cerro Gordo County Board of Health, Iowa

OfÀcials in Cerro Gordo County, Iowa, began looking into regulating animal feeding operations after the number of hog farms in Iowa started to grow. Floods in North Carolina and new regulations in Colorado meant that many hog farms began relocating to Iowa. Many citizens had concerns over the effects of

CAFOs, and the Iowa State Association of Counties wanted to review air quality issues. OfÀcials in Cerro Gordo County originally began working on a regulation that required inspections and was based on public health concerns, since farms were already exempt from any regulations related to zoning. However, Iowa state senators soon introduced legislation that passed and prevented any animal feeding operations from being regulated from a public health angle as well.

As Iowans were now prevented from regulating animal feeding operations in terms of zoning or public health, ofÀcials in Cerro Gordo County decided to place a moratorium on the construction of new animal feeding operations in that county. They wanted to temporarily stop the growth of animal feeding operations until they could get better science about their effects. Cerro Gordo County Ordinance #40, the "Animal ConÀnement Moratorium Ordinance," went into effect on May 14, 2002. Since the moratorium did not address public health or zoning, ofÀcials were able to get around the rules and still have a way to temporarily control animal feeding operation growth in their county. The ordinance placed "a 1-year moratorium on any new construction, expansion, or activity occurring on land used for the production, care, feeding, or housing of animals." The ordinance also afforded "local public health ofÀcials adequate time to appropriately assess health and environmental concerns that may be related to conÀned animal feeding operations and concentration of animals; establish objective measurable standards of enforcement; exercise the Board of Health's responsibility to protect and improve the health of the public; refrain from impacting farm operators unfairly; and provide penalties for violations of the provisions hereof pursuant to Chapter 137, Code of Iowa" (Cerro Gordo County, 2002).

The moratorium was Àrst adopted by the Cerro Gordo County Board of Health. It was then presented to the county board of supervisors by the health director on behalf of the board of health. Before the board of health adopted the moratorium, they held an investigative meeting in which representatives from the Iowa Farm Bureau and other industry spokespeople exchanged opinions on the issue of animal feeding operations. The moratorium was created through a collaboration between local and county ofÀcials—health department staff, the board of health, and the board of supervisors. The moratorium did not receive any help or backing from state ofÀcials, who were concerned about the political nature of the ordinance. However it did receive backing from a Globe Gazette editorial.

The moratorium was immediately met with resistance from state ofÀcials. The Cerro Gordo County Board of Supervisors was contacted by a local legislator, and the Iowa Farm Bureau stated they would challenge the county budget. The Iowa Farm Bureau threatened to take the county to court. There were concerns over the cost of a court trial, which was estimated to be as high as $60,000. The county attorney doubted the legality of the moratorium and ultimately recommended removing it. The moratorium was in effect until June of 2005, when it was repealed by the county board of supervisors.

Since the moratorium was repealed there have been a few hog farms built in Cerro Gordo County, but the decline in pork prices has prevented any large growth of hog farms. Health ofÀcials believe that if the county had not implemented the animal conÀnement moratorium, there would have been many more farms built in their county, since many hog farms were built in counties south of Cerro Gordo County. There is now a process for siting new animal conÀnement operations in Iowa that uses a Master Matrix scoring system. The Cerro Gordo County Board of Supervisors tracks the Master Matrix system, but so far no animal feeding operations in Iowa who have applied using this system have been denied the right to build.

Conclusion

Concentrated animal feeding operations or large industrial animal farms can cause a myriad of environmental and public health problems. While they can be maintained and operated properly, it is important to ensure that they are routinely monitored to avoid harm to the surrounding community. While states have differing abilities to regulate CAFOs, there are still actions that boards of health can and should take. These actions can be as complex as passing ordinances or regulations directed at CAFOs or can be simply increasing water and air quality testing in the areas surrounding CAFOs. Since CAFOs have such an impact locally, boards of health are an appropriate means for action. Boards of health should take an active role with CAFOs, including collaboration with other state and local agencies, to mitigate the impact that CAFOs or large industrial farms have on the public health of their communities.

Appendix A: Regulatory DeÀnitions of Large CAFOs, Medium CAFOs, and **Small CAFOs**

Animal Sector	Size Thresholds (number of animals)		
	Large CAFOs	**Medium CAFOs[1]**	**Small CAFOs[2]**
Cattle or cow/calf pairs	1,000 or more	300-999	Less than 300
Mature dairy cattle	700 or more	200-699	Less than 200
Veal calves	1,000 or more	300-999	Less than 300
Swine (over 55 pounds)	2,500 or more	750-2,500	Less than 750
Swine (under 55 pounds)	10,000 or more	3,000-9,999	Less than 3,000
Horses	500 or more	150-499	Less than 150
Sheep or lambs	10,000 or more	3,000-9,999	Less than 3,000
Turkeys	55,000 or more	16,500-54,999	Less than 16,500
Laying hens or broilers[3]	30,000 or more	9,000-29,999	Less than 9,000
Chickens other than laying hens[4]	125,000 or more	37.500-124,999	Less than 37,500
Laying hens[4]	82,000 or more	25,000-81,999	Less than 25,000
Ducks[4]	30,000 or more	10,000-29,999	Less than 10,000
Ducks[3]	5,000 or more	1,500-4,999	Less than 1,500

Data: Environmental Protection Agency

1 Must also meet one of two "method of discharge" criteria to be deÀned as a CAFO or must be designated.

2 Never a CAFO by regulatory deÀnition, but may be designated as a CAFO on a case-by-case basis.

3 Liquid manure handling system

4 Other than a liquid manure handling system

Appendix B: Additional Resources

American Public Health Association. Precautionary moratorium on new concentrated animal feed operations. http://www.apha.org/advocacy/policy/policysearch/default.htm?id=1243

Center for a Livable Future. http://www.livablefutureblog.com/

Environmental Health Sciences Research Center. Iowa concentrated animal feeding operation air quality study. http://www.public-health.uiowa.edu/ehsrc/CAFOstudy.htm

Environmental Protection Agency. Animal feeding operations. http://cfpub.epa.gov/npdes/home.cfm?program_id=7

Food and Water Watch. http://www.foodandwaterwatch.org/

Impacts of CAFOs on Rural Communities. http://web.missouri.edu/ikerdj/papers/Indiana%20--%20CAFOs%20%20Communities.htm#_ftn1

Land Stewardship Project. http://www.landstewardshipproject.org/index.html

Midwest Environmental Advocates. http://www.midwestadvocates.org/

National Agriculture Law Center. Animal feeding operations reading room. http://www.nationalaglawcenter.org/readingrooms/afos

National Association of Local Boards of Health. Vector control strategies for local boards of health. http://www.nalboh.org/publications.htm

Pew Charitable Trusts. Human health and industrial farming. http://www.saveantibiotics.org/index.html

Pew Commission on Industrial Animal Farm Production. http://www.ncifap.org/

Purdue Extension. Concentrated animal feeding operations. http://www.ansc.purdue.edu/CAFO/

State Environmental Resource Center. http://serconline.org

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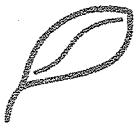

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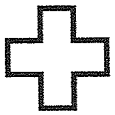

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- *Hazards to Human Health*
- *Environmental Damage*
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- *More on the Issues*
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The Issues

< Back to Legal Information

Confined animal feeding operations (CAFOs) have a bad rep - and with good reason. These giant livestock factories cause a multitude of health, environmental, economic, and quality of life problems.

What is a CAFO?

A confined animal feeding operation (CAFO) is a giant livestock factory in which hundreds or thousands of animals are housed and fed in large confinement buildings. The animals have barely any room to move and no opportunity to pasture. In Iowa, CAFOs are predominately hog operations, but chicken, turkey and cattle operations are found in the state, too.

In hog confinements, the pigs stand on slatted floors and their wastes fall into huge lagoons beneath the confinement. These waste pits store anywhere from hundreds of thousands to millions of gallons of liquid manure for months at a time.

Because of the nature of the waste pits, the manure putrefies, emitting toxic ammonia and hydrogen sulfide gases. These gases are so harmful that farm workers have died from asphyxiation when they entered an improperly vented CAFO.

Even without accidents, the noxious gases negatively affecting neighbors when they escape into the environment. Eventually, the liquid manure is applied onto agricultural fields as fertilizer, further disturbing people who don't even live near CAFOs.

Because of the many problems associated with CAFOs, the American Public Health Association called for a moratorium on all new factory farms back in 2003. More recently, a two-year study released in 2008 study by the Pew Commission on Industrial Farm Animal Production outlined the risks of industrial agriculture.

There are many reasons to be concerned if there is a CAFO in your community.

Hazards to Human Health

The byproducts of manure and the rampant use of antibiotics pose a serious health threat to communities with CAFOs.

- The ammonia and hydrogen sulfide gases produced by stagnating liquid manure can cause respiratory problems, nausea, diarrhea, headaches, burning eyes, confusion, tension, depression, and fatigue.
- A University of Iowa study found children are particularly susceptible to asthma.
- Unsanitary, crowded confinements can become a breeding ground for disease. To fend off infections, non-therapeutic antibiotics are added to livestock feed. According to the Union of Concerned Scientists, over 70% of all antibiotics used in the US are fed to livestock for preventive care as well as to boost growth rates.
- In 2001, the American Medical Association has warned in that the rampant use of antibiotics in factory farms is contributing to the evolution of antibiotic-resistant bacteria, which it

considers a serious impending health crisis. We are now starting to see the emergence of deadly strains of antibiotic-resistant bacteria.

- A University of Iowa study published in 2009 has linked MRSA (methicillin-resistant *Staphylococcus aureus*) to factory farms, finding a new strain, ST398, in 70% of hogs and 64% of swine workers in one Midwest facility.
- In Holland, it's been reported that 60% of all pigs are infected with ST398 and 30-40% carry the bacteria in either their respiratory tract or skin. A Dutch government study found MRSA ST398 in 10% of its slaughtered pork and a Dutch journal also reported on a woman not associated with hog farms that contracted MRSA ST398 while hospitalized.
- Similarly, a Worldwatch Institute report linked Avian Flu to the location of large-scale poultry production to nearby cities.
- In 2007, the Food and Agricultural Organization of the United Nations (FAO) warned, "excessive concentration of animals in large scale industrial production units should be avoided."

Environmental Damage

Animal feeding operations produce enormous amounts of manure - 100 times more than the amount of human sewage sludge processed in US municipal wastewater plants. Communities with CAFOs see the their streams, creeks, and ponds deteriorate as nitrogen, phosphorus, microbes, ammonia and antibiotics from liquid manure pollute their waterways.

- Lagoon leaks and manure misapplied on fields can pollute streams and well water of nearby residences.
- Agricultural runoff from spreading manure on crop fields wind up in local waterways from heavy rains and melting snow.
- Accidental manure spills dump high volumes of toxins into waterways causing serious water pollution and fish kills, not to speak of making streams, ponds, and lakes unsuitable for recreational use.
- Since manure contains antibiotics, antibiotic-resistant genes are spreading through waterways. A study conducted at the University of Illinois discovered that some antibiotic-resistant genes found in manure lagoons are transferred "like batons" from one species of bacteria to another.

Local Economy Degradation

- Property owners see the value of their homes and property decrease as much as 30-40% when CAFOs move into an area. One factory farm forces an average of 10 family farms out of business. County economies can weaken as people move away; local businesses lose vitality, and sales and property taxes plummet.
- Hog laden tractor-trailers drive over roads not built to accommodate their heavy weight or frequent trips. The result is the physical deterioration of a community's physical infrastructure. And who winds up paying for repairs? Local communities do, with local taxpayers experiencing higher taxes and reduced local services as communities struggle to keep up with the extra maintenance.
- What about the economic benefits of factory farms to local communities? There aren't many. Few new jobs are created, new building construction materials are often outsourced, and the hog corporations, which are usually located out-of-state, pay no taxes to the community.
- In fact, counties that experienced increasing numbers of CAFOs did not see increased levels of economic development. They also may have lost the opportunity to strengthen their economies with other development projects, says an Iowa Policy Project study conducted by Iowa State University.

Loss of Quality of Life

For many people, what was once a family's cherished home or a retired couple's dream house becomes a prison. Many neighbors of CAFOs report they are unable to leave their homes to enjoy their yards, gardens, or outdoor activities because of the gagging, nauseating odors or overwhelming fly infestations the confinements produce. CAFOs are definitely not good neighbors.

More information on The Issues:

Human Health Hazards Articles
Environmental Impact Articles
Air Pollution and Odor
Water Pollution
Waste
Socioeconomics Articles

Take Action Today!

In many counties throughout Iowa, and throughout many states, the proliferation of CAFOs and the lack of adequate governmental regulations is causing a serious environmental problem, injuring air quality, water quality, and the quality of life for those who live in the vicinity. If this is OK with you, do nothing. However, if you would like to help insure the quality of your environment and your ability to enjoy life in Iowa, there are some simple steps you can take that will help make a difference.*

1. Educate Yourself*
Read articles on this site and articles linked on the many pages of this site. The 30 minutes plus you spend reading will make you an informed citizen and voter. You will understand the issues, the threat to your quality of life, and what needs to happen to protect your quality of life. Sitting on the sidelines is not an option, unless you're comfortable living next to a CAFO and not caring how your community may be affected over time.

2. Contact Elected Officials*
Although they are supposed to be representing the interests of their constituents, they are clearly influenced by agri-business campaign contributions and agribusiness-funded political action committees (PACs). If they don't hear from you, they assume you're happy with the job they are doing and the way they vote. If you DO make the effort to contact them, your voice is amplified many times, as so few people make the effort. This page has all of the contact information, the rest is up to you!

3. Talk to your Neighbors*
Many people are either not informed or are ill-informed. Make the effort to visit with your neighbors; find out their position, and help them find the information they need to develop informed positions.

4. Report Suspicious Activity*
Call Iowa Citizens for Community Improvement at 515-282-0484 immediately if you see what might be a CAFO being constructed or if you see what might be an illegal manure dumping.

5. Consider Legal Action
Unfortunately in today's world, legal action is often the only option that will stop a CAFO in its tracks. David E. Sykes, P.C. offers litigation services for individuals and communities who are impacted by a CAFO in their neighborhood and are seeking to protect their families quality of life and declining property values.

****From the** *Jefferson County Farmers & Neighbors, Inc.* **website.***

More Information on Factory Farming

There is no shortage of studies and reports by well-respected institutions and organizations on the damaging impacts of factory farms. Jefferson County Farmers & Neighbor, Inc. has compiled

numerous articles and reports on the negative effects of factory farming on one's health, property values, quality of life, community, and the environment.

It's crucial to become educated on factory farming to learn how they can affect you and your family. These reports and articles will give you a solid education on the problems associated with confined animal feeding operations and why they are a bad idea for neighbors and communities.

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Agricultural Animals and the Law

By Katherine Hessler and Tanith Balaban

The legal issues surrounding agriculture and livestock farms have undergone vast changes through the last 50 years. These changes were heralded by Earl L. Butz, secretary of agriculture under Presidents Richard Nixon and Gerald Ford, who said that farming "is now a big business" and the family farm "must adapt or die" by expanding into large operations reliant on industrial pesticides, herbicides, and fertilizers. Whether this is true or not is open to debate.

What is not open for debate is that the shift from small to large farms has been dramatic and has led to a panoply of legal issues. These include habitat loss and degradation; soil erosion and sedimentation; water resources depletion; soil and water salinization; agrochemical releases; nonpoint water pollution through runoff from fields and livestock operations; chemical air pollution; antibiotic resistant bacteria; salmonella, E. Coli, and Pfiesteria outbreaks; increased injury to workers; and the development of inhumane animal management practices.

Because the trend is toward larger farms and livestock operations, it is unlikely that a solo or small firm practitioner will represent the larger companies. Instead the solos and small firm lawyers will more likely represent someone complaining about intensive farming practices and must address numerous legal issues, including the impact on land values and the environment as well as concerns of neighbors.

Approximately 10 billion land animals are raised and killed for meat, eggs, and milk each year. Of those 10 billion animals, about 35 million cattle are raised for beef, 9 million for milk, and 1 million for veal. Approximately 95 percent (9.5 billion) of the animals in food production are birds.

Most Americans today get their food from a system that raises animals in intensive confinement—several thousand pigs or tens of thousands of chickens per barn. This system of livestock husbandry is called either an animal feeding operation (AFO) or a concentrated (or confined) animal feeding operation (CAFO) and is commonly known as factory farming. This new system for raising animals for food results in new problems for consumers, neighbors of the operations, the environment, workers, and the animals. Intensive animal crowding indoors is not the traditional form of livestock husbandry and has led the industry to create new techniques in animal handling to make the business more efficient. These new systems also lead to problems that may result in legal issues.

For example, a single hog farm with 10,000 animals will

produce as much waste as a city with a population of 100,000 people. The question of waste disposal becomes one of the central concerns for a factory farm. And the phenomenally high concentration of waste results in bad odors, flies, and chemical and infectious compounds in the air or water runoff sufficient to create significant health and environmental problems. The U.S. Centers for Disease Control and Prevention (CDC) state that in 2003, the nation's 238,000 feeding operations produced 500 million tons of manure. (For more, see the CDC's web page on concentrated animal feeding operations: www.cdc.gov/cafos /about.htm. See also the U.S. Environmental Protection Agency's web page on national pollutant discharge elimination systems: http://cfpub.epa.gov/npdes /home.cfm?program_id=7.)

The overcrowded conditions of the animals create additional problems for the industry, its neighbors, and consumers. The stressful conditions for the animals result in illness and injury. One way factory farmers address the illness problem is to treat *all* the animals with sub–therapeutic levels of antibiotics. This reduces illness among the animals but may contribute to the creation of antibiotic–resistant diseases. The stress of overcrowding can cause the animals to fight among themselves, leading to injury or death. To address these concerns, factory farmers de–beak chickens so they cannot peck at each other and dock the tails of pigs; both procedures are done without anesthesia. Because of the enormous numbers of animals in each barn, the animals typically do not ever leave the barn and are fed automatically, reducing the time people spend tending to them. This results in long delays before dead animals are removed from the midst of the other animals. All of these practices result in concerns for food safety, environmental protection, animal welfare, and the value of adjacent properties.

Federal Legislation

Clean Water Act. On factory farms, raising livestock implicates the Clean Water Act (CWA), which governs the operations of AFOs and CAFOs. In order for an agricultural operation to be considered a CAFO, a facility must first be defined as an AFO.

AFOs are agricultural operations where animals are kept and raised in confined situations. AFOs congregate animals, feed, manure, dead animals, and production operations on a small land area instead of an operation where cattle are allowed to range for food in pastures. AFOs are defined as facilities where animals are confined and fed for 45 or more days in any 12–month period and vegetation or forage is not sustained in the normal growing season over any portion of the lot or facility.

Under the CWA, CAFOs are split into large, medium, and small sizes depending on the number and type of animals, the contact with surface water, and the extent to which the facility could pollute surface and groundwater. Federal regulations require CAFOs to obtain a permit and to develop

plans designed to keep animal waste from contaminating surface water and groundwater. It is important to note there is no private right of action contained within the CWA. Instead, any aggrieved party must file a complaint with the Environmental Protection Agency (EPA).

Clean Air Act. The Clean Air Act (CAA) is also relevant because of the significant amount of chemicals released into the air from CAFOs. These releases come from the barns where the animals are housed as well as from manure lagoons and other waste sites. Methane, hydrogen sulfide, nitrogen, and ammonia are released in significant quantities and can lead to air and water pollution and illness.

Within the CAA are two additional areas of focus for CAFOs. The first is the Comprehensive Environmental Response, Compensation, and Liability Act, and the second is the Emergency Planning and Community Right–to–Know Act. These statutes and related regulations require factory farms to report their emissions of ammonia and hydrogen sulfide when they emit more than 100 pounds per day. Industry response to the reporting requirements has been strong, and it is not clear whether the EPA will stand by them or will weaken or eliminate them.

Other federal statutes. There is no federal legislation regulating the conditions of animals being raised on farms. Federal law focuses primarily on the integrity of the food supply.

The Animal Health Protection Act allows for the quarantine, destruction, and disposal as well as restriction of transit of diseased livestock. The Animal Disease Risk Assessment, Prevention, and Control Act of 2001 requires a report on foot–and–mouth disease, bovine spongiform encephalopathy (BSE—also known as "mad cow disease"), and related diseases. The Animal Enterprise Terrorism Act makes it a crime to travel in interstate commerce or use the mail for the purpose of damaging or interfering with any animal enterprise (including farms). The Commercial Transportation of Equine for Slaughter Act regulates the commercial transportation of equine for slaughter. The Humane Slaughter Act provides acceptable methods of slaughter of animals to be used as food; it exempts birds. The Twenty–Eight Hour Law restricts the transportation of animals such that they may not be confined in a vehicle for more than 28 consecutive hours without unloading them for feeding, water, and rest, with some exceptions that extend the time; birds are not covered.

State Constitutional Protections

Some state constitutions, including those of New York, Hawaii, and Nebraska, contain provisions protecting traditional ways of life, including hunting, fishing, and farming. Thus, depending on the state, a livestock owner may have state constitutional protection.

Other state constitutions contain provisions specifically addressing protections for animals. For example, Florida has

a constitutional provision to protect pigs, and in 2008 California passed Proposition 2 prohibiting veal crates, battery cages, and sow gestation crates that do not allow animals to turn around freely, lie down, stand up, and fully extend their limbs.

State Legislation

All 50 states have animal cruelty statutes. However, most of these statutes explicitly exempt common farming practices. Oregon's anticruelty statute is somewhat different because it exempts only "good" farm practices and has no farm exemption for intentional or knowing torture or the malicious killing of an animal.

Some states are now considering whether to require minimum standards of care. Most notably, New Jersey requires humane standards for the care of farm animals. This statute was challenged in *New Jersey Society for the Prevention of Cruelty to Animals v. New Jersey Department of Agriculture,* 2008. The question presented was whether certain practices could be deemed humane. The court said that the New Jersey Department of Agriculture was required to do more than accept currently used practices: Their job was to identify and allow only those practices that met a humane standard, and they had failed to do that. The court accepted the agency's decision with respect to certain practices but deemed that its blanket exemption of routine practices was an abuse of the interpretive process because the statute requires humane practices.

This is an area likely to see additional development across the country and bears watching.

Right–to–Farm Laws

One aspect that filters into every legal issue surrounding livestock farming is right–to–farm laws (RTFs). RTFs have been adopted in all 50 states. This is important because RTFs modify the law of nuisance (discussed below).

Generally RTFs cover the growing and harvesting of crops; the feeding, breeding, and management of livestock; and other agricultural and horticultural activities. However, many RTFs apply only to commercial activities, so hobbyists or non–farmers do not qualify for the nuisance protection.

Although RTFs modify nuisance laws, they do not have any impact on environmental laws or pollution legislation. Thus, producers must comply with legislation governing clean water and the disposal of animal manure, absent agricultural exemptions. In addition, negligent or improper operation at an agriculture facility is not protected.

Generally, lawsuits against people or companies raising livestock have two points of entry—when the enterprise first starts and when the operation changes or expands the nature or size of its operation.

Public and Private Nuisance Actions

Nuisance is a use of property that causes injury to others

and comes in two forms: private and public. A private nuisance is one that affects the use or enjoyment of land; normally it is privately enforced through a tort action for damages. A public nuisance affects the public at large, does not need to be connected to the land, and is normally enforceable by public officials. However, a public nuisance can give rise to a parallel private nuisance action if private lands are also affected.

As previously stated, the law of nuisance may be modified by RTFs. Common RTFs state that a farming operation shall not be considered or come to be considered a nuisance if it was not a nuisance at the time it began operation, even if conditions change in the surrounding area. Usually the agricultural use must have been in place for one year.

These RTFs modify the traditional "coming to the nuisance" rule—creating an implicit negative easement, prohibiting development on surrounding property and preventing adjacent property owners from suing to prohibit or modify the use as an agricultural nuisance.

In other cases, some courts will consider priority in time as an important factor in nuisance cases and may hold against a plaintiff who "came to a nuisance."

These laws do not always protect a farm once its use changes or expands. For example, if an owner raised livestock but then added a slaughterhouse or a processing plant at a later date, this expanded use may not be protected. It is also not clear how the RTFs would affect a dispute between a small farm and a large one.

Another limitation on RTFs may require that the farm engage in good agricultural practices as a condition to protection under the RTFs. However, "good practices" is not usually a defined term. Perhaps further developments will clarify this dialogue.

Nuisance actions are considered a supplement to regulation and litigation under the environmental laws. Nuisance actions may be precluded if Congress intended an environmental statute to be the exclusive remedy for a particular offensive use or condition, or if the alleged nuisance has received (or is eligible for) a state or federal permit to operate.

Zoning Issues

Zoning is another issue for those who raise livestock. Some communities concerned with the development potential of existing agricultural lands can, and have, adopted zoning laws that are designed especially to protect open tracts of land. This may affect individuals trying to sell their property.

For example, a community may adopt a large lot zoning structure that requires minimum lot sizes to be at least ten to 25 acres per housing unit. There may be other protections such as mandatory cluster design, open space residential design, and transfer of development rights.

Other zoning issues may arise when communities restrict the type or number of animals allowed on a property. It may be unlawful to picket livestock or allow livestock to roam in close proximity with residences or commercial buildings where foodstuff is prepared, kept, or sold.

In addition, some city zoning may not allow roosters, may bar swine, and may limit the number of animals that may be raised as food, such as chickens and rabbits, within the city limits.

Other Issues

Many legal issues arise as a result of factory farming and some are now just beginning to be explored. These issues include, but are not limited to, the demand for organic and locally produced livestock and produce, concern over heavy use of antibiotics fed to livestock (about 70 percent of anti–biotics sold in the United States are given to healthy livestock), and disease outbreaks. From this arises a host of legal issues, including nutrition, conservation, genetic engineering, food safety, animal cruelty, insurance policies for farmers, school lunch programs, water quality, cloning, organic farming, and much more.

This may be a rapidly changing area of law in the coming years. Before he was elected president, Barack Obama talked about the need to change agribusiness, boost organic farming, and promote local and regional food systems. President Obama appointed Tom Vilsack, the former governor of Iowa, to be secretary of agriculture. Vilsack has talked about reducing subsidies to megafarms and supports better treatment of farm animals.

Conclusion

In the end, no agricultural operation should ignore good neighborly relations, adequate buffers from neighboring residences and setbacks from boundary lines and water sources (creeks, wells, and ponds), humane animal husbandry, the health consequences of their actions, and compliance with all environmental laws. The manner in which CAFOs attend to these issues (or fail to do so) will likely be a subject of increasing interest for the legal community in the years to come.

Katherine Hessler is the director and clinical professor for the Center for Animal Law Studies at Lewis and Clark Law School, Portland, Oregon; she may be reached at khessler@lclark.edu. Tanith Balaban is a member of the Oregon State Bar; she may be reached at tbalaban@gmail.com.

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Breaking News on the Global Animal Feed Industry

Impending US swine farm looks to source local feed

By Aerin Curtis, 19-Jan-2016

Related topics: Manufacturers, Suppliers, Markets, Swine

A new swine facility is seeking to find answers to questions from neighbours as it works to source local feed and build in Buffalo, North Dakota.

When completed, the breeding facility operated by Minnesota-based Pipestone Systems would house about 6,500 breeding sows along with young piglets and replacement gilts, said Barry Kerkaert, president of Pipestone Grow Finish.

Piglets would be removed after about 23 days and relocated with the farmers in Minnesota and Iowa who own the farm, he said. The group is still looking for farmers willing to participate from North Dakota.

The $15m project would look to source local feed and feed ingredients, he told us. The feedstuffs include corn, dried distillers grains with solubles, 900 tons of soymeal and 300 tons of other feed ingredients.

"The estimated total feed cost is more than $2m a year and will be sourced locally," he said. *"But we don't have a specific supplier identified at this point."*

Project details

The facility will sit on about 35 acres, including roads and a grove of trees, said Kerkaert. A series of buildings will house the animals, offices, feed and storage and a composting area.

In addition to building costs there would be an additional $4m involved in establishing the livestock production, he said. When operational it should employ about 17-20 full time workers and several part-time positions.

The group is looking to expand into North Dakota after being contacted by the state commissioner of agriculture and asked to bring in a facility, he said. *"They have grains to be fed, and people, and population, and good infrastructure,"* he added.

Additionally, the location offers good bio security as there are not many pigs in the area, he said.

Community questions

The group has had one information meeting with area residents, said Kerkaert. The facility also is moving through the application process and is currently in the comment period for its application to the health department.

"There hasn't been any agricultural development with livestock for 20 years and though they had it when they were younger, it is something they're not familiar with so they have a lot of concerns," he said of the questions the group has received.

The company runs about 56 other, similar facilities, and have more than 300 farm families involved in the process, he said. And the group has been operating for about 25 years, he said.

"We try to instill confidence in the people," he said. *"We do know what we're doing. These facilities are designed to last 40 years, and these farmers that have chosen to invest in those communities are proud [of them] and will take care of those facilities."*

The group fielded questions from the public that predominately dealt with concerns about the smell from the facility, the possibility of flies and road damage, said Kerkaert.

There will be an odor to the facility, as there is with any livestock operation, he said. However, the group will do what it can to mitigate the smell.

Precautions include that all animal waste will be maintained underground in concrete tanks, he said. There won't be earthen lagoons or outdoor storage pits.

"We'll sign a road haul agreement and we'll be maintaining the road in as good or better condition than it was when we came," he said.

There will be flies attracted to the facility and animals, he said, however, the group has had experience in managing pests.

"We have insect management control programs and flies don't fly away, they stay close to the food source," he said. *"It shouldn't be a risk to the neighbors. It's in our interest to control it."*

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Friday, January 22, 2016

Jeremy Lang
Environmental Engineer
N.D. Department of Health, Division of Water Quality
918 E Divide
Bismarck, ND 58501

Subject: I support approval of the Buffalo, ND hog farm

Dear Environmental Engineer Lang:

I want to thank you for the excellent work you do in balancing the laws of the state (in protecting our natural resources) with the development of new commerce that drives our state's economy.

I'm writing in support in the proposed hog farm near Buffalo, ND for several reasons.

First, having moved to North Dakota from Minnesota in 2000...I saw first-hand the benefits from livestock production in that state. I was a County Extension Agent so I drew up the manure management plans that allowed farmers to utilize the manure from said livestock farms (thereby reducing commercial fertilizer usage). I also saw the benefits from being able to feed corn and soybeans that were grown locally, instead of having to ship these bulk commodities (adding costs of either trucking and/or rail) out of state. I saw the extra jobs created by livestock farms. I also saw the additional tax revenues created by these farms. And finally, I saw technological advances and cost-share programs (through NRCS) that allowed farmers/ranchers to do a better job with manure management and odor management.

Provided that Rolling Green Family Farms abides by our laws, there is no reason to create an atmosphere of emotions and drama.

It is interesting to me to see this overreaction from the people of Buffalo, ND, because my farm in Minnesota was surrounded by livestock farms...4 of which were within 1/2 mile of me. And I had livestock myself. And we all lived in harmony. Our setback provisions in my home county (Cottonwood County) called for setbacks of ONLY 1/2 to 3/4 of a mile (depending on the number of animal units) and to my understanding the proposed site is as much as 1-mile from any nearby buildings/farmsteads/etc. That is a more than adequate "buffer" zone, in my humble opinion. Desolate and rural settings like the one near Buffalo are the PERFECT location for livestock farms like the proposed one!

Thank you for your consideration, and thank you for doing your job so effectively in helping our citizens and industry to follow the laws of North Dakota.

Sincerely,

Jeffrey R. Missling
4726 48th Ave S
Fargo, ND 58104

Friday, January 22, 2016

Jeremy Lang
Environmental Engineer
N.D. Department of Health, Division of Water Quality
918 E Divide
Bismarck, ND 58501

Subject: I support approval of the hog farm

Dear Environmental Engineer Lang:

Any opportunity to expand a part of agriculture in our state should be embraced. The ag economy is what makes towns like Buffalo, ND and to stand in the way when a farm is trying to shore-up their bottom line is wrong. If these folks were not concerned with the health and well-being of those around them, they would not have made such sincere efforts to follow the regulations that they need to meet set forth by the health department. When a business venture is proceeding properly, let's not stand in their way because of what we THINK may occur even before they are given a chance.

Sincerely,

Jerry Jeffers
16804 99th St SW
Rhame, ND 58651

Friday, January 22, 2016

Jeremy Lang
Environmental Engineer
N.D. Department of Health, Division of Water Quality
918 E Divide
Bismarck, ND 58501

Subject: I support approval of the hog farm

Dear Environmental Engineer Lang:

If they are following all the guidelines to start a new operation what more can be asked of them. We don't want to make nd a unfriendly place to do business. I support the new hog farm

Sincerely,

Darrick Johnson
4451 69th St NE
Wolford, ND 58385

Friday, January 22, 2016

Jeremy Lang
Environmental Engineer
N.D. Department of Health, Division of Water Quality
918 E Divide
Bismarck, ND 58501

Subject: I support approval of the hog farm

Dear Environmental Engineer Lang:

Why are people opposed to this hog farm in Buffalo? They are working with the health department to meet all the requirements for public health and safety. There is no reason fear-mongering should stop this farm from moving forward.

I find it truly amazing that numerous hog operations exist throughout Minnesota, a much more populated state than North Dakota, and yet there is considerable backlash to any type of animal operation proposal for ND.

I contacted a hog producer in Minnesota to find out more information about his operation.

He has two barns, a 2400 head nursery and a 2400 head finishing barn. He stated that as long as proper pit additive maintenance procedures are performed, odor problems are virtually non-existent. A few days of the year, when conditions are just right, odors might possibly be detected up to 1/2 mile away.

This producer also stated that a 12000 head sow operation that he was familiar with, which is larger than the one being proposed in Buffalo, could potentially has odor problems upwards of a mile if the conditions were favorable. He indicated that these "favorable conditions" are only a couple days out of the year, most frequently when the weather is transitioning from winter to spring with cool humid days that have a gently breeze.

This producer then indicated a couple important preventative measures that would considerable help reduce any odor impact of the operation. First was placing the proposed farm so that the prevailing NW winds blow away from the populated area and second would be requiring that significant tree shelter belts be placed around the farm.

He finished by stating hog operations have changed considerably by using technology over the last couple decades and that the odor problems people remember from year ago are just not the problem that they used to be. A whole new system of biological pit additives has tremendously removed the odor problems that people routinely associate with these types of operations.

I grew up in proximity of a couple small hog operations that on certain days would remind me that these farms were nearby. I was surprised though, whenever I visited this hog producer in Minnesota. Although this MN producer's operation was many times larger than the local hog farms that I grew up next to; I would never smell any indication that there were approximately 5000 hogs nearby. Only when I was within a few hundred feet of the barns would I begin to notice a hog odor. And never did that odor increase to what I considered offensive.

Livestock expansion is good for North Dakota. It's good for the grain farmers too, and I think we should welcome the hog farm near Buffalo.

Thank you for this opportunity to comment.

Sincerely,

Marty Visto
9805 105th Ave SE
Oakes, ND 58474

Friday, January 22, 2016

Jeremy Lang
Environmental Engineer
N.D. Department of Health, Division of Water Quality
918 E Divide
Bismarck, ND 58501

Subject: I support approval of the hog farm

Dear Environmental Engineer Lang:

I believe that the proposed hog farm is good for the economy in North Dakota. If we look at the states surrounding us they all have an expansive livestock industry and this is something we need to have in North Dakota. The proposal has followed all of the rules and regulations and should not be restricted in any way.

Sincerely,

Chris Brossart
4510 Highway 17
Wolford, ND 58385

Saturday, January 23, 2016

Jeremy Lang
Environmental Engineer
N.D. Department of Health, Division of Water Quality
918 E Divide
Bismarck, ND 58501

Subject: I support approval of the hog farm

Dear Environmental Engineer Lang:

I support business growth and diversification in North Dakota. It's good for our economy. And a livestock farm is a business just like any other, so I support the proposed hog farm planed for Buffalo, North Dakota.

As a County Commissioner, Chairman of two western North Dakota Organizations (Vision West and North Dakota Association of Oil and Gas producing Counties) which deal with energy development and population growth. Moving forward is always been hard, as very often we are faced with a Challenge or Change in areas of smaller rural development and these types of issue seems to become major topics of discussion.

I worked along side many other pork producers and ranching operation owners back some years ago to establish the health department rules and regulations for confined livestock operations. Since that time we have amended, added and clarified parts of the century code and the Health Department has been very supportive at every stage.

Today I am a board member of a newer generation board supporting the use of corn into food, material products and feed for livestock operations. One of our goals is to gain feed yard spaces in North Dakota to support the Aberdeen South Dakota slaughter plant. Some four hundred fifty thousand head will get slaughtered their annually in the very near future and if North Dakota could supply two hundred thousand head of these beef animals it's a win -win for both Agriculture, our state economy, and small rural American which a majority of our state still is today. Benefiting, crop production and keeping the crops raised here off the rail ways, keep sales tax dollars at home for repairs and maintenance of operations, generating employment in areas which may lack employment opportunities, provided additional income to livestock /crop operations during depressed prices.

Again I support the hog farm planned and will always support livestock feeding operations which are regulated under our State Health Department rules and regulations under the North Dakota century code.

Sincerely,

Daryl Dukart
470 96th Ave SW
Dunn Center, ND 58626

Sunday, January 24, 2016

Jeremy Lang
Environmental Engineer
N.D. Department of Health, Division of Water Quality
918 E Divide
Bismarck, ND 58501

Subject: I support approval of the pig farm

Dear Environmental Engineer Lang:

I support the proposed pig farm near Buffalo, ND. Businesses that have met all the Health Department regulations should not be penalized because of fear mongering and a "not in my backyard" mentality. Let agriculture continue to grow and support ND.

Sincerely,

Teresa Dvorak
1740 104th Ave SW
Manning, ND 58642

Sunday, January 24, 2016

Jeremy Lang
Environmental Engineer
N.D. Department of Health, Division of Water Quality
918 E Divide
Bismarck, ND 58501

Subject: I support approval of the hog farm

Dear Environmental Engineer Lang:

I support approval of the hog farm.

Sincerely,

Shane Gunderson
30203 54th Ave SW
Berthold, ND 58718

Sunday, January 24, 2016

Jeremy Lang
Environmental Engineer
N.D. Department of Health, Division of Water Quality
918 E Divide
Bismarck, ND 58501

Subject: I support approval of the hog farm

Dear Environmental Engineer Lang:

I am writing to give my support of the proposed hog facility near Buffalo North Dakota. Livestock production in North Dakota significantly lags behind other neighboring states, that being said the family proposing the operation has met all the laws/standards that are required of it. Why then should it even be a consideration weather or not they are allowed to operate? All the comments of I have heard from opponents are downright ridiculous, ranging from not wanting to see pigs every day (they'll be in barns) to not even caring weather or not it will effect them, they just don't want it. A facility of this type would bring excellent jobs an influx of outside capital into a small community that could desperately need it. If a business of some other sort wanted to move in I doubt there would be any dissenters. The hog operation will also benefit other area farmers by providing another market for feed stuffs and possibly lowering the basis on selling their crops to local elevators. I urge the Department of Health to do the right thing and approve this facility based on merit/science, and not to give into fear mongering and rumors.

Craig Vaughn

Sincerely,

craig vaughn
104 Bedrock Ln
Cavalier, ND 58220

Sunday, January 24, 2016

Jeremy Lang
Environmental Engineer
N.D. Department of Health, Division of Water Quality
918 E Divide
Bismarck, ND 58501

Subject: I support approval of the hog farm

Dear Environmental Engineer Lang:

I was raise in South Central Minnesota in the heart of Hog farms. My father was a Hog farmer.
The proposed hog farm is NOT the hog farm of my father or grandfather. This is highly technical with trained and educated workers. The waste product will be a benefit to the area farmers. (people are against the smell--but -- with technology the smell is gone) It is a natural product which will not have a negative effect on the environment. It will be located away from any town--but the people of the town allow anhydrous tanks on the main street. These are very very dangerous.
If we don't support production ag, The bacon with your eggs at breakfast will be coming from China.
We have heard the cry of the people of North Dakota---Our schools are dying. The town is dying. What can we do? What can we do? ----Here is an opportunity to have Children in the schools and the town to grow.

Sincerely,

Myrene A Peterson
5140 136th Ave SE
Enderlin, ND 58027

Sunday, January 24, 2016

Jeremy Lang
Environmental Engineer
N.D. Department of Health, Division of Water Quality
918 E Divide
Bismarck, ND 58501

Subject: I support approval of the hog farm

Dear Environmental Engineer Lang:

I am writing to express my support for the proposed hog farm near Buffalo. Increased livestock production is good for everyone: The community gains tax dollars, the local grain farmers gain an additional market, and other local businesses gain a valued customer.
From what I hear, the owners have fulfilled their regulatory requirements, and the opposition, at this point comes from folks that don't want a hog farm nearby. But the set- backs are reasonable and protect the neighbors from any realistic problems and concerns. I just hope that emotion is not allowed to overrule sound science, rules that are already in place, common sense.
I encourage you to allow the project to go forward,

Sincerely,

Diane Hanebutt, 4-H Mom
PO Box 226
New Salem, ND 58563

Sunday, January 24, 2016

Jeremy Lang
Environmental Engineer
N.D. Department of Health, Division of Water Quality
918 E Divide
Bismarck, ND 58501

Subject: I support approval of the hog farm

Dear Environmental Engineer Lang:

The proposed hog farm That is to be located North East one fourth of Section 4 of Howes Twp in Cass County; will have a large economic impact on the Buffalo and surrounding area. There will be 17 high paying jobs that will bring in families to the area.
The 2016 Hog operations are extremely will managed and have to be very efficient to be profitable. These farms use the newest technology to reduce disease and the use of antibiotics.
The Veterinary Feed Directive that will be going into effect on January 1, 2017 prohibits the use of antibiotics in the feed or water for growth promotion. The use of antibiotic can only be used for the treatment of disease as a proscription from a Veterinarian. This proscription is only valid for 6 months for a particular group of animals.
One year storage of manure will allow the manure to be pumped from the storage and injected into the soil; this will reduce any odors from this operation. The manures fertilizers value is much greater that chemical fertilizer. The manures nitrogen phosphorus and potash level will be monitored to comply with the Dept of Health's regulations.

The Axillary services such as livestock hauling, purchasing of feed and ingredients will benefit the local business and farmers
This hog operation will be a win,win for animal agriculture, the community of Buffalo, and 17 additional workers that will be employed by this operation. It also increase the tax base.

Sincerely,

Andrew A Peterson D.V.M
13484 Highway 46
Enderlin, ND 58027

Monday, January 25, 2016

Jeremy Lang
Environmental Engineer
N.D. Department of Health, Division of Water Quality
918 E Divide
Bismarck, ND 58501

Subject: I support approval of the hog farm

Dear Environmental Engineer Lang:

Livestock expansion is good for North Dakota. It's good for the grain farmers too, and I think we should welcome the hog farm near Buffalo.

We had a large hog farm built in our county (Ramsey) about 10 years ago, there were many people from Devils Lake that opposed the farm. There has been no problems with the hog farm and I don't think the average citizen in Ramsey County even knows that the hog farm was built.

We need local markets for our grain and livestock farms are part of the solution.

I'm in favor of the proposed new hog farm in Buffalo. It's good for our rural communities to have growth, and growing livestock farms helps the other farmers in the area too. Since the family involved is meeting Health Department requirements, why should anybody be allowed to stand in their way?

Sincerely,

Paul Becker
9250 58th St NE
Crary, ND 58327

Monday, January 25, 2016

Jeremy Lang
Environmental Engineer
N.D. Department of Health, Division of Water Quality
918 E Divide
Bismarck, ND 58501

Subject: I support approval of the hog farm

Dear Environmental Engineer Lang:

If those involved with the proposed hog facility near Buffalo,ND have met all requirements needed and asked of it by the state, it should be allowed to be built.
Expansion of animal agriculture is much needed in North Dakota.
Support the facility.

Sincerely,

Tom Christensen
7114 110th Ave SE
Verona, ND 58490

Monday, January 25, 2016

Jeremy Lang
Environmental Engineer
N.D. Department of Health, Division of Water Quality
918 E Divide
Bismarck, ND 58501

Subject: I support approval of the hog farm

Dear Environmental Engineer Lang:

I'm in favor of the proposed hog farm near Buffalo that was in the news this week. If the family has met all the requirements of the Health Department, they should be able to grow their business.

Sincerely,

Perry & Diana Moser
13700 52nd St NE
Baldwin, ND 58521

Monday, January 25, 2016

Jeremy Lang
Environmental Engineer
N.D. Department of Health, Division of Water Quality
918 E Divide
Bismarck, ND 58501

Subject: I support approval of the hog farm

Dear Environmental Engineer Lang:

Agriculture in ND continues to be number one as an economic engine. Continued support of properly vetted production units such as this hog farm is very important to feeding the nation not to mention maintaining the health and viability of rural communities..

Sincerely,

Frank E. Walker
319 2nd St SE
New Rockford, ND 58356

Tuesday, January 26, 2016

Jeremy Lang
Environmental Engineer
N.D. Department of Health, Division of Water Quality
918 E Divide
Bismarck, ND 58501

Subject: I support approval of the hog farm

Dear Environmental Engineer Lang:

I support the proposed hog farm near Buffalo. Business' like this are much needed in our state, and not only benefit the local community; but area farmers via the product and co-product utilization in operations of this nature. We are a country with free-market principles that we preach all around the world; if Rolling Green Farms is following all procedures and full cooperation is given throughout the permitting process there should be no reason that the community and the State of North Dakota shouldn't be happy to have them.

Sincerely,

Seth Estenson
8484 Highway 20
Warwick, ND 58381

Tuesday, January 26, 2016

Jeremy Lang
Environmental Engineer
N.D. Department of Health, Division of Water Quality
918 E Divide
Bismarck, ND 58501

Subject: I support approval of the hog farm

Dear Environmental Engineer Lang:

I believe that North Dakota should support the hog farm in Buffalo, ND. This family has been meeting all of the requirements of the Health Department and should not be penalized for doing so. A business such as this will bring many new jobs to the area and will benefit grain farmers in the area that are selling their crops as feed to the hog farm. As a state that is largely comprised of agriculture, I believe we should do as much as we can to promote agriculture and encourage new farmers to start their business. I don't believe that anyone should be allowed to stand in the way of this new hog farm as I only see this as a benefit to the community.

Sincerely,

Jennie Brossart
4510 Highway 17
Wolford, ND 58385

Tuesday, January 26, 2016

Jeremy Lang
Environmental Engineer
N.D. Department of Health, Division of Water Quality
918 E Divide
Bismarck, ND 58501

Subject: I support approval of the hog farm

Dear Environmental Engineer Lang:

I support the approval of the proposed hog farm near Buffalo. The Rolling Green Family Farm has met all the requirements of the ND Health Dept for health and safety. North Dakota needs livestock expansion just like any other business and will provide jobs and a sale of feed from ND producers. I see no reason that it should be opposed if all the requirements are met.
There are other hog farms in ND and they do not pose a health and safety problem for anyone in the communities they are located in. Why should it be opposed near Buffalo.

Sincerely,

Donald Boardman
811 Thompson St
Bottineau, ND 58318

RECEIVED
JAN 25 2016
DIV. OF WATER QUALITY

January 20, 2016

ND Department of Health
Division of Water Quality
918 East Divide Avenue
Bismarck, ND 58501-1947

To Whom It May Concern:

I have interest in a family farm near Buffalo, ND and wish to express my opposition to a 9,000-hog operation which is proposed by Pipestone Holdings - Rolling Green Family Farms, to be located on land very near to our family farm.

My concerns begin with the fact that this project was kept very quiet, obviously with little interest in educating or collaborating with the citizens of Buffalo and surrounding rural area. News seemed to break just prior to the deadline for submission of letters of opposition. This does not appear to be a community-friendly approach or one that shows concern for the local residents.

Air and water pollution, health hazards and quality of life are three prime considerations and concerns to the citizens of this area. They should be concerns as well to the state of North Dakota and to the North Dakota Department of Health.

I would ask that you consider the conditions that you and this out-of-state enterprise will be imposing upon the people of the Buffalo area. I would ask you to prevent this hog farm from moving forward by refusing to award the permit to Pipestone Holdings - Rolling Green Family Farms .

Sincerely,

Chelsea Monda

Chelsea A. Monda
1446 – 11th Avenue South
Fargo, ND 58103

RECEIVED
JAN 15 2016
DIV. OF WATER QUALITY

3610 140th AVE SE
Buffalo, ND 58011
January 12, 2016

Dear Sirs;

I have been informed a few days ago that we will be having a pig farm 1 1/4 miles from our farm site. I have studied the situation on line and have been very upset with what I found. First, the odor, flies, and disease. Second, our gravel roads that they will be traveling on with semis at least five times a week with feed and hauling their hogs. Third, will our property have the value it has now? what people will they hire to work there? Its a safety question when your my age. We lived in this farm site for 53 years and love the peaceful atmosphere. I feel my life has been turned upside down. I hope you take this all under consideration.

Your truly
Judith VonBank

Received January 15, 2016

North Dakota Department of Health

Dear Sirs:

I have been informed a few days ago that we will be having a pig farm 1 ¼ miles from our farm site. I have studied the situation on line and have been very upset with what I found.

First the odor, flies, and disease. Second, our gravel roads that they will be traveling on with semis at least four times a week with feed and hauling their hogs. Third, will our property have the value it has now?

What people will they hire to work there? It's a safety question when you're my age. I've lived in this farm site for 53 years and love the peaceful atmosphere. I feel my life has been turned upside down. I hope you take this all under consideration.

Yours Truly,

Judith Von Bank

3610 140th Ave SE

Buffalo, ND 58011

Received on January 25, 2016

To: NDDH

I am writing this letter as a concerned land owner of Cass County. It is concerning the permit for Rolling Green Family Farms RE LLC (Wrong: LLP) Hog Operation being built on Section 4 of Cass County.

I believe it would be harmful to the growth of our community, as we have had several families from Fargo/West Fargo move out to this area and buy/build homes. Not only in Buffalo, but along this County 3 Road.

I also have the following concerns for the hog operation of their size:

1. Decrease to land value.
2. Contamination of underground water.
3. Manure Management
4. Odor

My husband and I owned/operated our own farrow-to-finish hog operation for 15yrs. Although, much smaller than this operation, we still had to manage the manure and odor. Even though we kept our facility clean and well maintained and the manure pit used liquid bacteria, we had odor.

So, please reconsider this permit and deny!

Thank you!

Joan Boyd

RECEIVED
JAN 25 2016
DIV. OF WATER QUALITY

Sandra Cromwell
14006 37th St SE
Buffalo, ND 58011
January 20, 2016

ND Dept. of Health
Div. of Water Quality
918 East Divide Ave.
Bismarck, ND 58501-1947

Dear ND Dept. of Health:

RE: Notice #ND-2015-019

I am requesting a public hearing before finalization of this permit. We are asking that you seriously consider the effects of this situation long and short term. I have deep concerns of the quality of air, water and life if this CAFO is permitted in this area, as well as property values of homes and business if this permit is granted.

As far as health, I have terminal small cell lung cancer that that I am receiving chemo and radiation therapy for. I cannot breathe well or sit outside on windy days, and with this facility coming in I won't be able to be outside on the good days that I have. I am not on oxygen at this point by trying not to exert myself. If the air becomes too polluted there will not be an option but to use the oxygen at a great risk of the short time of life that I have left. Quality life is all that I asking for at this time.

I will miss out on the chance of watching my grandchildren and great-grandchildren when they come to see us. Please consider this as a serious situation. Thank you for your time.

Sincerely,

Sandra Cromwell

RECEIVED
JAN 2 3 2016
DIV. OF WATER QUALITY

Vicki Wendt
3805 139 Ave SE
Buffalo, ND 58011

North Dakota Department of Health
Division of Water Quality
600 E Boulevard Ave
Bismarck, ND 58505

January 20, 2016

Dear North Dakota Department of Health,

I am from Buffalo, ND. I am writing in opposition to the permit requested by Rolling Green Family Farms RE, LLP for a 9,000-hog farm southeast of Buffalo.

I adamantly oppose the construction and operation of the proposed 9,000-hog site due to the obvious stench that large hog farms produce. I am greatly concerned about how this will affect my quality of life as well as my property value. I am proud of my home 4 miles straight south of Buffalo. My husband and I built here in 2001 and have been enhancing our property ever since. We have a great back yard with an in-ground swimming pool and outdoor kitchen, including a fire place and wood-fired pizza oven. We have many extended family gatherings in our yard and many quiet afternoons on our deck enjoying the beautiful North Dakota sunsets and fresh air! Hog farms are well known for creating an unbearable stench that can be smelled from many miles away. There is no way that a hog farm 3 miles from my yard will not be smelled from my yard. And, even worse, plans for disposing manure into farmland includes land a half mile behind my house! In fact, per field drawings provided by your office, fields 10, 20 and 21 are all within a mile of my house. That's 305.5 acres right around my house that are planned for being covered in hog manure!

We've learned that an operation like this can't be within a half mile from a residence. We all know a half mile is unreasonably close. The manure on the hog farm site will be in concrete pits under the buildings and still, by your restrictions, must be at least a half mile away from a residence. So how is it possibly ok to cover 300 acres of farmland within a mile of my home with manure?

A brief internet search quickly produces multiple stories of hog-farm stench issues around the country. There are multiple lawsuits. There are millions of dollars in damages awarded to property owners. Nobody can honestly claim that this stench isn't going to affect our community. There is just so very much wrong with what is happening here.

We are not trying to close down an existing multi-generational family farm. We absolutely do not approve of the corporate farm moving in and disrupting our way of life.

I am one rural resident. All of my neighbors have the same concerns, including the residents in town. The only ones not opposing this are those standing to benefit financially. This will deter new residents to Buffalo. This will affect our property value. This will affect our quality of life. There will be lawsuits. I beg you: stop this now!

Vicki Wendt

Vicki Wendt

Vicki Wendt
3805 139 Ave SE
Buffalo, ND 58011

North Dakota Department of Health
Division of Water Quality
600 E Boulevard Ave
Bismarck, ND 58505

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Vicki Wendt

RECEIVED
JAN 19 2016
DIV. OF WATER QUALITY

1-16-16

ND Dept of Health, Division of water Quality
Att: Jeremy - 4th floor

I am writing in regard to the pig operation proposed to be built in our neighborhood at Buffalo, ND.

I have just recently heard about this project, so have many questions and am very much opposed to it. No one has talked to me about the drainage over my land. Then it goes on to Interstate #94 ditch, under the highway a on.

It would affect the air quality for us, the condition of Howe township road that passes it, possibly flies. I have a neighbor who has a handicapped grand child with them alot. This is near the site. With the air quality there would be, the child could not be outside. I live about 1 1/2 miles away + have alot of health problems, so would not want to be outside in that air either.

Please try to do whatever can be done to stop this project.

Thank you for your attention.

Jacqueline Marcks
Buffalo, ND

Received: January 19, 2016

North Dakota Department of Health

Attention: Jeremy

I am writing in regard to the pig operation proposed to be built in our neighborhood at Buffalo, ND.

I have just recently heard about this project, so have many questions and am very much opposed to it. No one has talked to me about the drainage over my land. Then it goes onto Interstate #94 ditch, under the highway and on.

It would affect the air quality for us, the condition of Howe township road that passes it, possibly flies. I have a neighbor who has a handicapped grandchild with them a lot. This is near the site. With the air quality there would be, the child could not be outside. I live about 1 ½ miles away and have a lot of health problems. So would not want to be outside in that air either.

Please try to do whatever can be done to stop this project.

Thank you for your attention.

Jacqueline Marcks

PO Box 121

Buffalo, ND 58011

RECEIVED
JAN 15 2016
DIV. OF WATER QUALITY

3610 140th AVE SE
Buffalo, N.D. 58011

January, 15, 2016

Dear Sirs:

It has come to my attention that there are people who who like to put a hog feeding system 1 1/4 miles from our farm. I have lived here all my life and have valued the fresh air that I have lived with. I feel no one has the right to contaminate my fresh air with the smell of hogs. I have problems breathing, because I have asthma.

I wouldn't want a bunch of trucks going by near with dust and wrecking the roads. I think it could destroy our property values. and people would not want to build homes because of the smell.

I would appreciate it if you would not grant a permit to these people who would like to build a hog set up in our territory.

Thank-you very much.

Sincerely
Robert Bork

Received January 15, 2016

North Dakota Department of Health

Dear Sirs:

It has come to my attention that there are people who like to put a hog feeding system 1 1/4th miles from our farm. I have lived here all my life and have valued the fresh air that I have lived with. I feel no one has the right to contaminate my fresh air with the smell of hogs. I have problems breathing, because I have asthma.

I wouldn't want a bunch of trucks going by hear with dust and wrecking the roads. I think it could destroy our property values, and people would not want to build homes because of the smell.

I would appreciate it if you would not grant a permit to these people who would like to build a hog set up in our territory. Thank you very much.

Sincerely,

Robert Von Bank

3610 140th Ave SE

Buffalo, ND 58011

Received Jan. 20, 2016

NDDH

To whom it may concern:

I am writing concerning about a pig set up which will be built approximately 2 miles east and two miles south of Buffalo, ND. I am upset and against such a thing.

Reason 1- we built a new home one and a half miles south of Buffalo on County Road 38. The home is appraised at half a million dollars. Having this hog farm 2 miles east would certainly decrease the value of the home for resale.

Reason 2- We are retired, but when we farmed, (my husband farmed), he raised hogs. There is nothing worse than the smell of hogs, and I know we will be able to smell “pigs!”.

Reason 3- Since we have farm land around that area, runoff is a worry.

Reason 4- What about the effects on underground water? That is our source of water, and heaven forbid should that become contaminated.

Reason 5- How about the competition of the fertilizer with our local fertilizer dealers?

These are just a few of my concerns. I truly hope no permit is issued to allow this set up.

Thank You

Stephanie Baasch

13905 36th Street SE

Buffalo, ND 58011

RECEIVED
JAN 20 2016
DIV. OF WATER QUALITY

13905 36th St SE
Buffalo ND
January 15 2016

To whom it may concern:

I am writing concerning about a pig set up which will be built approx 2 miles east and two miles south of Buffalo, ND. I am upset and against such a thing -

Reason 1 - we built a new home one and a half miles south of Buffalo on County Road 38 - The Home is appraised at a half a million dollars - Having this hog farm two miles east would certainly decrease the value of the home for resale -

Reason 2 - we are retired, but when we farmed, (my husband farmed), he raised hogs - There is nothing worse than the smell of hogs - and I know we will be able to smell "pig!" -

Reason 3 - Since we have farm land around that area, runoff is a worry -

Reason 4 - what about the effects on underground water - that is our source of water - and heaven forbid should that become contaminated

Reason 5 - How about the competition of the fertilizer with our local fertilizer dealers?

These are just a few of my concerns - I truly hope no permit is issued to allow this set up - Thank you

Stephanie Beasch

1-11-16

RECEIVED
JAN 14 2016
DIV. OF WATER QUALITY

Jeremy
c/o
N.D. Dept of Health
Div. of Water Quality

Roy Thompson
PO Box 194
Buffalo, ND
58011

Jeremy:

As to our phone conversation today here are some of my concerns

Smell: When Jack Rabbit farms was started in Maddville S.D the neighbors ~~were~~ were told the same thing, some odor at certain times. They are now living a nightmare we hope to avoid, check this out at Maddville Times.com. Jack Rabbit Farms

Wells: They are hoping to run this farm, or factory lets call it, on TWO wells, a couple neighbors had small hog operations a few years ago and had to pipe in rural water as the well water was too high in salts for the hogs to do well.

We are not set up for the truck traffic, which is already bad at times, or the the influx of workers, Housing is in short supply here.

We really need a public meeting as some of my neighbors have been in ag all their lives and are better informed then I to bring some educated questions to this subject.

Many are quite concerned

What do they do with the liquid manure when the ground freezes and it can't be dug in?

As I said these are only some of my concerns. This proposed hog factory is kicking up some serious dust around here. One thing about it, its got all the neighbors visiting again

Would like to here from you

Thanks

Rob

NDDH

Received: January 14, 2016

Dear Jeremy,

As to our phone conversation today, here are some of my concerns.

Smell: When Jack Rabbit farm was started in Madville, SD the neighbors were told the same thing, some odor at certain times. They are now living a nightmare we hope to avoid, check this out at MadvilleTimes.com/Jack Rabbit Farms.

Wells: They are hoping to run this farm, or factory let's call it, on two wells, a couple neighbors had small hog operations a few years ago and had to pipe in rural water as the well water was too high in salts for the hogs to do well.

We are not set up for the truck traffic, which is already bad at times, or the influx of workers, housing is in short supply here.

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What so they do with the liquid manure when the ground Freezes and it can't be dug in?

As I said, these are only some of my concerns. This proposed hog factory in kicking up some serious dust around here. One thing about it, it's got all the neighbors visiting again. Would like to hear from you.

Thanks

Roy W Thompson

PO Box 194

Buffalo, ND 58011

RECEIVED
JAN 14 2016
DIV. OF WATER QUALITY

1-11-16

Sheila Thompson
3517 142nd Ave. SE.
P.O. Box 194
Buffalo, ND 58011

Jeremy,

It's hard to put into words how finding out about a large (thousand) hog operation going just down the road from me, can actually affect your daily life,

this operation is called Rolling Green Family Farms RE. LLC.

I was notified Friday by the mayor of Buffalo, who had just found out somehow. It was all kept a secret from the close neighbors it would actually affect the worst. I just live a short distance down the gravel road where they want to put it.

My husband has done research about a operation they started in SD. and how people there are ~~lesser~~ now living the "nightmare"

You can read about it at
madvilleTimes.com - Jackrabbit farms

Here is the permit information
ND-2015-019
Application date 10/8/15 # NDAF00853
" Name Rolling Green Family Farms RE LLC
Mailing add: 1308 S. Hwy 75,
Pipestone, Mn. 56164
Telephone 507-825-4211
Proposed Permit Exp. date 12/31/2020

We have a great quality of life here and that would all end.
I can't even imagine the stench and trying to be outside.
A big operation like this does not belong here.
We sure need to bring it to someones attention that can help us. Anything you can do to help us would be greatly appreciated.
It would affect so many things the odor, the traffic, trucks huge buildings, noise, water/land quality.

try to imagine how you would feel if someone told you this was going to be built right by you!

Please look into what is being done to help us out. We want to keep our peaceful countryside.

thank-you

Sheila

1-11-16

ND Department of Health

Jeremy,

It's hard to put into words how finding out about a large (thousands) hog operation going just down the road from me, can actually affect your daily life.

This operation is called Rolling Green Family Farms RE. LLC. I was notified Friday by the mayor of Buffalo, who had just found out somehow. It was all kept a secret from the close neighbors it would actually affect the worst. I just live a short distance down the gravel road where they want to put it. My husband has done research about a operation they started in SD, and how people there are now living the "nightmare".

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Mailing add: 1300 S Hwy 75

Pipestone, MN 56164

Telephone: 507-825-4211

Proposed Permit Exp. Date 12/31/2020

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Try to imagine how you would feel if someone told you this was going to be built right by you!

Please look into what is being done to help us out. We want to keep our peaceful countryside.

Thank you,

Sheila Thompson

3517 142nd Ave SE

PO Box 194

Buffalo, ND 58011

Jan. 20, 2016

North Dakota Dept of Health,

RECEIVED
JAN 25 2016
DIV. OF WATER QUALITY

I am writing this letter as a concerned land owner of Cass County. It is concerning the permit for Rolling Green Family Farms RE, LLC Hog operation being built on Section 4 of Cass County.

I believe it would be harmful to the growth of our community, as we have had several families from Fargo/West Fargo move out to this area and buy/build homes. Not only in Buffalo but along this County (3) Road.

I, also, have the following concerns for the Hog operation of their size:

1. Decrease to land value
2. Contamination of underground water
3. Manure management
4. Odor.

My husband and I owned/operated our own Farrow-to-finish Hog operation for 15 yrs. Although, much smaller than this operation, we still had to manage the manure and odor. Even though we kept our facility clean and well maintained and the manure pit used liquid bacteria, we had odor.

So, Please, reconsider this Permit and deny!

Thank you!

RECEIVED
JAN 25 2016
DIV. OF WATER QUALITY

Alan Dostert

405 4th Street North
Buffalo, ND 58011
Phone: 701.261.9589

ND Dept. of Health

Division of Water Quality
918 East Divide Avenue
Bismarck, ND 58501-1947

To whom it may concern:

This letter is to express concerns over the Commercial Swine Operation proposed in Howe Township, at a location just south and east of the city of Buffalo. My concerns revolve around to primary issues (with several lesser issues that I won't address here). Those issues are; potential runoff and environmental issues with odors.

I come from a farm background and actually grew up 3.5 miles directly west of a much smaller swine operation. Our family saw and experienced firsthand negative experiences with that much less intensive operation.

My wife's family farm lies nearly directly in the path of possible run off. Understanding that the holding cells for the manure are to be designed for the 100 year rain event, the concern here is what occurrence of a 100 year event has historically occurred in this area of Cass County and additionally what assurances are in place to protect the environment if the management of this facility were to "overfill" or otherwise mismanage the capacity of the holding structures – I have been all too experienced with other "100 year events" that affected Grand Forks, ND (while living there), Moorhead, MN (while living there), and Minot, ND (while operating a branch office and having direct family there). The point is that with 'global weather change', 100 year events seem to happen much more frequently, and they have all had a certain "human factor" in the ultimate failure to protect private property and lifestyle.

Of a much greater concern is the odors that emanate from such operations. My experience is that there is no way to control the odors that have their origins at the confinement/holding area/manure pits, and the seasonal sickening effects resultant form the agitation and subsequent dispersal of the manure when the large exterior holding cells are discharged/emptied.

My family moved to Buffalo for a quiet and serene way of life. I have lived next to, and experienced the sickening effects of a smaller rural family farm based swine operation, the lagoon effects from operations at American Crystal Sugar (as it affected both Grand Forks and Fargo/Moorhead), the methane releases from the landfill operations in Fargo, and never in my worse dreams thought I would be facing similar, in not worse potential in Buffalo, ND.

The potential effects of such environmental desecration will reverse the long ongoing focused efforts to build our city and offer a quality of life that other locations cannot match. Please carefully consider what we have to lose and I strongly urge you to reject the commercial swine operation permit – it will hurt this community greatly!

Alan D. Dostert, Very Concerned Buffalo Resident and Community Participant

January 17, 2016

Strommen, Rachel A.

From: Rockeman, Karl H.
Sent: Tuesday, February 09, 2016 4:12 PM
To: Lang, Jeremiah M.; Strommen, Rachel A.
Subject: FW: Rolling Green Family Farms

Karl Rockeman, P.E.
Director
Division of Water Quality
North Dakota Department of Health
(701)328-5210

From: Amon Baer [mailto:eggs@rrt.net]
Sent: Tuesday, February 09, 2016 2:26 PM
To: Rockeman, Karl H.
Subject: Rolling Green Family Farms

2-9-2016

Karl Rockeman:

I am writing to offer my support for the construction of the hog confinement facility proposed by Rolling Green Family Farms in Cass County near Buffalo ND. North Dakota is in need of diversifying the agricultural base of the economy and livestock development can play a key role. The size of this operation will add many millions of dollars to the local economy of western Cass County.

Amon Baer
28415 40th Ave. S.
Lake Park, MN 56554
218-937-5350

RECEIVED
JAN 25 2016
DIV. OF WATER QUALITY

To the North Dakota Department of Health,

My wife and I (& soon to be baby) just built our home less than 1.5 miles east of the proposed hog farm operation (Rolling Green Family Farms RE, LLC) southeast of Buffalo, ND.

Health is wealth and I consider it to be the most important thing in my life. I have a concern that this farm could have negative air quality impacts to my family, which could result in health issues.

I am concerned that when the small containment pond at this farm overflows, that contaminated water will be surface running across a downstream neighbor and could cause impacts to his farmland.

I am disappointed in the permitting process in the state of North Dakota. I believe that the setback distance for the nearest home should be greater than 0.5 miles, and personally being less than 1.5 miles from the proposed farm, I believe it should be greater than that distance as well. I also believe that when a farm of this footprint is applying to construct somewhere new, like in this situation, that there should be a mandatory informational meeting required for all local public. It is very unfortunate to know that this facility could have broke ground without the adjacent landowner even knowing about it.

The proposed route trucks will use to get to and from the farm will be to travel north one mile off of the Ayr exit (off I-94), then go west 0.5 miles, and then south 0.5 miles. Why impact more of the township and county roads than needed? I suggest they change their proposed route to traveling 0.5 miles north off of the Ayr exit and then 0.5 miles west to the farm. This will limit the road maintenance agreements the farm will need to acquire for keeping up the county and township roads. The more they travel on their own road, the less they impact the public roads. Changing the driving route as proposed, will dramatically reduce the impact of increased traffic and the degrading of roads, for at least eight of the closest neighboring homes.

Increased truck traffic on the route my family and I drive is a safety concern that we would have to live with and be cautious of for the rest of our lives. One reason we moved to rural Buffalo was for a quieter, safer, and more private environment. Another reason was to enjoy our evenings on our future backyard deck to enjoy the sunsets to the west and the fresh air of the country. It is unfortunate that our new neighbor to the west could be a large hog farm rather than a more typical neighbor such as a young family with kids and a dog.

I understand that the landowner of this hog farm is trying to bring more value to his farm operation, and I commend him for being proactive and progressive with his farm. Unfortunately for my family and I, we gain little direct personal value from this proposed hog farm because of the location of it to our new home.

In closing, I wish I would have known about the potential building location of this hog farm before my wife and I began construction on our home in May of 2015. Knowledge of this would have surely factored into one of the largest decisions we have made in life. It is unfortunate that a large hog operation could be our upwind neighbor.

I ask you to re-consider the location of this hog farm, thank you,

Andrew Fraase

RECEIVED
JAN 25 2016
DIV. OF WATER QUALITY

To whom it may concern:

As the mayor of Buffalo, North Dakota, I am writing today to see if I can find out what has gone wrong with regulations in our state that can take away the rights of our people to control the environment in which they live and their quality of life.

I know you have received letters from many wonderful people who are very concerned about the proposed changes to take place in their life and which will greatly change the place that they call home. I know that many of them have done research and were able to express concerns about water quality, gases released in the hair, odor, the lagoons which will contain the manure from the pigs, sanitation, disease, dealing with the dead animals-the list goes on and on.

There is no need for me to add to what has already been expressed by dozens of letters which have been sent to you from Buffalo and other parts of the state as well as letters from people who no longer live in Buffalo but continue to have an interest in our town. I would rather ask some questions to which I have sought answers without success.

Why would investors and a company like Rolling Green Family Farms come to North Dakota to invest? Rolling Green told us that they had been invited to North Dakota, they haven't broken any laws, and that they were here to stay. They said that if we didn't like them coming here we had better change the law.

Has Rolling Green Farms ever had problems in other places with hog farms that they have established?

Why has this all been keep quiet with only a very few people knowing what was going to happen? It was only by chance that I found out about it a few days before I hastily called a public meeting on January 18.

Why did the local investor in Buffalo not want such a meeting and did nothing to advertise it?

Why have officials in Bismarck known about this for almost a year and also kept it quiet.

Why didn't the Cass County Commission know about this project?

Why wouldn't the local family who has sold the land for this project have visited with their life long neighbors and friends?

Why were the contracts already signed for farmers who were to receive fertilizer from this project and Rolling Green Farms refused to give us the names?

Why would Rolling Green Farms attend our meeting with an attorney? Why would they harass Mr. Randy Coon, a man from our community, while he was trying to speak on our behalf at our meeting? Mr. Coon has worked in ag economy research for about forty years at NDSU. Why was his job threatened two days later by the Executive Director of a very important ND Ag organization? Maybe I can answer that. It was probably because the son of the man who sold the land is the vice-president of that organization.

Why did it take so long for the North Dakota Department of Health to listen to our concerns and finally grant us some time to collect information and have a public hearing? Was it

because we were finally able to get to the right people to intervene on our behalf?

I have been told that the Health Dept. will only consider health issues when granting this permit? Who will consider the other issues like land devaluation, increased truck traffic, wear and tear on country roads, and quality of life?

Why have we had so many phone calls from individual people and organizations offering us help? Why are they so concerned that this project be stopped here and now?

Why would Rolling Green tell us at our meeting that they hired mostly college graduates to work and that these people would have big salaries. Buffalo might very well benefit from sixteen or seventeen new families moving into town. Our city would benefit from hundreds of thousand of dollars put into our local economy and Rolling Hills would contribute to churches and other organizations. They would become part of our town. Past experience of others, much of the information available, indicates that that is not true.

I wonder who is going to inspect this operation and how often? What will happen if there are violations? How many people are working to keep track of farms like Rolling Green in our state?

I could continue this list for a long time. However, I think the most important thing at this time is that the people of the Buffalo Community have just begun in their efforts to stop this pig farm in our area. We have many people on our side and we are prepared to do what it takes. It is shameful that so many people are upset by this project. It will end up with a lot of heart ache and expense for our community which may, in the

end, be impossible because we are going up against something or someone of which we know so little. This is not just a Buffalo problem but a problem which the entire state needs to be concerned about. Our state government should be here to represent the people of our state and their interests....not the interest of big business.

Sincerely,

Antoinette M. Fraase Babcock

Antoinette M. Fraase Babcock
Mayor of our home, Buffalo

RECEIVED
JAN 25 2016
DIV. OF WATER QUALITY

Arnetta Frueh
14006 37th St SE
Buffalo, ND 58011
January 20, 2016

ND Dept. of Health
Div. of Water Quality
918 East Divide Ave.
Bismarck, ND 58501-1947

Dear ND Dept. of Health:

RE: Notice #ND-2015-019

I am requesting a public hearing before finalization of this permit. We are asking that you seriously consider the effects of this situation long and short term. I have deep concerns of the quality of air, water and life if this CAFO is permitted in this area, as well as property values of homes and business if this permit is granted.

We have the City of Buffalo within 3 miles with K-3rd grade school age children, a preschool, and a daycare all within the radius of harm according to the CDC.

Also our property is our legacy to our children and grandchildren and we are not willing to take a chance of losing this or our investment of our property.

As far as health, I have stage 4 kidney disease that I have controlled for four years. I do this by staying healthy and away from any harm as far as insects (mosquitos and fly's) because of parasites. With this facility comes fly's that number in the millions. As far as air control the pathogens that will be in the air are deadly to my well being. I will not be able to be out doors and enjoy my gardening and playing with my grandchildren or just sitting and enjoying the view and fresh air.

Please consider this as a serious situation. Thank you for your time.

Sincerely,

Arnetta Frueh

Cameron Gilley
2910 146th Ave SE
Ayr, ND 58007

North Dakota Department of Health
Division of Water and Air Quality
918 E Divide Ave.
Bismarck, ND 58501

To whom it may concern:

I am a 16-year-old living in Cass County. Pipestone is planning to make a new pig farm (Application #DNAF00853) about 6 miles southwest of my house. I am worried that the new farm will produce large quantities of waste that will contaminate groundwater, and also spread E coli and Salmonella. I have lived near these farms before and they were terrible. They smelled incredibly bad, and were ugly. They do not produce high quality jobs, and overall do not provide my community enough benefits to get over their many faults. Please address these concerns.

Thank you,

Cameron Gilley

Cameron Gilley

January 19, 2016

1449 – 8th Street South
Fargo, ND 58103

RECEIVED
JAN 25 2016
DIV. OF WATER QUALITY

ND Department of Health
Division of Water Quality
918 East Divide Avenue
Bismarck, ND 58501-1947

To Whom It May Concern:

I am writing this letter to address my concerns over a hog operation which is to be located near Buffalo, ND. I am a Fargo resident, but my family has a farm near the proposed site of this operation. I spend a great deal of time at the family farm and therefore have a stake in your decision to grant a permit to Pipestone Holdings/Rolling Green Family Farms RE. I feel that the negative impact could be felt here in Fargo as well.

Air and water pollution are obvious environmental issues with an operation of this scope. Historically, corporations are concerned with making money, as opposed to being good stewards of the land. Buffalo and the surrounding area will see the future of their community turned over to outside interests and one can only imagine the continuing regulatory problems.

There are a number of health hazards that you should also consider as you make this decision. Research shows that pathogens, to include salmonella and E.coli are present in hog waste, certainly a concern to public health. In addition, ammonia and hydrogen sulfide, which cause respiratory problems, are released into the air. These conditions will expose the surrounding area to health risks, and the level of drift cannot be fully determined.

Quality of life is a final concern. I have lived on a farm with a small number of hogs, as well as had neighbors with hogs and I know that the odor that comes with hogs cannot be ignored. Those were very small operations, not the 9,000 hogs of the proposed project.

Due to concerns of environmental impact, health hazards and quality of life, I am strongly opposed to this project. Please do not allow this effort by out-of-state entrepreneurs to be railroaded through with blatant disregard for the environmental and health issues that will be imposed upon the land of Cass County and the citizens who live in this area. Please make your decision as though this 9,000 hog enterprise was going to be in ***your*** backyard. Please prevent this project from moving forward by refusing to award the permit to Pipestone Holdings/Rolling Green Family Farms RE.

Sincerely,

Candace S. Shultz

RECEIVED
JAN 25 2016
DIV. OF WATER QUALITY

North Dakota Department of Health
Division of Water Quality
91 East Divide Ave
Bismarck, ND 58501-1947

To Whom it May Concern:

I am writing to express my concern about the potential building of the "Rolling Green Family Farm, LLC" at Buffalo, ND. I am part of the fourth generation to be raised on a family farm south of Buffalo. This farm is less than 2 miles from the proposed site. As was most of the community, I was very surprised by the news of this possibility.

My concerns are founded on quality of life for the surrounding area and the community. Air quality will certainly be affected. Pigs smell! And the effect of the foul odor will be an issue for more than the immediate area. Continued exposure to the foul odor certainly diminishes quality of life. In addition to the unpleasantness, exposure to ammonia, hydrogen sulfide and organic dust are known to have adverse effects on respiratory health.

Water quality may be affected. The increased volume of waste will carry with it the potential of pathogens and excessive nutrients. This increased input in a water-shed area may not be over-come by best practices, and the increased concentration of the waste may result in increased water born disease.

The high concentration of swine will increase the health risks from pathogens. In maintaining the interior environmental conditions, pathogens are trapped and increase the risk of respiratory conditions, such as asthma, for workers. Research is also being done to identify the impact on neighboring areas.

My background in science pushes me to research the environmental and physical impacts. However, the socioeconomic impact of such an operation is just as great. The LLC touts up to 17 new positions being created. These jobs will not likely be skilled positons, and how many will actually choose to live, buy, and pay taxes in Buffalo? Ultimately, these 17 positions may have the effect of destroying even more jobs, further depleting a shrinking rural population.

Buffalo is a small but proud community. It has met obstacles and challenges with resolve and cooperation. The people have a sincere interest in what is best for the community. Educated and thoughtful problem solving are hallmarks of the approach taken in facing change and challenge. The community values the unique qualities of life in the open spaces – clean air – clean water – potential for good health. Large corporations notably have little concern for the communities they inhabit. North Dakota needs to take strong measures to support the rural population. I urge you to **listen to the concerns of the community**. Thorough research of the impact of such a COFA on the community and surrounding areas would seem the most prudent next step.

Yours truly,

Carol L Beaton

Carol L. Beaton
1326 9th St. S.
Fargo, ND 58103

RECEIVED

JAN 19 2016

DIV. OF WATER QUALITY

North Dakota Dept. of Health, Div. of Water Quality

To Whom It May Concern:

I'm writing this letter in regards to the proposed Rolling Green Family Farms draft permit for a large
swine opperation near the town of Buffalo, ND. I am oppose to this opperation being built in our community. I am the sole heir to my family's farm and I'm very, very upset with the adverse air quality and water shed down stream to lower elevations that this operation will impose, not only on our property, but our city itself. The large number (ruffly 10,000 pigs) will effect the surrounding area with a horrendous smell that will definitely effect the farms located near the proposed site, and the city of Buffalo. Our land is located around the perimeter of the proposed site and I know the air quality we will be exposed to while we farm our land will be overpowering. I also am concerned with the water shed. The drainage coming across the property will directly effect our property and from our land it will drain right onto the I-94 ditches. I can not believe the State Highway Department is, in good faith, approving this permit. I also am concerned with the amount of water this operation will be using on a daily basis. It is my understanding that Rolling Green Family Farms will be drilling wells on the property to supply the water it needs. The wells on the surrounding farms are artesian (which to my knowledge isn't good for animals), so how will they get fresh water? Our rural water system was not installed to handle the amount of water needed to supply large feed lots, so how will that issue be handled? Will we have to pay for a new water system for someone else's business? I believe the parent company behind this proposed operation has run into many problems in Minnesota and South Dakota with regards to not being able to maintain their promises of air quality and water shed management to the communities, townships, counties and state departments where their operations are located. The draft states that the manure pits and the spreading of manure will be a source of odor. There are no assurances that this smell won't inundate my family farm, the neighboring farms and the city of Buffalo. Our experience with similar sources of odors prove that such inundation happens regularly over much greater distances what has been proposed (the swine operation in Larimore, the beet plants in East Grand Forks and Moorhead, the Fargo lagoon and Fargo garbage dump). Please don't put this burden on our community. Its hard enough already to try to keep our community growing. Would you want to move to a lovely small bedroom community and get to your work place and realize that your cloths and hair smell like manure?

I am asking that you not grant approval for this permit. Please, do not grant this permit.

Sincerely,

Carolyn Dostert
305 4th St N
Buffalo, ND 58011

Received: January 25, 2016

To: NDDH

Dear Sir:

I live in Buffalo, ND, a small town in Cass County and I have just heard that a local man has sold land to a company that plans to start a pig breeding operation which will accommodate 9000 plus pigs. This just seems unacceptable to me.

We have worked hard for many years to build a community that has a variety of activities, is attractive to look at, and we are interested in encouraging new people to settle on existing property. We have active churches, excellent schools and a population eager and willing to achieve our goals.

This pig enterprise is truly going to threaten our way of life. The odor, air quality, and water pollution will be unacceptable, and will make it difficult to have a normal atmosphere in which to work and play.

I'm sure the Rolling Green Family Farm has pages of statistics that will show our worries are groundless, but common sense and experience tells us otherwise. Can this be stopped?

Yours Truly,

Carolyn Pfeifer

PO BOX 152

Buffalo, ND 58011

Buffalo, ND
Jan. 20, 2016

RECEIVED
JAN 25 2016
DIV. OF WATER QUALITY

ND Dept. of Health
Div. of Water Quality
918 East Divide Ave.
Bismarck, ND

Dear Sir:

I live in Buffalo, ND, a small town in Cass Co. and I have just heard that a local man has sold land to a company that plans to start a pig breeding operation which will accomodate 9000+ pigs. This just seems unacceptable to me.

We have worked hard for many years to build a community that has a variety of activities, is attractive to look at, and we are interested in encouraging new people to settle on existing property. We have active churches, excellent schools and a population eager and willing to achieve our goals.

This pig enterprise is truly going to threaten our way of life. The odor, air quality, and water pollution will be unacceptable, and will make it difficult to have a normal atmosphere in which to work and play.

I'm sure the Rolling Green Family Farm has pages of statistics that will show our worries are groundless, but common sense and experience tells us otherwise.

Can this be stopped?

Yours truly,
Carolyn Pfeifer
PO Box 152
Buffalo, ND 58011

January 21, 2016

RECEIVED
JAN 25 2016
DIV. OF WATER QUALITY

To ND Dept of Health,

We are very concerned about the proposed large hog operation by Buffalo. Charles has COPD and it is crucial that he has healthy clean air to breathe. It could limit his time outdoors or even having our windows open. Not to mention the smell. We have raised small herds of hogs and known what it's like. We can't imagine the stench from thousands of hogs. It has been found that there is an association between living in proximity to high-density livestock production and community-acquired infections with methicillin-resistant Staphylococcus aureus, known as MRSA. This is especially dangerous for someone in poor health.

What about our water supply? roads? We get water from Cass Rural Water. Will there always be enough water? This operation would be extremely hard on our roads. Our taxes could go up to maintain them.

As far as jobs for Buffalo, there are no houses available in Buffalo. Workers would be coming from outside the area.

We live in the southwest corner of section 25. Please give this serious consideration and not give approval. Sincerely, Charles & Marlene Sheldon

3417 144 Ave SE Buffalo ND 58011-9763

Received: January 25, 2016

To: NDDH

We are very concerned about the proposed large hog operation by Buffalo. Charles has COPD and it is crucial that he has healthy clean air to breathe. It could limit his time outdoors or even having our windows open. Not to mention the smell. We have raised small herds of hogs and know what it's like we can't imagine the stench from thousands of hogs. It has been found that there is an association between living in proximity to high density livestock production and community acquired infections with methicillin-resistant staphylococcus aureus, known as MRSA. This is especially dangerous for someone in poor health.

What about our water supply and roads? We get water from Cass Rural Water. Will there always be enough water? This operation would be extremely hard on our roads. Our taxes could go up to maintain them.

As far as jobs for Buffalo, there are no houses available in Buffalo. Workers would be coming from outside the area.

We live in the southwest corner of section 25. Please give this serious consideration and not give approval.

Sincerely,

Charles and Marlene Sheldon

3477 144 Ave SE

Buffalo, ND 58011-9763

1-20-16

To whom it may Concern

I am a resident of Buffalo, N.D. and I'm very much Conserned about the quality of our air & eventually our Water if a Pig Farm is placed close to us. We have alot of people in our Community with health issu that really worry us. Please take this into Careful Consideratio for us.

Claudia Von Bank

Just a note...

RECEIVED
JAN 27 2016
DIV. OF WATER QUALITY

Received on January 25, 2016

To: NDDH

To whom it may concern,

I am a resident of Buffalo, ND and I'm very much concerned about the quality of our air and eventually our water if a pig farm is placed close to us. We have a lot of people in our community with health issues that really worry us. Please take this into careful consideration for us.

Claudia Von Bank

PO Box 164

Buffalo, ND 58011

1-22-16

RECEIVED
JAN 25 2016
DIV. OF WATER QUALITY

ND Department of Health
Division of Water Quality

To Whom This May Concern:

We are writing in regards to the hog farm this is to be constructed near the town of Buffalo. We reside four miles southwest of the town of Buffalo. We have a family grain farm and my husband and I reside there with our five young children.

We am concerned with the air and water quality that the farm is going to produce. That is a lot of pigs and they are going to let off lots of harmful smells and waste. We have children in the Elementary school in Buffalo which is only going to be 3 miles from the hop farm. We are also concerned that there are going to be pipes running approximately five miles from the hog farm that the waste is going to be traveling through. That is going to get the hog farm practically in our yard when the spread the waste. Our kids go fishing at many spots along the Maple River. Are these hog farmers going to make sure all the waste gets pumped on time and doesn't overflow on the land and end up in our water? If they live in Pipestone MN I don't think they are going to be too concerned about the air we breathe and the water we drink here in Buffalo ND.

Also, there is to be 17-20 jobs with this hog farm. Where are they going to live? There is one house and one lot for sale in Buffalo, two houses for sale in Tower City so I'm guessing pretty much everyone that is going to work at this farm is going to commute from Fargo. We feel like this will not be of any benefit to our community.

We would like the State of North Dakota to reconsider the proposed hog farm near Buffalo so isn't built.

Thanks for your time,

Corey Hovelson
Kristi Hovelson

Corey and Kristi Hovelson
13526 36 St SE
Buffalo, ND 58011
7016335626

RECEIVED
JAN 19 2016
DIV. OF WATER QUALITY

Craig and Vicki Wendt
3805 139th Ave SE
Buffalo, ND 58011

January 14, 2016

Karl Rockeman, P.E.
Director of Water Quality
North Dakota Department of Health
918 E Divide Ave
Bismarck, ND 58501

Dear Mr. Rockeman,

We are writing in strong opposition to the Rolling Green Farms commercial hog operation being proposed near Buffalo, ND. This operation is proposed for 1-39-54 section 4, SE of NW ¼. We consider health, safety and natural enjoyment crucial issues for everyone and support environmental protection whenever we can. However, we are especially concerned about this hog operation since it is proposed to be installed near our property.

Specifically, we are concerned about the owner's efforts and success at controlling the manure produced by such a facility. What measures would be taken to ensure surface and ground water quality? Would those measures be monitored and enforced? We are also concerned about air quality. The high concentration of livestock creates a decidedly unpleasant and possibly unsafe environment for those working in the facility and living all around it.

We, like many of our neighbors, have lived in Buffalo for many years. One of the reasons we choose to call this home is the beauty of our surroundings. We hunt, fish, hike, camp and spend many hours of our precious summers outdoors. The risk to our water and air quality, to our environment overall, is too great for such a facility to be installed here. Please do not allow it to go forward.

Thank you for your time and especially for your consideration of the continued safety and beauty of North Dakota's natural environment.

Sincerely,

Craig Wendt Vicki J. Wendt

Craig A. Wendt and Vicki J. Wendt

Strommen, Rachel A.

From: Lang, Jeremiah M.
Sent: Friday, February 05, 2016 2:21 PM
To: Strommen, Rachel A.
Subject: FW: I support approval of the pig farm

-----Original Message-----
From: Dallas Hager [mailto:user@votervoice.net]
Sent: Friday, February 05, 2016 1:53 PM
To: Lang, Jeremiah M.
Subject: I support approval of the pig farm

Dear Environmental Engineer Lang,

Beef - "It's what's for dinner" and as far as I am concerned....Pork - "It's what's for breakfast" and I like breakfast. North Dakota (so am I) is a proud supporter of Agriculture and pork production fits that bill too.

I support our right to diversify and grow our own food. Our nation did not become great by holding back our entrepreneurs.

If all of the requirements by the health administration have been met, then the concern of smell should carry little weight as this to can be minimized.

Sincerely,

Dallas Hager
203 Territorial Dr
Rugby, ND 58368
dallas_hager@yahoo.com

RECEIVED
JAN 2 5 2016
DIV. OF WATER QUALITY

To the North Dakota Department of Health,

The largest concern I have with the potential hog farm construction by Rolling Green Family Farms RE, LLC is the location of the site. My husband & I just built a house less than 1.5 miles east of the proposed site. If we were aware of this potential hog farm construction, we would have reconsidered the location we chose. I can't help but be a bit disappointed that we were not made aware of this before starting construction of our home this past spring.

Another concern I have with the location of this site is the increased traffic on the road that I drive daily. In the future, this would affect not only myself, but my family. I need to be reassured the road conditions would be routinely monitored and the traffic speed be enforced.

I am worried about the odor and the potential hazardous air quality that would be leaving the farm. My husband and I built our house in the country to enjoy the outdoors and quiet environment. Now, I will worry if the air quality is safe each time we are out in our yard as well as make do with the odor issues that will be brought with the common west winds of North Dakota.

Unfortunately, there is very little direct benefit to my family and me due to the very close location of this large hog farm to my new home. For this reason, along with others listed above, I am asking you to please re-consider the location of this hog farm.

Thank you,

Danielle Fraase

RECEIVED
JAN 25 2016
DIV. OF WATER QUALITY

North Dakota Department of Health, Division of Water Quality,
918 East Divide Avenue, 4th Floor,
Bismarck, ND 58501

Public Notice Number: ND-2015-019

Application Number: NDAFO0853

Applicant Name: Rolling Green Family Farms RE, LLC
Mailing Address: 1300 South Highway 75, Pipestone, MN 56164
Telephone Number: 507.825.421

January 20, 2016

My concerns in granting a permit are based on the presence of pathogens in the liquid waste generated by this facility, the application, (type of soil, topography and weather conditions when applied) and the lack of long term monitoring of the ground water and soil.

From email exchanges with the Dept. of Health you do not have adequate regulations with regard to this type of operation and the waste it will create.

I request that you with hold final approval of the permit pending legislative review.

Information is included on one type of pathogen.

Thank You

David W Percel
401 Pearl St N
Buffalo, ND 58011

Copies to:
Senator Terry M. Wanzek
Representative Bill Devlin

22nd District:
Senator Gary A. Lee
Representative Wesley R. Belter
Representative Peter F. Silbernagel

Pig farms, manure fertilizers linked to MRSA infections

Methicillin-resistant Staphylococcus aureus (MRSA) infection is caused by a type of staph bacteria that's become resistant to many of the antibiotics used to treat ordinary staph infections.

Tim Parsons / Oct 2013

Researchers from the ***Johns Hopkins Bloomberg School of Public Health*** have for the first time found an association between living in proximity to high-density livestock production and community-acquired infections with methicillin-resistant Staphylococcus aureus, commonly known as MRSA.

Their analysis concluded that approximately 11 percent of community-acquired MRSA and soft tissue infections in the study population could be attributed to crop fields fertilized with swine manure. The study is the first to examine the association between high-density livestock operations and manure-applied crop fields and MRSA infections in the community. The results were published online Sept. 16 in JAMA Internal Medicine.

According to the Food and Drug Administration, nearly 80 percent of antibiotics in the United States are sold for use in livestock feeds. The manure produced by these livestock and applied to crop fields contains antibiotic-resistant bacteria, resistance genes, and about 75 percent of the antibiotics consumed by the animals.

For the study, researchers identified patients with MRSA infections and skin and soft tissue infections reported in electronic medical records provided by Geisinger Health System. The two case groups were compared to patients who never had a MRSA infection. Patients received an exposure score based on their distance from the production, the number of animals at livestock operations, the amount of manure spread on crop fields, and the size of the field. The researchers noted that between 2005 and 2010, about 3,000 patients with MRSA and 50,000 with skin and soft tissue infections were diagnosed and treated in the Geisinger Health System.

The cases came from more than 446,000 Pennsylvania residents between 2005 and 2010. The study identified 1,539 cases of community-associated MRSA and 1,335 cases of health care–associated MRSA. The researchers found a significant association between community-associated MRSA and application of swine manure to crop fields. A similar but weaker association was found between swine operations and community-associated MRSA. No association was found between dairy farms and MRSA infections.

"This is the first study that has linked MRSA infection and skin and soft tissue infections in the community to high-density livestock production. The results require replication, but we believe we have provided additional strong evidence that these livestock practices have important public health consequences," says Joan A. Casey, lead author of the study and a doctoral candidate in the Bloomberg School's Department of Environmental Health Sciences.

Brian Schwartz, senior author and a professor in the Bloomberg School's Department of Environmental Health Sciences, says, "We had a unique opportunity to evaluate these practices because of our work with the Geisinger Health System. The study shows the utility of electronic health records for demonstrating the unrecognized public health consequences of operations with environmental impacts."

In addition to Casey and Schwartz, authors of the study are Frank Curriero, Sara E. Cosgrove, and Keeve E. Nachman, all of Johns Hopkins.

Funding for the research was provided by the New York University–Geisinger Seed Grant Program, the Johns Hopkins Center for a Livable Future, the Johns Hopkins Sommer Scholars Program, and a National Institute of Environmental Health Sciences Training Grant.

Regarding: Application Number: NDAFO0853
Applicant Name: Rolling Green Family Farms RE, LLC
Mailing Address: 1300 South Highway 75, Pipestone, MN 56164

RECEIVED
JAN 25 2016
DIV. OF WATER QUALITY

TO: ND Dept. of Health
Div of Water Quality
918 East Divide Ave
Bismarck ND 58501-1947

Comments:

This proposed development in my neighborhood (I own a home Approx. 2 miles from site) brings a number of questions.

Please consider the following questions and issues:

- Public notice was during a busy time (Holidays) and most in the community have indicated that they have not had time to adequately investigate. I feel strongly that there should be a longer opportunity for community members to investigate this application to determine what issues they may have.
- I have questions regarding one aspect of this application in particular. The application indicates that they will compost dead animals. My understanding that there is to be over 6000 (possibly up to 9000) animals. 10% death events are not unheard of in such operations. I would like to hear their plan to deal with the dead animals.
    - Smaller events: Composting means a lot of things to a lot of people. It can mean simply stacking and allowing them to rot down to later spread on fields. Exactly how will they manage the vermin breeding/attracting/breeding issues around animal composting? Rats, Flies and other vermin are known to be heavily drawn to such operations and this can cause spread of disease via these vermin.
    - Large events: Composting hardly seems to be an acceptable manner to dispose of upwards to 900 dead animals. This could be both an extreme nuisance to the neighbors but further, could create serious issues with drainage from run-off of the dead animals. (runoff from this site ultimately ends in Red River which is a water supply for a large number of communities) What pathogens could such a composting event release into the water supply, drainage, or possibly even the air?
    - The stench of such an event, if not handled properly, would be unbearable for miles around.
- The site ultimately drains into the Red River. I'm not convinced that this application does not need to be reviewed/approved by Canadian officials. If the drainage project from Devils Lake is a concern to Canadian officials, it would seem that this might be as well.

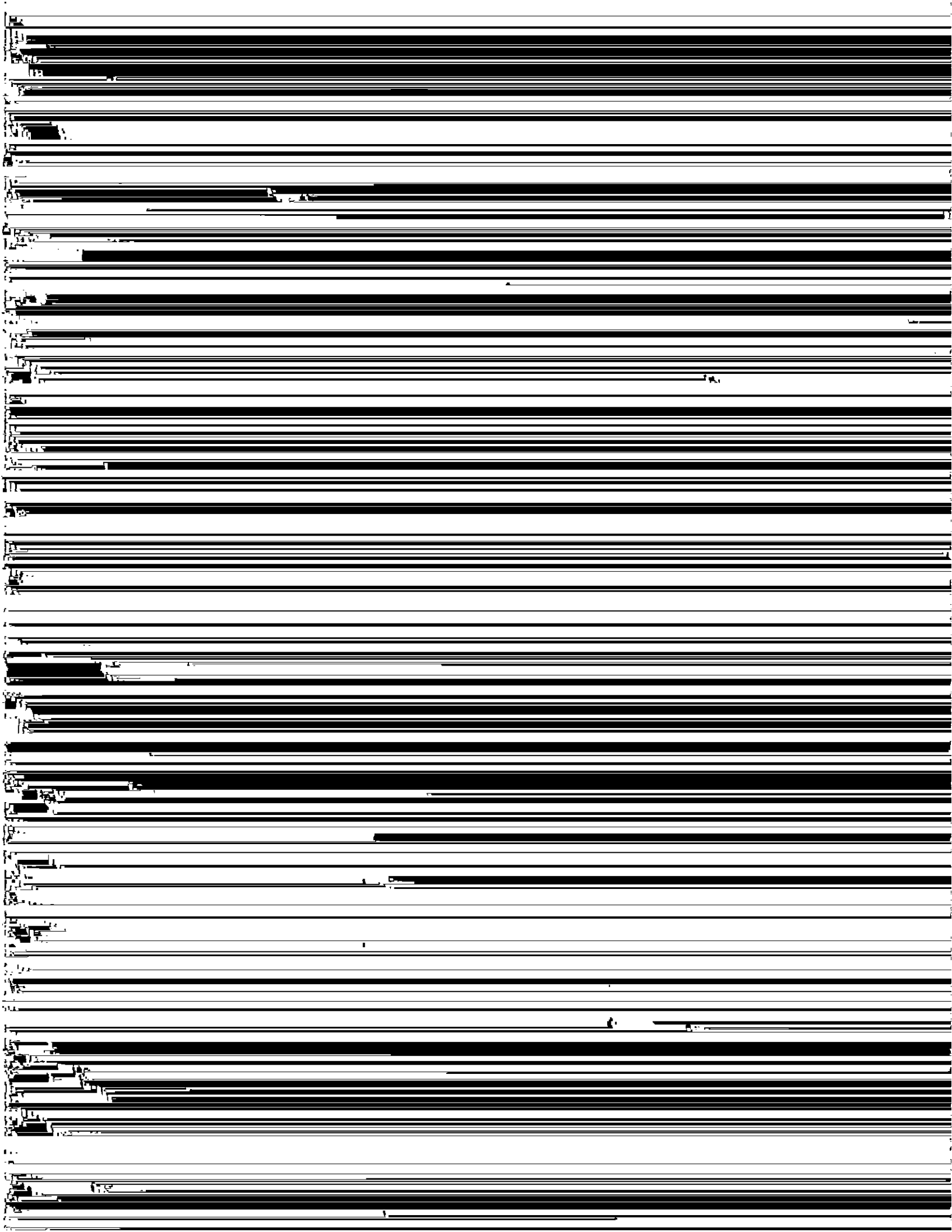
- Amount of nitrates in run-off from Manure that is to be incorporated in local fields may have at least temporary effect in water quality.
- There does not appear to be adequate property local to the site (north of I94 and South of the Railroad) to accept the volume of liquid manure. The applications suggest that monitoring will take place to prevent more manure for getting applied than the property can properly use. However, what happens if manure production exceeds this? What is the plan to make use of this product?
- Expected manure volumes section does not address the nitrates/nitrites that will be present in pig manure. How will this be mitigated and kept from State waters?
- Site is located in a site that will drain surprisingly fast ultimately into the Red River. Any accidents would be hard to contain since they are right on the Buffalo River waterway.

Personally, I'm not certain that I am totally opposed to this project. However I'd like answers to issues I've raised and hear what concerns others in the community may have. Again, many of us only found out about this project shortly before the meeting on 1/18. I was not able to attend that meeting as the first I heard about the project was 20 minutes prior to the meeting. I was unable to attend.

To that end, I'm asking that your department plan follow-up public hearing(s) prior to approving this application.

Sincerely,

EeJay Smith
3345 142 Ave SE
Buffalo, ND 58011



From: -Info-Dept. of Health
Sent: Wednesday, January 20, 2016 10:20 AM
To: Rockeman, Karl H.
Cc: Glatt, Dave D.
Subject: FW: The Stink about the Hog Farm Near Buffalo North Dakota

FYI
Londa

From: Eric Lien [mailto:ericl@champindustries.ca]
Sent: Wednesday, January 20, 2016 10:09 AM
To: -Info-Dept. of Health
Cc: buffalond@ictc.com; Today2b4u@aol.com; jthomas@wday.com; Grondahl, Chris D.
Subject: The Stink about the Hog Farm Near Buffalo North Dakota

I'm opposed to the new 9000 head hog farm purposed near Buffalo. Livestock pollution seems to be the biggest threat to the small community of Buffalo. North Dakota has witnessed what large corporations have done to the Western part of the state with the oil boom. Looking at the concerns given today with other large hog farm proposal. There is no denying there are health risks attributed to these types of farms.
One case being Chapel Hill NC, has a similar operation. People have reportedly suffered from headaches, diarrhea, and repertory problems according to a study by researchers at the University of North Carolina. These hog farms emit hydrogen sulfide. This is a gas that most often causes flue like symptoms in humans, large concentrations have been attributed to brain damage. The National Institute of Health reported that 19 people died as a result of hydrogen Sulfide.

The quality of life that people from the area are used to would drastically change. People in the small community currently enjoy the fresh air without the pungent odor of 9000 head of hogs producing nearly 3 gallons of solid waste a day, per hog That's roughly 27,000 gallons of Solid/Liquid waste a day on a 9000 head operation. The vast amount of sewage gas, with 70% being methane, and 29% carbon dioxide. The methane being about half of the chemical weight of air. Will cause a lingering effect to the area. Dispersed by the warm southern winds in the summer time blowing directly to the town and a more lingering affect in the winter. Ammonia is also a toxic form of nitrogen released in gas form during waste disposal, and it can carry more than 300 miles through the air before settling in the ground or lakes, and rivers. Where it will cause an algae boom, killing most aquatic animals.

Looking at water quality, a number of residence around the area still run well water. High levels of nitrate go hand in hand with large livestock operations. These high levels of Nitrates in drinking water increase the risk of methemoglobinemia (Changes in red blood cells) or Blue baby syndrome. Animal waste its self contains Salmonella, E coli, Cryptosporidium, and fecal coliform which can be 10-100 times more concentrated than human waste. And more than 40 diseases can be transferred to humans through this manure. North Dakota being a Plains State (meaning flat), we are often prone to flooding conditions. What were to happen to Pipestones underground storage in the event of a flood that can last weeks? Although Pipestone says it's out of the flood plain. I do remember stretches of Interstate 94 closed that were also out of the flood plain. Even without a flood, at some time the storage has to be emptied. In 1995 an eight acre waste lagoon burst causing 25 million gallons of waste into a local river. That spill alone killed 10million fish and closed 364,000 acres of wetlands. In 2011 an Illinois hog farm spilled 200,000 gallons of sewage into a creek killing 110,000 fish. 2012 a Carolina dairy left carcasses rotting polluting the area. Run off from hog farms in North Carolina are believe to be a main contributor to Pfiesteria piscicida causing skin irritations short term memory loss, burning eyes and other cognitive problems in local people. The risks clearly outweigh the rewards, I wouldn't want to have my family and neighbors exposed to these risks.

When doing research on the internet, I seen nothing short of horror stories. From smaller operations than the one purposed near Buffalo. It's these types of concerns that are raising citizen resistance to the new wave of hog

farming. In Kansas, 18 counties have passed referendums opposing factory hog farms. Wayne County, in Illinois, has imposed an emergency ban on more large-scale hog farms (anything over 1000 head) and the state legislature is considering a state-wide moratorium. Kentucky's Attorney General has issued an opinion declaring that "industrial-scale hog operations are not reasonable, prudent and accepted farming methods." Iowa, Minnesota and Missouri are also scenes of intense citizen opposition. The states and communities are already acquainted with large Hog farms.

Although Pipestone mentioned on the good side it would bring up to 20 jobs to the area. I'm not sure anyone has mentioned to them, the Obama Administration is touting a 5% unemployment rate nationally, And North Dakota's unemployment being 1-2%. The 20 jobs offered didn't seem to impress the local community.

Historically speaking North Dakota seems to commit to out of state companies and make the populous deal with the problems. Once these companies have already been established it seems impossible to deal with the repercussions that the companies bring.

Best regards!

Eric Lien
204 Strand Ave N.
Buffalo North Dakota 58011
920-242-4858
ericl@champindustries.ca

RECEIVED

JAN 19 2016

DIV. OF WATER QUALITY

JAN.16-16

ND Dept of Health---Water Qualty

ATTN: JEREMY

Dear sir.

This letter is in reguard to the permit for the pig factory to be located in Buffalo ,ND.

I'm against this proposal. My wife and I own and farm the land immediately south of the site. The plans call for surface water to drain south onto my land and beyond.

The proposal states the run off will go south in A Ditch and under A ROAD. They do not say this ditch,and road happens to be INTERSTATE 94 A FEDERAL HIGHWAY. Also this ditch does't drain out completely as the culverts are to high.
I also manage and farm land to the north of this site right across the road . my farm site and other land that I own and farm , all are within a ½ mile to 1 and a half away.

The whole project has been so hushed up !!!!! I just found of this 10 days ago. The people doing this have not said anything to me. I,ve farmed all my life and raised pigs for years . I know the smell that comes with it.

A lot of concerned people are just finding out about this project, I,m sure you will hearing more complaints.

Any action you can take to halt ths thing before going forward, would greatly be APPRECIATED!!!!!!!

THANK YOU.

GERALD MARCKS Gerald Marcks

BUFFALO, ND

RECEIVED
JAN 21 2016
DIV. OF WATER QUALITY

January 16, 2016

ND Department of Health
Division of Water Quality
918 East Divide Ave.
Bismarck, ND 58501-1947

Re: Public Notice ND-2015-019

To Whom It May Concern:

We have just been informed of this public notice. We are genuinely concerned about the establishment of the Rolling Green Family Farms, RE, LLC Livestock facility located in the SE ¼ of the NW ¼ Section 4 Township 139N, Range 54W, in Cass County, North Dakota. Specifically, we are concerned about the quality of life due to the odor, the environmental impact on the water and the devaluation of property values.

Respectfully,

Gregory Sproul

Gregory Sproul

RECE
JAN 25 2016
DIV. OF WATER QUALITY

Jan. 21, 2016

To the North Dakota Department of Health,

I am writing regarding the proposed confinement hog farm operation (Rolling Green Family Farms RE, LLC.) by Buffalo, ND. in the hope of having a public hearing.

I do not understand why this proposal would even be a consideration in Cass County. Cass County is fastest growing county in ND. So why place this facility in an area of potential growth? The county is concerned with water and water quality. This proposed building is at a high elevation and I have strong memories of the flood of 1997 when our ditches were filled with water that ended up in Fargo. We also have the Maple River to the west of the proposed site. If we have a quick freeze up in the fall, the liquid pig manure that is supposed to be injected into the soil will end up on top of the frozen ground, creating a strong odor for an extended period of time, and then be subjected to the spring runoff. Another concern is the upkeep and safety of the roads that will be used. The county road is a main artery for residents. The proposal is for 1 mile of county road and 0.5 of a township road to be used. Is Cass County going to guarantee that the present residents will have safe roads to utilize? I am also concerned that there will be enough regulations and supervision to monitor this facility before compliance is broken. They say this facility will be in operation for 40 years.

Historically homes by confinement hog barns depreciate in value. How is this fair to the residents of Buffalo and the surrounding area. My son and daughter in law just built a new home and are expecting their first child. What makes it right for an out of state company to forever change the lives of many?

I am disappointed that this project has come as far as it has. I do not believe this type of raising livestock reflects the culture of the area. The fact that this proposal has come through the backdoor makes me very skeptical as to the benefit of the town of Buffalo and the surrounding area. When I look at this project there are very few that will benefit and many will suffer. I have yet to talk with an individual from this area that agrees with the project.

I believe the residents of this county deserve better.

I hope you take into consideration the greater good and your present Cass County residents.

Sincerely,

Gwen Fraase

Gwen Fraase

I have been a long time resident of Buffalo, ND. I am extremely concerned about the proposed hog farm just outside of town. The unknowns of odor, air born health effects, water quality and drainage are my concerns. With prevailing winds out of the southeast this farm will put us right in the crosshairs of stench filled air, along with airborne pathogens. Other concerns are on the impact of other fertilizer businesses located in and around town losing business with little or no gain to the community. The location puts the site next to Interstate 94 and will operate with no need to use the town for anything. Claims of economic gains for this area are just conjecture and have no real data for their support.

I don't understand why the state of North Dakota allows outside interests to come in making claims of economic development only to leave residents with no course of action if the claims of the company are not met. This group from Pipestone MN can come in tell us they have every right to be here because they have purchased the land and tell us there will be no adverse effects and if their claims are not true we will have no course of action except to move. The fact is, if you take a drive down to Iowa, or even West of Larimore ND and get with in about five miles of the hog farm operations you will smell the odor. Representatives from Pipestone Holdings admitted the farm will produce an odor but were offended at the fact that we are not happy to have it our back yard.

I ask you to please consider the requests of the majority of residents of Buffalo, North Dakota and not the money and claims of the group from Pipestone Holdings, Pipestone MN.

Thank You for your time and consideration.

Hal Grieve

204 4th Ave S

Buffalo, ND.

Hal Grieve

RECEIVED
JAN 2[illegible] 2016
DIV. OF WATER QUALITY

ND Department of Health
Division of Water Quality
918 East Divide Avenue
Bismarck, ND 58501

Dear ND Department of Health and Division of Water Quality Board members,

I am sending this letter as I am concerned about the recent news of a swine operation coming to Buffalo, ND. I am a descendent of Nelson and Jane Nudell and stand to inherit the land from my mom and dad, Alan and Kim Webster. I have copied and pasted their letter on to my letter because I have the same concerns as theirs.

Their letter is copied below:

We are writing this letter in response to the very recent news that a swine farm was on the agenda for approval near Buffalo, ND. We are suspicious as to why this information wasn't made public until the very last minute. Being born and raised in North Dakota, we were both brought up in farming communities. We question why a local farmer would sell his land to a large corporation and the news didn't become public until now. The whole thing smells like a shady deal. If it were such a great project, then why all the secrecy? We read the articles in the Fargo Forum along with the news video presentations from the meeting in Tower City.

We own 2 quarters of land ½ mile south of the site of the proposed swine operation in Buffalo, ND. Our land is on the south side of Interstate 94. This land was originally homesteaded by Nelson and Jane Nudell and bought by their son Lorne and Helen Nudell. The land went into a trust to my brothers and me (Kim). We then bought the land from my brothers, Keith Nudell and Kent Nudell. We currently rent our farm land to the Buhr Brothers of Buffalo, ND. It is our hope to pass this land on to our two sons, Seth Webster and Jared Webster. Custer, SD is where we live and are retired from the teaching profession. We have connections in Buffalo, ND and visit up there to check on the land numerous times.

We are concerned because there is a drainage system that flowed from the land north of Interstate 94 to our land directly south of Interstate 94. We are concerned about the drainage that might affect water quality, the spread of disease, and the odor. We are equally concerned about the value of the land as this pig operation emits toxics into the water drainage and land. Does this corporation have a plan for disposal of dead animals and the placentas? Would these be a source for flies and possible disease? We have so many questions and are feeling rushed about getting this letter sent to you in time for your deadline meeting! We plan to be in ND for spring planting on our land in Ellendale, ND in May and would gladly come up for meetings at that time.

This sounds like a rush deal. We would hope you would give the farmers and the community more time to gather their research and answer their questions before you make a hasty decision that has the possibility of hurting a lot of people's livelihoods and the town's peacefulness. We would hate to see a large corporation take away from the livelihood of the farming community of Buffalo. We doubt this corporation is going to support the local businesses. **We strongly urge you to give the citizens of Buffalo more time to gather information.**

Thank you for letting me share my parent's letter along with my concerns as I feel your decision will directly affect my family and me.

Sincerely,
Jared Webster
Custer, SD 57730

JW
1-21-16

January 20, 2015

RECEIVED
JAN 25 2016
DIV. OF WATER QUALITY

Jennifer Fraase
3564 143 Avenue Southeast
Buffalo, North Dakota 58011

ND Department of Health,
Division of Water Quality,
918 East Divide Avenue
Bismarck, North Dakota 58501-1947

To Whom It Concerns:

I would like to offer my thoughts in regards to the proposed confined pig operation that is being proposed 1.5 miles from where I live. After doing research regarding confined animal feeding operations (CAFO), it is quite obvious that there are more cons for the community surrounding these operations than positives.

The amount of manure a CAFO of this size will produce is huge. Our family farm had a 500-pig operation (1 mile from our family home) for years and I know what the smell from that was like when the manure was spread. The smell hung in the air for days. I walk, ride bike or snow shoe 4-6 times a week. It was not enjoyable to be outside walking during the days the manure was spread and the days following until it was dug into the ground. If this pig operation is allowed to be built, it will destroy our fresh air not only from the manure being spread but from the odor that will come from having an operation with 9,000 hogs. Walking, biking or snow shoeing with that smell in the air is not something that I care to be doing. This is one reason that I live in the country, to have fresh air. This benefit of living in the country will be destroyed by this pig operation.

Which brings me to another issue, how many people in the surrounding area will want to have their windows open in the spring through fall months? We will be forced to keep our windows shut and have to run our air conditioners more to stay cool. This will increase my electric bills and cause poorer air quality in my home. It's common knowledge that fresh air is much healthier for people versus air conditioned air. No one wants to go to sleep to the smell of pigs including myself. Whenever I can, I sleep with my windows open. This will not be happening if this CAFO is allowed to be built.

Manure can contain plant nutrients such as nitrogen and phosphorus, pathogens such as E. coli, growth hormones, antibiotics, chemicals used as additives to the manure or to clean equipment, animal blood and silage leachate from corn feed. (Source: Understanding Concentrated Animal Feeding Operations and Their Impact on Communities by Carrie Hribar, MA) From my reading on CAFO's and the cause of manure, I have found that there are over 150 pathogens found in animal manure which cause numerous diseases and side effects. This is not something that I want to be exposed to nor should our community be exposed to these pathogens.

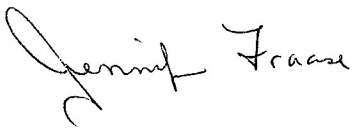
Another concern with an operation of this size is the threat to our groundwater and our aquifers. According to Leveling the Field – ISSUE BRIEF #2, Environmental and Health Problems in Livestock Production: Pollution in the Food System, manure gets into surface and ground water when lagoons spill or break, or when the CAFO

operator spreads or sprays too much manure on the land around the operation. This is a serious concern and one that the North Dakota Health Department should take into consideration. From the research that I did, spills and leaks frequently occur and manure storage units leak above the legal limit.

My last point is what this CAFO is going to do not only to my own property but to my neighbors also? According to studies done by Dakota Rural Action, they found that property within a 3 mile radius of a CAFO loses 6.6% in property valuation, and property within 0.10 mile of a CAFO loses up to 88% in property valuation. (~ Dakota Rural Action, CAFO Economic Impact (June 2006) (citing North Central Regional Center for Rural Development (1999:46); Siepel et al. (1998)). I quote another study: A 1999 study in Missouri found that the average loss of land value within three miles of a CAFO was $112/acre.~ Mubarak Hamed et al., The Impacts of Animal Feeding Operations on Rural Land Values 2 (Cmty. Policy Analysis Ctr., Univ. of Mo., May 1999) (finding that "there is a relationship between proximity to a CAFO and the value of proper ty"). As a landowner within .5 mile of this proposed CAFO, I am totally against this operation. My land values are going to go down because of this as will my house value. Who is going to want to purchase a house 1.5 miles from a 9,000 pig operation? The argument for this operation is economic development? What kind of economic development is this to people like myself and my neighbors who are going to lose value on our land and on our homes?

I am strongly opposed to this operation being built on the proposed location and I urge you to deny a permit for this to be built.

Sincerely,



Jennifer Fraase

RECEIVED
JAN 25 2016
DIV. OF WATER QUALITY

ND State Department of Health
Division of Water Quality
918 East Divide Avenue, 4th Floor
Bismarck, ND 58501-1947

To whom it may concern:

I am writing this letter to you in concerns of the pig farm that they want to put up by Buffalo, ND. My concerns are the air quality and drainage/runoff.
How are they going to contain the smell? Where is all the drainage from the pigs runoff going to go? I'm concerned that our rural neighbors are going to suffer health consequences because the air quality would not be taken care of.
Numerous gases are generated in swine facilities. Gases of most concern include carbon monoxide, carbon dioxide, methane, ammonia, and hydrogen sulfide. Gases can irritate the airways causing symptoms like shortness of breath, cough, runny nose, eye irritation, and difficulty breathing.
Additionally, gases may displace oxygen causing an **oxygen depleted atmosphere** which results in asphyxiation. Certain gases such as hydrogen sulfide may also interfere with oxygen utilization by cells causing a cessation of aerobic respiration leading to cell death. Methane may also be an explosion hazard. Several swine infections can be transmitted to humans, some with potentially serious outcomes.[1] KCRHS followed entire farm families living in a rural community over a period of 17 years to observe their health outcomes and identify health conditions, behaviors, and work duties that make injury and illness more likely. For example, KCRHS found that farm workers had the greatest risk of exposure to H1N1 and H1N2 (swine flu) infection, even greater than others who work with pigs (e.g., meat processing workers, veterinarians), since they come into contact with live pigs.[2]
Studies have discovered an increase in respiratory, neurobehavioral, and mental illnesses among the residents of communities next to factory farms. In a major study, residents in the vicinity of a large pig farm were found to have "higher reporting of headaches, runny noses, sore throats, excessive coughing, diarrhea, and burning eyes." A separate study determined that pregnant women and

children are especially susceptible to factory emissions. Waste from factory farms poses a serious risk for nearby residents. Manure and urine are generally stored in open-air pits known as lagoons. When the lagoons are full, large amounts of waste are applied to nearby land, compromising soil and water quality. Lagoons are also prone to spills, which can contaminate a community's water. Manure lagoons are known to release a number of air pollutants, including methane, a major greenhouse gas, and hydrogen sulfide, which the National Institute for Occupational Safety cites as a leading cause of death in the workplace.[1] Another concern is that if one of these open air pits fails and no one is there to fix it in a matter of 15-20 minutes ALL of the swine will die from their own stench. In fact, 25 percent of workers at pig factory farms report respiratory problems, including asthma, bronchitis, and organic dust toxic syndrome. .

Evidence suggests that living near a factory farm compromises residents' overall quality of life. Residents in towns near these farms are often forced to keep their windows closed and remain indoors due to foul odors. In a study of one town in the vicinity of a major factory farm, a third of the residents reported that their daily activities were affected by the presence of the operation. Proximity to a factory farm can also substantially decrease property values.[1]

We are also concerned about how this has been brought to our community. This is an urgent matter and since we haven't had much time to even find out about a lot of this information on the pig farm operation I believe their needs to be more information put out there before this operation comes into our community.

Sincerely

Jessica Peterson

Sources:

1. www.farmsanctuary.org/learn/factory-farming/factory-farmings-effect-on-rural-communities/

2. http://www.cdc.gov/niosh/docs/2015-175/

1-22-16

ND Department of Health
Division of Water Quality
918 East Divide Ave.
Bismarck, ND 58501-1947

Dear Sirs:

After reviewing the public notice and listening to comments, I believe that requirements have been met to issue a permit to Rolling Green Family Farms LLP. for the proposed Hog Facility to be located in the SE¼ of the NW¼, Sec. 4, 139N-54W. Howe Twshp.

As a land owner in Buffalo Township SE¼ Sec 20. I look forward to use of the manure as a fertilizer and increasing the organic matter of the soil.
Therefore I am in favor of the Hog Facility project.

Sincerely

John Kringler

RECEIVED
JAN 25 2016
DIV. OF WATER QUALITY

Jon Gilley
2910 146th Ave SE
Ayr, ND 58007

North Dakota Department of Health
Division of Water and Air Quality
918 East Divide Avenue
Bismarck, ND 58501

To whom it may concern:

I am writing to voice my concern with the permitting of a pig farm through application #DNAF00853 in western Cass County. Pipestone System has a pattern of moving into rural communities with weak environmental nuisance laws and steamrolling any opposition. If you research Pipestone Systems online, once they are in a community they are terrible neighbors. The area around Pipestone, MN, where Pipestone Systems originated and continues to operate, has some of the worst groundwater nitrate levels in the State of Minnesota.

I am concerned that permitting Pipestone Systems to build this pig farm in Cass County would result in contamination of groundwater and surface water by nitrates and phosphates. This facility would generate an unknown quantity of pig waste loaded with pathogen bacteria, including salmonella and E.coli. It would expose all of us who live here to odor, dusts, molds, bacterial endotoxins, and gases such as ammonia and hydrogen sulfide. It would negatively affect our quality of life and property values.

Please address these concerns.

Thank you,

Jon L. Gilley

Strommen, Rachel A.

From: Lang, Jeremiah M.
Sent: Friday, February 05, 2016 9:21 AM
To: Strommen, Rachel A.
Subject: FW: I support approval of the pig farm

-----Original Message-----
From: John Reinhardt [mailto:user@votervoice.net]
Sent: Friday, February 05, 2016 9:19 AM
To: Lang, Jeremiah M.
Subject: I support approval of the pig farm

Dear Environmental Engineer Lang,

North Dakota is an agricultural state. If was not for us producers people in America would have no food. This farm is away from towns and other farms so it will not disturb anyone. Look at the jobs it will give people. Help with bringing children to schools and also people buying supplies for the farm and personal use. Keep small towns going don't shut them down. Yes let the farm be set up. It will by far help the economy it will not hurt it

Sincerely,

John Reinhardt
4855 Highway 49
Glen Ullin, ND 58631
strnorman@yahoo.com

RECEIVED
JAN 25 2016
DIV. OF WATER QUALITY

North Dakota Department of Health

Division of Water Quality

918 East Divide Avenue

Bismarck, ND 58501-1947

RE: Permit approval for confinement hog facility near Buffalo, ND.

We are writing to express our concern about the proposed hog operation that is planned near my home. Our family lives on a farm one and a half miles south of the construction site and found out about it a little over a week ago. Our quick research has brought up three areas of concern.

The most obvious concern is the smell. While all animal activity results in odor, a look at a 2000 Wing and Wolf study in North Carolina and a 2002 joint study by Iowa State University and University of Iowa reveal the hazard of this air pollution. Harmful effects included headaches, sore throats, diarrhea, coughing, and burning eyes. The prospect of enjoying a day outside or the family reunion does not appear likely to happen.

The second concern is water quality. While there are standards in place to help prevent contamination, having the waterway drain through our farm from the section containing the hog operation makes us uneasy.

The third concern is the integrity of the company heading the hog operation. Our town meeting showed they are a group experienced at getting their way, quick to dismiss and ridicule dissenters, and not likely to be interested in anything other than making the most money possible. A search of newspaper articles showed another farm (Jackrabbit Family Farms, Milbank, SD) with the same ownership embroiled in a controversy over smell. After reading these articles it appears that Pipestone Systems will be unresponsive to our concerns once their site is operational.

While we would prefer that the hog operation never be built, we would at least like time to study our options to determine how we can safeguard our family's health.

Thank you,

Keith, Joni, Daniel, and Sarah Biggers

3790 141st Ave SE; Buffalo, ND 58011 (701)633-5311

RECEIVED
JAN 2 3 2016
DIV. OF WATER QUALITY

North Dakota Department of Health
600 East Boulevard
Bismarck, ND 58505

1-22-16

To Whom It May Concern:

I am writing in regards to the permit application submitted by Rolling Green Family Farms RE for a hog farm outside of Buffalo, ND. I haven't had much time to do research on this, as I just found out on Monday the 18th about this proposed hog farm coming to Buffalo. The reasons stating below is why I DO NOT want a 9000 pigs being raised 2.5 miles outside of Buffalo, ND.

1) Ammonia emissions from hog farms react with other gases to form fine particle pollution, a public health threat linked to lung function, cardiovascular ailments and premature death. (Please see my attached source sheet)
2) Air emissions from lagoons, sprayfields, and hog houses have been linked to neurological and respiratory problems.
3) Hydrogen Sulfide emissions from hog farms have been associated with respiratory and cardiovascular effects.
4) Hog waste contains disease causing pathogens & increases antibiotic resistance.
5) Evidence indicates adverse impacts on workers' and children's health.
6) Manure land application rates at hog Animal feeding operations result in high level of pollutants in groundwater and pose risks to drink water wells.

The reasons above are why I DO NOT WANT this hog farm to come to Buffalo. There are going to 200 families that would be affected by this hog farm. The risks are too great to me for having such a large hog farm so close the Buffalo community. It will affect the water table in a negative way. During the warm months, there is standing water in the summers south of interstate of the proposed hog farm location. The cat tails and tall grass are proof of that.

Livestock was not meant to be raised inside huge buildings with thousands of them in a building at one time. This many animals being raised in a small area is not good for our environment and poses many health risks to the community of Buffalo. Please do NOT issue a permit to Rolling Green Family Farms RE.

Best Regards,

Kimberly Von Bank

Kimberly Von Bank
200 2nd Ave S
Buffalo, ND 58011

Adverse Health Effects Of Hog Production
A Literature Review

Ammonia emissions from hog farms pose a serious public health threat.

- Ammonia emissions from hog farms react with other gases in the air to form fine particle pollution, a public health threat linked to decreased lung function, cardiovascular ailments and most seriously, premature death.[1]
- Recent analysis by NC State University (NCSU) researchers shows that fine particulate pollution is higher in Raleigh (and likely for all of the Triangle area) when air masses cross the high density hog counties on the way to Raleigh.[2] This analysis also found fine particulate levels in a rural town (Kenansville) in a high density hog county were very high relative to what would be expected.
- The 2003 National Academy of Sciences[3] report identified atmospheric ammonia nitrogen emissions as the most significant public health threat from Animal Feeding Operations[4] on a regional scale.
- Reducing ammonia emissions from Animal Feeding Operations makes sense not only for the obvious public health benefits, but also for economic reasons. The Benefit Cost Analysis conducted by Research Triangle Institute for the NCSU hog waste management evaluations found that a 50% reduction in ammonia emissions from hog farms in eastern NC will provide an estimated $190 million a year in benefits from avoided health impacts.[5]

Air emissions from lagoons, sprayfields and hog houses have been linked to neurological and respiratory problems.

- Subjects in a controlled exposure chamber who were exposed to air from hog operations for one hour reported headaches, eye irritation and nausea.[6]
- Unpleasant odors have been found to be a nuisance and emotional stressor on neighbors,[7] and are known to contain irritants that can cause damage to mucosal linings in the nose, throat and respiratory tract.[8]
- The 2003 National Academy of Sciences report identified odor as the most significant concern for local communities among the suite of air emission problems from Animal Feeding Operations.
- Researchers from the UNC School of Public Health and Duke University found that neighbors exposed to odors from hog operations showed evidence of reduced immune system function.[9]
- Evidence is also emerging that indicates that the health of citizens living near hog operations is negatively affected.[10] Research in Iowa and North Carolina showed that neighbors living within three miles of hog operations experience elevated levels of respiratory complaints relative to those living near other animal production operations or crop production.[11,12]
- Abhorrent odors can be exacerbated by the smell and sight of rotting flesh from hog carcasses that are often stored in "dead boxes" close to neighbors' property lines. "Dead trucks" that transport hog carcasses to rendering facilities also emit odor

Prepared by Environmental Defense Fund, Incorporated, March 2008
Joseph Rudek, Ph.D., jrudek@edf.org

Evidence indicates adverse impacts on workers' and children's health.

- An enormous amount of research exists to document the serious negative impacts to swine confinement house workers.[23] Effects include respiratory symptoms, reductions in pulmonary function and increased bronchial responsiveness.
- Researchers in Iowa found a high prevalence of asthma in children living on hog farms, especially farms that added antibiotics to feed.[24,25]
- A North Carolina study of 58,169 children found a 23% higher prevalence of asthma symptoms among students attending schools where staff noticed livestock odors indoors twice a month or more.[26]

Manure land application rates at hog Animal Feeding Operations result in high levels of pollutants in groundwater and pose risks for drinking water wells.

- Ground water nitrate levels beneath animal waste sprayfields are typically found to range from 10 to 50 parts per million (ppm).[27] The drinking water standard for nitrate is 10 ppm. Even wells drilled to clean aquifers below surface contaminated groundwater aquifers are at risk because well casing construction flaws can allow leaks of highly contaminated groundwater into drinking water wells.
- Results from a free well-testing program for people living adjacent to hog farms in North Carolina in 1996 found more that 10% of the wells tested failed to meet drinking water standards for nitrate. Three wells had nitrate concentrations in the 70 – 100 ppm range. The NC Department of Health and Human Services found that the results of the well testing program "*...illustrate a potentially serious groundwater problem to the people utilizing wells near Industrial Livestock Operations in five counties in eastern North Carolina.*"[28]

Community health experts are recommending safeguards to protect the health of rural residents.

- Based on the 2003 American Public Health Association's review of evidence of the health and economic impacts of concentrated animal feeding operations (CAFOs)[29] [30] and "evidence, albeit less certain, indicating impacts on children and CAFO neighbors from exposure to large concentrations of manure and their subsequent emissions of dust, toxins, microbes, antibiotics and pollutants in the air and water," the Association resolved that it would:

> *[U]rge federal, state, and local governments, and public health agencies to impose a moratorium on new Concentrated Animal Feed Operations until additional scientific data on the attendant risks to public health have been collected and uncertainties resolved.*

Hydrogen Sulfide Emissions

- Hydrogen sulfide (H_2S) is a colorless gas with a strong odor of rotten eggs that is detectable at concentrations as low as 0.5 ppb (0.0007 mg/m^3). Acute exposures to H_2S at 2 – 10 ppm have been associated with respiratory and cardiovascular effects, and people with asthma appear to be more sensitive to H_2S reporting headaches following 30 minute exposures to 2 ppm.[13] The EPA also reports that acute occupational exposures have been associated with a variety of central nervous system (CNS) transitory symptoms, such as dizziness, nausea, headache, and at higher exposure concentrations, serious conditions such as "abrupt physical collapse" and pulmonary edema.[14]
- The 2003 National Academy of Sciences report, noting hydrogen sulfide's risks to public health, recommended that the EPA and USDA should develop process-based mathematical models for atmospheric emissions of hydrogen sulfide, along with ammonia and methane, to identify management changes that decrease emissions.
- Of particular concern is the susceptibility of children to neurological effects associated with H_2S exposure.[15]
- The EPA Office of Air Quality Planning and Standards is in the process of re-evaluating H_2S toxicity to determine if it requires specific regulation.[16] The neurotoxicity has been cited as one of the principle reasons for increased scrutiny.
- In light of these efforts by the EPA Office of Air Quality Planning and Standards, it would seem reasonable and practical to continue to collect emissions data, and use this information in the evaluation of potential health impacts that can be used to inform the decision-making process by the Office of Air Quality Planning and Standards. It is premature to cease collecting this information at a time when an analysis of the exposure conditions is warranted.

Hog waste contains disease-causing pathogens & increases antibiotic resistance.

- Hogs and humans share many of the same disease organisms. Large quantities of antibiotics, many closely related to those used to treat humans, are used by pork and other livestock and poultry producers.[17]
- Environment Defense reported in 2005[18] that North Carolina's animal production industry, which is largely comprised of hog and poultry production, is estimated to use three million pounds of antibiotics annually. This is approximately the same amount of antibiotics that is estimated to be used *nationally* to treat humans.
- The vast majority of antibiotics are administered not to treat disease but rather to promote growth or to compensate for the crowded, stressful and often unhygienic conditions in industrial-scale livestock operations. An expanding body of evidence[19,20] links this frequent exposure of antibiotics to the development of antibiotic-resistant pathogens, contributing to the problem of reduced antibiotic effectiveness in humans, a growing health concern in the United States.
- There are also concerns about the exposure of workers or neighbors to antibiotics in the dust generated in the hog confinement facilities, which are vented to the outdoors.[21,22]

Community health experts are recommending safeguards to protect the health of rural residents. (continued)

- The American Public Health Association's recommendations were recently endorsed by a collection of American and European environmental scientists brought together in a symposium and workshop organized by the University of Iowa's Environmental Health Science Research Center and sponsored by the National Institutes of Environmental Health Sciences. The endorsement emerged from an expert community health workgroup assembled at the workshop in 2004, the results of which were recently published.[31] The workgroup found that "*...sufficient research exists to support action to protect rural residents from the negative community health effects of CAFOs*...." Furthermore, the expert workgroup recommended that permitting of CAFOs should include: consideration of total animal density in a watershed; environmental impact statements; public meetings and local decision making; regulation with standards applied to general industry with similar levels of emissions and type of waste handling; and bonding for manure-storage basins for performance and remediation.

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RECEIVED
JAN 25 2016
DIV. OF WATER QUALITY

January 20, 2016

North Dakota Department of Health
Division of Water Quality & Division of Air Quality
918 East Divide Avenue, Fourth Floor
Bismarck, ND 58501

To Whom It May Concern:

I reside and own property in Buffalo which is in close proximity of the proposed swine confinement facility filed by Rolling Green Family Farms. I have concerns and unanswered questions as to what an operation of 9,000 confined animals will impact the air and water quality of our community. I have the impression that this proposed project has applied for a permit without considering the ramifications to our community as everything seems to have been in secret with little information up front. What are the consequences to the environment and our community if all does not go as planned? What is the track record for Rolling Green Family Farms, who will be monitoring operating conditions and who will ultimately be held responsible for noncompliance and or any damage to the environment?

I am respectfully requesting a public hearing to provide necessary information and answers to the concerns this project will have to the environment and our community.

Thank you for your consideration.

Sincerely,

Lee Fischer
PO Box 2
Buffalo, ND 58011
(701) 633-5323

Received on January 25, 2016

To NDDH

I am a farmer with land on both sides of this proposed hog project. Our farm has three houses plus the fourth house my nephew just built this summer. All are 1.5 miles to the SE and E and NE of the proposed site.

We used to have a family sized hog, farrow to finish operation so I have been there, done that. But this place will be huge. Biggest one in the state in our back yard. Of course odor is an issue. They plan to raise 170,000 hogs/year (incorrect number). That can easily produce 40,000 dead pigs a year. Yes they will compost them, but they are used to weather 200-300 miles south of here. If it gets to cold it is tough to keep that compost pile going. Been there, done that. Also, will be about 16,000 placentas (after birth)/year.

They say the 10' pits have capacity for 1 year of storage. This huge pit will be very difficult to agitate before pumping. Heavy sludge will build up on the bottom they won't get out, making the pit have less capacity, break some water lines and sprinkler lines and pit is fuller faster than they think. What do you do with full pits the wrong time of year? We had some hay ground we went to when that happened. They think they will just pump it out in 7-8 days. They say they want to work with the local farmers but the land may not be ready at the same time and this country can freeze up by Nov. 1, or wet falls, we couldn't finish combining one year until the ground froze. Then they will try and get an emergency permit to spread the manure on top of frozen ground. Run off from this place goes SE to I94 highway ditch. Culverts take some of the water south but not all of it. Some comes east in highway ditch by our farm.

Economic development? They have not found a feed mill yet. There are none close by. Don't you think they should get these answers before you give out a permit? I think all cards should be on the table before you make any decisions.

Where are 17-18 full time employees are going to live where? They say to build houses. Most of the employee's wages will not make house payments and turnover rate for employees in this project will be high. So they go live in Casselton for example. That doesn't help Buffalo. You buy your groceries normally where you live.

Think about all that traffic in and out on our gravel roads all over the township. Rain or shine they will go and hurt the roads. They won't always take the shortest route to pavement. They want to enter in this site from the north which means an extra mile of gravel. If they would build their road east of the site they would only have one mile of gravel until the exit on I94. Their way of coming in from the north makes it all most two miles of gravel. Why wreck more roads (1 mile of county and ½ mile township).

They said 3-4 loads of pigs out per week and 5-6 loads of feed in per week. Rain or shine. When it rains farmers are not combining and running up and down the roads when it is wet. They will have to. Load restrictions, in spring on that county road, could make loads of feed go up to 7-8 loads.

Back to the quality of the workers. In other places like this the workers can't speak English or they work with shackles on their ankles. Check it out.

I am personally concerned about all the extra traffic by my house. We live in the country for privacy. All buildings equipment, houses, cars, will have to be locked up all the time. I am not retired yet but there are some neighbors that may want to sell their farmstead and move to retirement homes. Look how this will lower the value of their place. You say the workers could buy it. Maybe the one manager could buy it but most of the workers would not afford it. We just had two houses with a barn (farmstead) sell for around $270,000. They can't afford that.

My local fertilizer and seed dealers will sell less product. What will we benefit from? The profit will go out of state. There is a lot of confusion about the taxes they will pay.

Your application you put out has mistakes on it. Explain the facility description comments that should be received by December 23, when you did not release this public notice until December 28, 2015? The name is Rolling Green Family Farms RE LLC? Well, we found out Monday night January 18, 2015 at our public meeting (that I forced them to come) and talk to us (They only wanted to meet with a couple of neighbors). I said no way; you will talk to all the neighbors and the community of Buffalo. Again, they were trying to sneak in without people knowing.

They said it was a mistake the LLC should have been LLP (a partnership) of farmers. I am disappointed in Karl for not wanting to reissue the application with these (first two) corrections. People that did not make it Monday night don't know the truth. You ask what the big deal is, well for our local township taxes, will it be zoned commercial or agricultural? My local tax assessor has not gotten back to us yet. If it is a Partnership and they are MN farmers does that make it AG? Will the township get $400 or $10,000?

Isn't it only fair we have some answers before you give them a permit. Again, they want this to be a fast decision where all things are not addressed.

Another example, the Melvins and Rolling Green (Dr. Barry) said we have enough acres to spread manure on. Well instead of asking all the local farmers about using the manure (they were afraid to be up front with that) they put down all the land they farm with some of the land 6 miles, 8 miles, up to 10 miles away. Yes, they have some close and they can pump it through hose 3 to 5 miles. If you think they will haul it 6-10 miles away. They don't want to and they even put down their half section they drain tiled. You see they got enough acres (3300 acres) (not right amount of acres) for the permit but do you realize they will never put manure on those acres far away? What a scam. You realize they think you won't look how far away some of those acres are from the site. There sneaky plan is to show you, get the permit and then build it and then in 4 or 5 years try to dump it on the local neighbors fields within a few miles (including myself).

What a sneaky way to do it. What if some local farmers don't take it they could be stuck with manure they don't know how to get rid of? We as neighbors don't feel that is right. I hope the great state of ND feels the same way. I find it interesting what extent some people will go to benefit them and screw their neighbor. I think they call that arrogant. I hope you don't get suckered into their unpractical dream.

This is really ripping our community apart. They are trying to get permits to put hoses through state highway 38 and I94 (culverts). They don't have those answers yet but they want the permit from you. I talked to Mr. Gilbertson (NDDOT Fargo section manager) he told me "no hoses in culverts" (safety issues). I just can't believe they expect to get a permit without their ducks in a row.

I hope you will deny this permit and hold a public hearing to get some answers. Thank you Jeremy, Brady, and Karl, you all have been very helpful and courteous on the phone.

Lee Fraase

3564 143rd Ave SE

Buffalo, ND 58011

Public notice # NA-2015-019 1-20-16

RECEIVED
JAN 25 2016
DIV OF WATER QUALITY

ND Dept of Health

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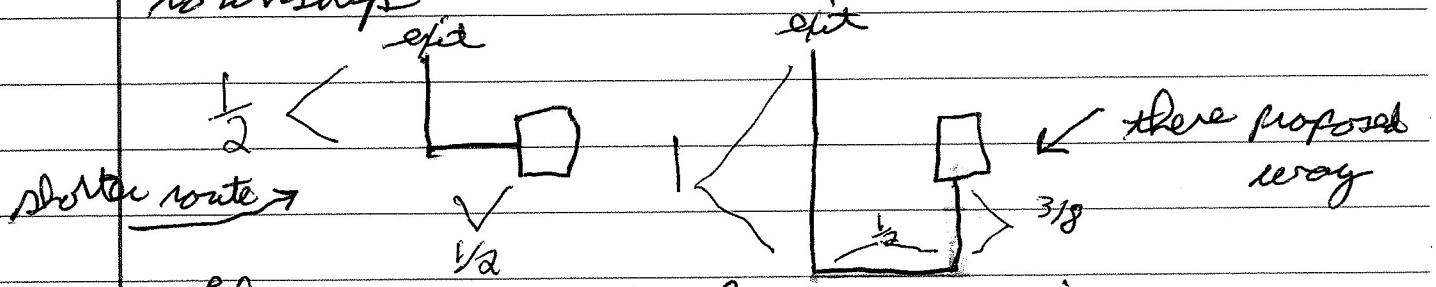

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meeting (that I forced them to come) and talk to us (They only wanted to meet with a couple of neighbors) I said no ways you will talk to all the neighbors and the Community of Buffalo. Again they were trying to sneak in without people knowing. They said it was a mistake the LLC should have been LLP (a partnership) of farmers. I am disappointed in Karl for not wanting to reissue the application with these (first two) corrections. People that did not make it Monday night don't know the truth. You ask what the big deal is, well for our local township taxes, will it be taxed as Commercial & agricultural. My local tax assessor has not gotten back to us yet. If it is P and they are MN farmers does that make it ag. Will the township get $400. or $10,000.? Isn't it only fair we have some answers before you give them a permit. Again they want this to be a fast decision where all things are not addressed.

Another example, The Melvins and Rolling Green (Dr. Barry) said we have enough acres to spread manure on. Well instead of asking all the local farmers about using the manure (they were afraid to be up front with that) They put down all the land they farm with some of that land 6 miles, 8 miles up to 10 miles away. Yes they have some close and they can pump it through hoses 3 to 5 miles. If you think they will haul it 6-10 miles away. They don't want to, and they never put down their half section they drain tiled. You see they got enough acres (~3300 A.) for the permit but do you realize they will never put manure on those acres far away. What a scam. You realize they think you won't look how far away some of those acres are from the site. There sneaky plan is to snow you, get the permit and then build it and then in 4 or 5 years try to dump it on the local neighbors fields within a few miles (including myself)

What a sneaky way to do it. What if some local farmers don't take it they could be stuck with manure they don't know how to get rid of. We as neighbors don't feel that is right & hope the great state of ND feels the same ~~way~~ way. I find it interesting what extent some people will go to benefit them (maybe) and screw their neighbor. I think they call that arrogant. I hope you don't get suckered into their unpractical dream. This is really ripping our community apart. They are trying to get permits to put hoses through state highway 38 and 194 (culverts) They don't have those answers yet but they want the permit from you. I talked to Mr. Gilbertson (NDDOT Fargo section manager) he told me "no hoses in my culverts" (safety issue). I just can't believe they expect to get a permit without their ducks in a row. I hope you will deny this permit and hold a public hearing to get some answers. Thank you to Jeremy, Brady, and Karl, you all have been very helpful and courteous on the phone

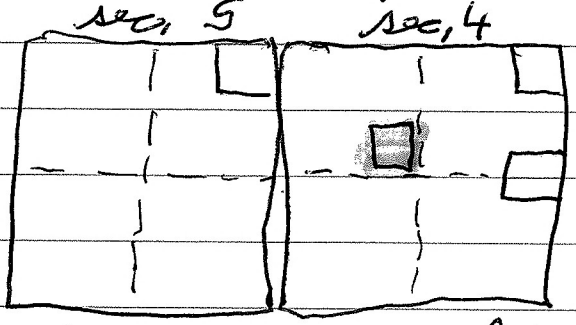
Lee K. Fraase

LEE K. FRAASE (8) 701-840-5117

RECEIVED
JAN 25 2016
DIV. OF WATER QUALITY

ND Dept of Health 1-22-16

This huge hog farm proposed to be built next to my farm is a concern. Did you know that there was three (3) old farmsteads within a ~~half~~ half mile of this site. I will draw you a map for section 4 and 5 in Howes township 139-54



I plan to pull out my old atlas and get you a copy of these. hopefully before Jan 26. Your wells located on the application come from an incomplete list of wells. I know all wells were not recorded before 1971. (that date came from Brady in your office). In the early 1970's the ones in sec. 4 and 5 were bulldozed over with a cat. Peter Keifer did the one I know. Back then they just pushed and buried everything and doesn't

it concern you that those wells, (I don't know the exact location of wells or if they had a well or not but most old farmsteads had wells for themselves and a few head of livestock) would not have been properly capped off. I believe they would have been shallow wells because deep flowing artesian needed a place to drain, and you don't see that residue. This huge hog barn would be within a half mile of these potential wells that were not properly capped off.

True story our farm is right next to I-94, they jogged their right of way or else it would have hit the big house. Before the eastbound lane was put in and I-94 completed. My distant relatives had a small gas station for the west bound road that was then old 10, I in the fifties they knocked all that down to finish I-94. About 12-15 years ago

on the North shoulder of eastbound lane, (because the farm is so close I know that highway like the back of my hand.) we noticed this big hole about 2 or 3 feet in diameter next to the cement. Like a sink hole. It was at least 2-4 feet deep and after a month or so we contacted NDDOT (Cassleton branch) they said they noticed it too and wondered how that could happen in a road that was packed and federally inspected. We dug out some old pictures and did some measuring and we decided by that, that sink hole was an old well quite certain it was the old well from the old gas station. DOT filled it in. Do before you grant any permit I would hope you would inspect those sites for wells that were just pushed over and not filled up properly. Wells that are not properly capped off can't be within a half mile of this barn.

Thanks you Lee K. Fraase

LEE K. FRAASE
Buffalo ND
701-840-5117

(3)

Received January 25, 2016

To NDDH

This huge hog farm proposed to be built next to my farm is a concern. Did you know that there was three old farmsteads within a half mile of this site. I will draw you a map for section 4 and 5 in house Township 139-54?

I plan to pull out my old atlas and get you a copy of these hopefully before Jan. 26th. Your wells located on the application come from an incomplete list of wells, I know all wells were not recorded before 1971. (That date came from Brady in your office). In the early 1970's the ones in section 4 and 5 were bulldozed over with cat. Peter Keifer sis the one I know. Back then they just pushed and buried everything and doesn't it concern you that those wells. (I don't know the exact location of the wells or if they had a well or not but most old farmsteads had wells for themselves and a few head of livestock) would not have been properly capped off. I believe they would have been shallow wells because deep flowing artesian needed a place to drain, and you don't see that residue. This huge hog barn would be within a half mile of these potential wells that were not properly capped off.

True story, our farm is right next to I94. They jogged their right of way or else it would have hit the big house. Before the east bound lane was put in and I94 completed, my distant relatives had a small gas station for the west bound road that was then old 10. In the fifties they knocked all that down to finish I94 about 12-15 years ago on the north shoulder of eastbound lane (because the farm is so close I know that highway like the back of my hand). We noticed this big hole about 2 or 3 feet in diameter next to the cement. Like a sink hole. It was at least 2-4 feet deep and after a month or so we contacted NDDOT (Casselton branch) they said they noticed it too and wondered how that could happen in a road that was packed and federally inspected. We dug out some old pictures and did some measuring and we decided by that, that sink hole was an old well. Quite certain it was the old well from the gas station. DOT filled it in, so before you grant any permit I would hope you would inspect those sites for wells that were just pushed over and not filled up properly. Wells that are not properly capped off can't be within a half mile of this barn.

Thank you,

Lee Fraase

3564 143rd Ave SE

Buffalo, ND 58011

RECEIVED
JAN 25 2016
DIV. OF WATER QUALITY

January 20, 2016

North Dakota Department of Health
Division of Water Quality & Division of Air Quality
918 East Divide Avenue, Fourth Floor
Bismarck, ND 58501

To Whom It May Concern:

I am writing to ask for more information from you before a final permit is issued in the matter of the Application filed by Rolling Green Family Farms to operate a swine confinement facility for over 8,000 animals.

I was born and raised on my family's farm south of Buffalo, moved away for 40 years and retired in Buffalo several years ago for the quality of life that small town living in North Dakota offers. I am an educated woman but am not educated about the requirements, rules and regulations that the State Department of Health has for making decisions about this type of commercial operation. I need to understand more about the maintenance of the facility and how it is monitored for potential environmental issues, such as air quality, odors, water contamination, etc.

Please consider a public meeting to provide necessary information for me and other concerned members of our community. We need accurate data and assurances about the reputation of the Rolling Green Family Farms. I rely on your agency to protect me and all the citizens of North Dakota from disease, health risks and environmental problems.

Thank you for your time and consideration of my request.

Sincerely,

Liane Rakow Stout

Liane Rakow Stout
P. O. Box 133
Buffalo, ND 58011
(701) 412-4485

RECEIVED

JAN 25 2016

DIV. OF WATER QUALITY

ND Dept. of Health

Division of Water Quality

918 East Divide Ave

Bismarck, ND 58501

To whom it may concern:

My husband George Vollmuth and I own land in Buffalo Township, four miles from the proposed hog operation by Buffalo. We have a couple of concerns and because George was away from Buffalo because of a clinic appointment in the cities we were not able to attend the town meeting last week.

Our concerns are water and waste management for such a large operation so close to neighboring homes and land. If the facility has up to 9000 hogs as part of this operation, will rural water be able to supply that amount of water without compromising the water use of the other local patrons? Also, how will diseased and dead animals be dealt with to avoid odor, flies, and contamination of land, air, and water?

Also, of course, one wonders what will happen to our land value with such a facility so close by.

Our hope is that you will consider the people of Buffalo and surrounding area to let them have their say at an open meeting that could be attended by property owners and residents of this area.

Sincerely,

Margaret Vollmuth

Date Received January 25, 2016

To: NDDH

To whom it may concern:

My name is Marian Kasowski . I live in the village of Buffalo, where a large pig operation is proposed near by.

We had a meeting with reps from “Rolling Green Family Farms RE, LLC”. A spirited meeting ensued with over 100 present.

At the onset, I was simply thinking of prevailing winds that would carry odor, but having heard the comments of several people who had researched the health issues involved with this operation, I am really concerned. Our contributor fund that eventually there will be contamination of ground water. We, in our area, are served with an aquifer water source by Cass Rural water. We must think ahead to the health of our children! The reps could not guarantee air quality either.

Please consider our plight in making your decision regarding the permit to build this 9000 animal facility.

Sincerely,

Marian Kasowski

PO Box 48

Buffalo, ND 58011

Buffalo, North Dakota 58011
January 20, 2016

RECEIVED
JAN 25 2016
DIV. OF WATER QUALITY

N.D. Dept. of Health
To whom it may concern...

My name is Marian Kasowski. I live in the village of Buffalo, where a large pig operation is proposed near by.

We had a meeting with reps from "Rolling Green Family Farms RE, LLC". A spirited meeting ensued with over 100 present.

At the onset, I was simply thinking of prevailing winds that would carry odor, but having heard the comments of several people who had researched the health issues involved with this operation, I am really concerned. One contributor found that eventually there will be contamination of ground water. We, in our area, are served with an aquifer water source by Cass Rural Water — We must think ahead to the health of our children!

The Reps could not guarantee air quality either.

Please consider our plight in making your decision regarding the permit to build this 9000 animal facility.

Sincerely,
Marian Kasowski
Box 48
Buffalo, N.D. 58011

RECEIVED
JAN 28 2016
DIV. OF WATER QUALITY

CASS COUNTY
GOVERNMENT

Board of County Commissioners

Chad M. Peterson
Fargo, North Dakota

Rick Steen
Fargo, North Dakota

Ken Pawluk
Fargo, North Dakota

Arland H. Rasmussen
West Fargo, North Dakota

Mary Scherling
Stanley Township, North Dakota

January 26, 2016

Terry Dwelle, M.D.
State Health Officer
E-mail: tdwelle@nd.gov
600 East Boulevard Avenue
Bismarck, N.D. 58505-0200

Dear Dr. Dwelle:

I had originally intended to correspond with you to urge the North Dakota State Health Department to extend the comment period and hold a public information meeting and hearing regarding a proposed concentrated livestock feeding operation near Buffalo, North Dakota. However, I was gratified to note on the Department's website on January 25th that a public meeting and hearing has now been scheduled for March 17, 2016.

The County Commission has heard concerns from a number of local residents. I believe it important that the permit approval process be explained and that the residents have an opportunity to voice their opinions in a public forum prior to making a final permit decision. Thank you for extending the comment period and scheduling the public meeting and hearing.

Sincerely,

Mary Scherling, Chairman
Cass County Commission

cc: Cass County Commissioners
Jason Benson, Cass County Engineer
Hali Durand, Cass County Planner

Heather Worden
Commission Assistant

PO Box 2806
211 Ninth Street South
Fargo, North Dakota 58108

701-241-5609
Fax 701-241-5728
www.casscountynd.gov

RECEIV
JAN 2 5 2016
DIV. OF WATER QUALITY

North Dakota Department of Health
Division of Water Quality
91 East Divide Ave.
Bismarck, ND 58501-1947

To Whom It May Concern:

We would like to register our concern regarding the possible hog farm operation at Buffalo, ND. Although we are not residents of Buffalo, we have had the opportunity to enjoy the area throughout the years. We have a vested interest in the area, as our grandparents' family farm is located very close to the proposed operation. We are the fifth generation to enjoy this property.

The farm setting has always offered wide open spaces, fresh air, safe and pleasant surroundings. The potential of 5000 hogs in a large confined feeding operation can only diminish the quality of this setting. In addition to the concern for general quality of life, the very real possibility of increased environmental hazards exists. Air quality will most certainly be affected. In addition, the high concentration of waste material in a confined area brings increased risk of bacteria and pathogens, giving rise to health concerns. Will the bacteria and pathogens find their way into the water supply? Technology may not be capable of overcoming this possibility.

What will be the impact of such a large operation on small farms, working to raise and sell their animals? It would seem to add more stress to an already struggling industry. North Dakota relies heavily on its rural economy, and family farms are the backbone of that economy.

Health and environmental concerns, air and water quality, and over-all quality of life are important enough to safeguard. This project sounds like progress, but at what cost to the land and the community around it? We hope that you will carefully consider the negative impact of this large operation on the community of Buffalo and the surrounding areas before issuing a permit.

Yours truly,

Michael F. Beaton, Jr.
2918 11th St. S.
Fargo, ND 58104

Jill Suppes
4601Timberline Dr.
Fargo, ND 58104

Jon Beaton
6412 Falbrook
Eden Prairie, MN 55344

Michelle Gilley
2910 146th Ave SE
Ayr, ND 58007

North Dakota Department of Health
Divisions of Water and Air Quality
918 East Divide Avenue
Bismarck, ND 58501-1947

To whom it may concern:

I live near the proposed pig farm in Cass County under application #DNAF00853. I am horrified at the speed this project is being pushed through without notifying the nearby residents. I found out about this project with barely a week to respond. Pipestone Systems is the true owner of this operation—not a family farm. I am horrified that this is being promoted as a family farm, when Pipestone provides the pigs and the labor.

I have many concerns. How much water will be used? Will the groundwater and air quality be monitored? How often will the farm be inspected? Does the State of North Dakota plan to enforce the payment of fines if the pig farm exceeds certain limits? Does the State of North Dakota even have set air and water quality limits for this kind of operation? Who will pay to clean up the mess if they decide to abandon the project? Where will all that waste go? Who is going to pay for the necessary road improvements? Is Pipestone Systems getting a tax break? Where is the Environmental Impact Statement?

Thank you,

Michelle A. Gilley

Strommen, Rachel A.

From: Lang, Jeremiah M.
Sent: Friday, February 05, 2016 2:21 PM
To: Strommen, Rachel A.
Subject: FW: I support approval of the pig farm

-----Original Message-----
From: Pam Brekke [mailto:brekkeag@polarcomm.com]
Sent: Friday, February 05, 2016 2:07 PM
To: Lang, Jeremiah M.
Subject: I support approval of the pig farm

Dear Environmental Engineer Lang,

I am a farmer from Prospect Township in Ramsey County. We fought the county commissioners for several years trying to get a 5,000 head hog barn up. We finally zoned our township ourselves and eventually got the barn up and running. In the 10 years it has been in operation we have not heard of one complaint about odor or water quality. The people who come into our communities and spread misinformation and lies to scare the public should be shut down. There are rules set in place by the ND State Health Department for a reason and that is to protect the producer and the public equally. If they see problems, they will have to be addressed before anyone can move ahead.

Anything we can do in this great state to increase opportunities for young people to stay here and have a future in agriculture has to be done. Don't let people scare you into believing things that are not true. Ask questions of the people who have studied these issues and use science based facts, not scare tactics.

Sincerely,

Pam Brekke
7205 99th Ave NE
Edmore, ND 58330

Sent: January 25, 2016

To: NDDH

To whom it may concern:

I am concerned about the proposed large hog barn setup, as it will cause more odors and also the excess water runoff could potentially run down the ditch right in front of my house.

I am a retired R. N. and farm wife who lives about 1 ½ mile from the proposed site.

The value of my home will certainly go lower. In the near future I have plans to sell my home so I can move to a senior citizen facility.

Sincerely,

Ramona Fraase

3687 743rd Ave SE

Buffalo, ND 58011

Jan. 16, 2016
Buffalo, N.D.

To Whom it may Concern:

I am concerned about the proposed large Hog Barn Setup, as it will cause more odors and also the excess water run-off could potentially run down the ditch right in front of my house.

I am a retired R.N. & Farm wife who lives about 1½ miles from the proposed Site.

The value of my home will certainly go lower. In the near future I have plans to sell my home so I can move to a Senior Citizen Facility

Sincerely,
Ramona Fraase

Ramona Fraase
3687 143rd Ave SE
Buffalo ND 58011-9623

RECEIVED
JAN 25 2016
DIV. OF WATER QUALITY

RECEIVED
JAN 2 2016
DIV. OF WATER QUALITY

January 22, 2016

Randal Melvin
4173 142nd Ave SE
Alice ND 58031

Rachel Strommen
North Dakota Department of Health
Water Quality Division
918 East Divide Ave
Bismarck ND 58501-1947

Rachel Strommen,

On December 28, 2015, a permit was issued to Rolling Green Family Farms RE, LLP and is currently in the public comment period. As a landowner who owns farmland adjacent to the site where Rolling Green Family Farms has applied for an NDPDES permit, I am writing in support of the project.

After reviewing the proposed permit, I feel that this livestock facility will have a positive effect on my farm. If anyone should be concerned about a detrimental effect it should be me. The surface water from this site will drain across my ground. The surface water will not be any more than what is currently flowing across my land.

My personal opinion is that any adverse environmental impact to our area is virtually non-existent. We do not have any open wells in that section of land. The nutrient management plan is going to be a huge boost to the farmers in this area. Furthermore, the livestock facility will have a positive economic impact and the potential ancillary benefits are exciting to imagine.

The services and diligence of the North Dakota Department of Health is appreciated, as well as, the thoroughness that has been put into the review of this application.

I support this permit application and hope to see the livestock facility constructed.

Sincerely,

Randal Melvin

Randal Melvin

Received January 25, 2016

To: NDDH

To Whom it may concern,

Reference to the application to build a pig facility SE of Buffalo, ND,

I'm a 60 yr resident of Buffalo. We have worked hard to keep it attractive and thriving. I'm concerned about the proximity to the city's only about 3 miles away.

Buffalo has a high ground water level. Most homes run sump pumps almost yr round, even with tiling. In rainy seasons I can dig 6 inches deep in my back yard and hit water. If contamination from manure pits or other run off gets into the ground water it would affect many. It happened at Carrington!

Other Concerns:

1. Air quality- both odor & diseases
2. House flies-bred in barn & compost
3. Loss of property value

It saddens me to see the way this is tearing our town apart. One of our local farmers has been threatened to have his winter job at NDSU taken away for speaking at the meeting. People have withdrawn their business from our CO-OP grocery store because of the Melvin interest in the store.

Mrs. Ray Wiemest

RECEIVED
JAN 25 2016
DIV. OF WATER QUALITY

Jan 21 - 2016

To whom it may concern,

Reference to the application to build a pig facility SE of Buffalo NC:

I'm a 60 yr resident of Buffalo. We have worked hard to keep it attractive and thriving. I'm concerned about the proximity to the city, only about 3 miles away.

Buffalo has a high ground water level. Most homes run sump pumps almost yr around, even with tiling In rainy seasons I can dig 6" deep in my back yard and hit water. If contamination from the manure pits or other run off gets into the ground water it would affect many. It happened at Carrington!

over

Other concerns:

Air quality - both odor + diseases

House flies - breed in barns & compost

Loss of property value

It seems nuts to see the way this is tearing our town apart. One of our local farmers has been threatened to have his winter job at NDSU taken away for speaking at the meeting. People have withdrawn their business from our CO-OP groceries store because of the Melvin interest in the store.

Mrs Ray Diemert

RECEIVED
JAN 19 2016
DIV. OF WATER QUALITY

January, 15, 2016

Mr. Jeremy Lang
North Dakota Department of Health
Division of Water Quality
918 East Divide Avenue
Bismarck, ND 58501-1947

Dear Sir:

In response to our telephone conversation regarding the permit to locate a confined hog operation in Howes Township, Cass County, North Dakota, I am putting my opposition to issuing this permit in writing. My farm is located on the Hill/Howes Township line, approximately 2 miles from the proposed citing, so I feel it is important my concerns be documented.

I am a fourth generation farmer (my Great Grandfather homesteaded in the Buffalo area), and in addition to farming I work part-time. I hold B.S. and M.S. degrees in Agricultural Economics from North Dakota State University and have worked for the Agribusiness & Applied Economics Department for over 40 years. My areas of research are economic impact assessment, economic base analysis, input-output analysis, and econometric modeling. My research background makes me uniquely qualified to comment on the economics of this project, and I did a thorough review of literature to learn more about confined hog operations. Although this is not a formal research paper, I will source and provide references for the salient points I will present. This will guarantee that my concerns are based on published information and not personal opinion.

My concerns with this facility are many. First, the corporation should have contacted the near-by farms because it looks like they were sneaking around and trying to get this built before anyone noticed. I found this type of behavior common with confined hog operations, and echoed in an article where one Iowa landowner stated, "If this were the right thing to do, he could have called his neighbors and told us about it and asked about our concerns, instead of sneaking around" (Sager and Caulfield 2014).

As an agricultural economist who works on economic impact assessments, the claim that this project will have an economic impact on the community is questionable. Economic impacts are based on new dollars coming into an economic unit, or a community's economy. It is likely that all inputs for this operation will come from outside the region. Local purchases of corn would not have an economic impact because those purchases would bring no new dollars into to the economy. There currently are three unit-train loading facilities within 15 miles of the proposed cite. It also is unlikely that workers would locate in Buffalo when cities with more amenities are within driving distance. Corporate profits will not stay in the region and opportunity costs must be considered in the analysis. The additional truck traffic on township roads will require

upgrades and maintenance at a time when their budgets are already stressed. This facility would most likely result in tax increases for local residents. Hog manure to be used as fertilizer would bring dollars to the corporation which also would leave the community as these sales would replace local retailer's volume of sales. My preliminary analysis is supported by other published studies (MacCammal 1988; Gomez and Zhang 2000; Durrenberger and Thu 1996; Abeles-Allison and Conner 1990; Foltz et al. 2002; Lawrence 1994).

Health concerns for neighbors who live near a confined hog operation are well documented. Hog waste contains disease-carrying pathogens, such as Salmonella, E. coli, and Cryptosporidium, and fecal coliform which can be 10 to 100 times more concentrated than human waste (Nation Resource Defense Council 2013). In addition, the Environmental Protection Agency says that manure often contains hormones, pathogens, and toxic metals (Huber and Mills 2013). About 70 percent of the antibiotics used in the United States are fed to animals that are not sick. Many in the scientific community have expressed concern that the system will increase antibiotic resistance and put human health at risk (Wallinga 2004). A 2002 study found antibiotics in one-third of the water samples taken near a confined animal feeding operation (Wallinga 2004). Air emissions from confined hog operations contain ammonia which reacts with other gases in the air to form fine particle pollution, a public health threat linked to decreased lung function, cardiovascular ailments, and more seriously, premature death (Research Triangle Institute 2003). Hydrogen sulfide is also released into the air, and is associated with respiratory and cardiovascular problems. Numerous other studies document the health risks associated with confined hog operations, with increased risks for those who work in these facilities. Beyond being unpleasant, these emissions adversely affect human lungs, brains, and other organs (Kilburn 2011). Clearly, the health risks associated with a confined hog operation are a concern to me and my neighbors.

Environmental concerns associated with a confined hog operation are also justified. My farm has a well that is only 2 miles from the proposed facility. Pollution from these types of facilities in Iowa and North Carolina are well documented. The risk to the environment is a great concern, and promises that it will never happen here are meaningless. Environmental accidents do happen elsewhere and there is no guarantee that will not happen in Buffalo, ND. Contaminated surface and ground water would be a serious problem for people living in the area. Selected studies that document these types of accidents include Peach (2014), Huber and Mills (2013), and Natural Resources Defense Council (2013). An additional problem that the neighbors will have to deal with is flies as they are attracted to this type of facility. These insects could become an extremely annoying and also are a health hazard.

All of the literature I reviewed had one common theme. The odor generated by a confined hog operation is terrible. With many farmsteads and the city of Buffalo in close proximity to the facility, a large number of residents who have lived a long time in their homes will be affected. Despite all the promised that these facilities do not smell, all studies that I reviewed refuted this claim. There are legitimate health concerns associated with the air quality surrounding large confined hog operations. The odor goes beyond the very real nuisance of living with stench in

the air. Odors associated with giant hog farms affect the lives of people for miles around, not just those in adjoining farms. Few would be willing to stay in, or move to, such a community if they have the opportunity to locate elsewhere (Ikerd 1998). Homeowner's property values will be negatively affected. Most people's biggest investment is their home, and to have it devalued so a corporation can produce hogs in our community is a very poor trade-off. One study I reviewed calculated the dollar decrease in home values per hog grown in their community. The corporation that wants to locate a large hog operation in our area also built one in Davison County, South Dakota. Problems the local neighbors have had with that facility are well documented in local newspapers (Associated Press 2014; Heidelberger 2015; Heidelberger 2014). Their struggles with Jackrabbit Farms are on-going as they felt they were guaranteed there would be no odor from the operation, but instead are stuck with a very unpleasant odor. Their complaints to the corporation have not been adequately addressed, and in fact, Mr. Kerkaert (Pipestone Vice President) was quoted in the Dakota Free Press as saying, "We just exercised our rights, and we are tired of being harassed". This does not sound like the kind of neighbor we want in the Buffalo community. It appears to me this corporation just wants to dump this facility in our community with little regard for the many life-long residents of the area. This corporation is just an entity that wants to make a profit, but does not live, contribute, or care about the Buffalo community. On their permit application they call themselves Rolling Green Family Farm RE, LLC, which appears to be a sub-corporation of Pipestone Systems. According to their website, this corporation has hog operation in Minnesota, Iowa, Nebraska, South Dakota, and Missouri, with a total of 39 confined hog operations.

I encourage you to deny the permit for a confined hog operation in the Buffalo community. In my analysis of the proposal, I find the socio-economic consequences far outweigh the benefits. The Buffalo community deserves better than to have a potential environmental disaster located in the area. I believe if you asked residents what they would least like to have come into their community, a confined hog operation would be at the top of the list. This letter became almost a mini-report, but I felt it was necessary to make a strong case as to the negatives associated with the citing a confined hog operation within the community. Again, I would strongly urge the North Dakota Health Department to reject this permit and spare the community from the loss of its quality of life. Thank you for reading my letter and reviewing the facts I have presented.

Sincerely,

Randy Coon

Randy Coon

References

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Associated Press. 2014. South Dakota Hog Farm Neighbors Battle Over Smell. Internet Website: http://washingtontimes.com/news/2017/aug/14/south-dakota-hog-farm-neighbors-battle-over-smell/.

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RECEIVED
JAN 25 2016
DIV. OF WATER QUALITY

To the North Dakota Department of Health, Jan. 21, 2016

I am a township officer in Howes township which is also the location of the proposed hog facility, Public Notice Number: ND-2015-019. I have concerns with the location of this facility because there has been a lot of discussions with neighbors (residents) that live near this part of our township. I would like to be assured that under conditions that it is difficult to properly inject and dispose of the manure and waste waters that the applicant is monitored to not cause risks to our residents and water drainage systems. What I mean is the applicant told me that if unfavorable weather conditions occur, they can dispose their waste on top of the ground even if it is frozen. This will cause a huge odor problem and potential run off into ditches and normal drainways.

Another concern for our township is the extra traffic on some of our roads. The large size of this project will require a lot of heavy traffic to build and develop this facility. After it is completed the normal daily traffic will be less but will occur almost every day of the year during weather conditions that make it difficult to maintain our roads for the safety of all our residents. The applicant has said he would discuss how they would help maintain these roads. I need to be assured that some agreement will be made and also enforced.

I have a strong opinion about the location that the applicant has chosen to enter into this facility off of our township road. The plan indicates that they will exit I- 94 and go north one mile on a county road and then turn and go west a half of mile on our township road and then enter the land to the south and build a road until they are on the site of the facility. I have discussed with the applicant that they could enter their facility by going only a half of mile north on the county road and then enter the land to the west and build their road going west until they are on the site. This option is more beneficial to all other public traffic that also uses these roads as a mile of public roads is not subject to unsafe conditions as a result of this large project that will be here for many years.

I am asking you to provide the residents of my township that I represent a chance to address this public notice at a public hearing. I hope you will understand the concerns that our township and its residents have and please feel free to contact me to further discuss some of these issues. My telephone number is 701-261-6308.

Ron K. Fraase Howes Township Officer

Ron K. Fraase

ND Department of Health
Division of Water Quality
918 East Divide Avenue
Bismarck, ND 58501

RECEIVED
JAN 25 2016
DIV. OF WATER QUALITY

Dear ND Department of Health and Division of Water Quality Board members,

I am sending this letter as I am concerned about the recent news of a swine operation coming to Buffalo, ND. I am a descendent of Nelson and Jane Nudell and stand to inherit the land from my mom and dad, Alan and Kim Webster. I have copied and pasted their letter on to this letter because I have the same concerns as theirs.

Their letter is copied below:

We are writing this letter in response to the very recent news that a swine farm was on the agenda for approval near Buffalo, ND. We are suspicious as to why this information wasn't made public until the very last minute. Being born and raised in North Dakota, we were both brought up in farming communities. We question why a local farmer would sell his land to a large corporation and the news didn't become public until now. The whole thing smells like a shady deal. If it were such a great project, then why all the secrecy? We read the articles in the Fargo Forum along with the news video presentations from the meeting in Tower City.

We own 2 quarters of land ½ mile south of the site of the proposed swine operation in Buffalo, ND. Our land is on the south side of Interstate 94. This land was originally homesteaded by Nelson and Jane Nudell and bought by their son Lorne and Helen Nudell. The land went into a trust to my brothers and me (Kim). We then bought the land from my brothers, Keith Nudell and Kent Nudell. We currently rent our farm land to the Buhr Brothers of Buffalo, ND. It is our hope to pass this land on to our two sons, Seth Webster and Jared Webster. Custer, SD is where we live and are retired from the teaching profession. We have connections in Buffalo, ND and visit up there to check on the land numerous times.

We are concerned because there is a drainage system that flowed from the land north of Interstate 94 to our land directly south of Interstate 94. We are concerned about the drainage that might affect water quality, the spread of disease, and the odor. We are equally concerned about the value of the land as this pig operation emits toxics into the water drainage and land. Does this corporation have a plan for disposal of dead animals and the placentas? Would these be a source for flies and possible disease? We have so many questions and are feeling rushed about getting this letter sent to you in time for your deadline meeting! We plan to be in ND for spring planting on our land in Ellendale, ND in May and would gladly come up for meetings at that time.

This sounds like a rush deal. We would hope you would give the farmers and the community more time to gather their research and answer their questions before you make a hasty decision that has the possibility of hurting a lot of people's livelihoods and the town's peacefulness. We would hate to see a large corporation take away from the livelihood of the farming community of Buffalo. We doubt this corporation is going to support the local businesses. **We strongly urge you to give the citizens of Buffalo more time to gather information.**

Thank you for letting me share my parent's letter along with my concerns as I feel your decision will directly affect my family and me.

Sincerely,
Seth Webster
Gregory, SD 57533

1-21-16

FAX COVER SHEET

Recipient Information:
To: Environmental Health Section
Fax#: 17013285200
Subject:

Sender Information:
From: Shawn (Frueh)
Pages: 2
Date: Jan 20, 2016

Comments:

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RECEIVED
JAN 20 2016
DIV. OF WATER QUALITY

Shawn Frueh
5240 W 102nd Ave
Apt. 210
Bloomington, MN 55437

January 20, 2016

ND Dept. of Health
Div. of Water Quality
918 East Divide Ave.
Bismarck, ND 58501-1947

Dear ND Dept. of Health:

RE: Notice #ND-2015-019

I am requesting a public hearing before finalization of this permit. We are asking that you seriously consider the effects of this situation long and short term. I have deep concerns of the quality of air, water and life if this CAFO is permitted in this area.

I am concerned that the air quality will be very harmful my parents and grandmother. Both of them have compromised immune systems and this could seriously affect their quality of life. I also go home often to get away the busy life in the city for peace, rejuvenation and quality time with my parents.

My parent's legacy to us children is also being threatened with the prospect of losing minimal of 40% of their property value. If this facility is permitted, that is a serious threat to natural aging of our parents, and their retirement financially. Please consider taking a second look at allowing this permit. Thank you for your time.

Sincerely,

Shawn Frueh

RECEIVED
JAN 19 2016
DIV. OF WATER QUALITY

TIM FRUEH
14006 37TH ST. SE
BUFFALO, ND 58011

ND Dept. of Health
Div. of Water Quality
918 East Divide Ave.
Bismarck, ND 58501-1947

Jan. 12,2016

Re: Public Notice #ND-2015-019

I am requesting a public hearing before finalization of this permit. We are asking that you seriously consider the effects of this situation long and short term.

I have deep concerns of the quality of air, water, and life if this CAFO is permitted in this area as well as the property values of homes and businesses if this permit is granted.

We have the City of Buffalo within 3 miles with K-3rd grade school children, a day care, preschool as well as the city itself.

Our property is our legacy to our children and grandchildren and we are not willing to take a chance of losing this or our investment of our property.

We have immediate family that come and enjoy the quality of life that we have here in the country. The information that we have researched says it's deadly to small children, elderly, and those with compromised health issues. I have two family members that this could affect with negative health results. My wife has stage 4 kidney disease and my mother in-law, who lives with us, has terminal lung cancer that at this time is in remission for the time being.

We have researched this issue and find nothing positive about this except for the company itself. There is no increase in community value – only decline, no increase in community revenue, and causes the community to become divided with irreparable damage that takes years to repair if ever.

We have contacted the land owner that sold the land, contacted another land owner of another site. We have also contacted the Howes Township and the County Commissioner. In visiting with then they say they have no control over this situation. We are seriously in need of help in this situation.

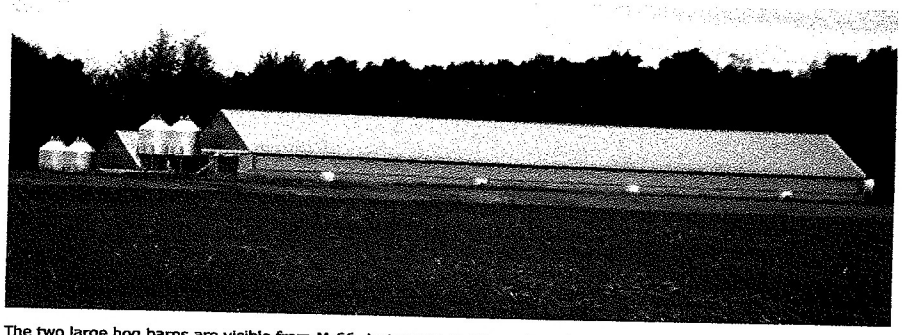
I am sending some of the information that I found of interest in researching corporate hog operations. I am sure that in your own research you will also find that this is a serious situation that needs to have a second look at. Thank you for your time.

Please review the following:
www.cdc.gov/nceh/ehs/docs/understanding

Sincerely,

Tim Frueh

Pig farm brings complaints



The two large hog barns are visible from M-66, just south of Athens. Residents in the area have complained about the smell. Don Reid photo

Is Market Selloff Pointing to a Bear Market?
Bloomberg
Bloomberg

By Don Reid
dwreid@aol.com; @DReidTDR

Posted Oct. 12, 2015 at 7:14 AM

Coldwater, Mich.

SHERWOOD TOWNSHIP — Pat Meyer admitted that he knows Sherwood Township trustees can't do anything about it, "but I want to complain about the odors of pigs." He wanted it on public record that when conditions are right, the smell from a new hog farm in the township is unbearable.

Matthew and Mary Yoder have constructed two huge metal barns at 800 Mendon Road to house 2,500 hogs each. The property is just north of M-60/66 and west of M-66 between Athens and Oliverda Lake.

Meyer said that this summer at his home, located to the south of the hog farm, "there at the end you could taste the pig (feces) in your mouth. I could pump my sewer on the ground, and it wouldn't smell so bad."

The main problem is that although the smell will lessen in the winter, right now there are still mornings and temperature inversions.

Myers also said that when the wind changes, with the smell blowing towards Athens half-a-mile away, "I'm sure they smell it, too."

The farm meets Michigan's Right to Farm standards as best farm practices, according to the Michigan Commission of Agriculture and Rural Development. The manure is put into pits and treated for later use on farm fields.

Myer said he understood that, but its was the smell from the barns that concerned him.

"I don't think I should have to put up with that," he said. "Nobody out there does."

He added that the smell devalues property in the area.

"The guidelines and the regulations are all set forth by the state," Sherwood Township Supervisor Dave Meyer explained. "Township zoning had nothing to do with it."

The problem has existed since the hog farm started operation in August, "but unfortunately, there is nothing to do about it," Meyer said.

More videos:

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TV GUIDE

Celebrities Share Personal Reactions to David Bowie's Death

David Bowie Dead at 69

On another note, Sherwood Township did receive a good audit for the 2014-15 fiscal year, which ended March 31.

"You have a very strong balance sheet," Kim Bontrager of Locey CPA of Sturgis said. "You've done a very good job."

Last fiscal year, the township had planned for a break-even budget, but ended the year $44,000 to the good.

"This shows good management of your expenses," Bontrager said.

She also noted that the township took too much depreciation for three years from 2009. When adjusted, that meant the township had $325,000 more in assets than what showed on its books. It finished last fiscal year with $255,000 in cash in its general and fire funds.

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Jackrabbit Farms officials speak with Davison County residents about their concerns with Jackrabbit Farms during a meeting on Thursday afternoon at the Davison County Courthouse in Mitchell. (Matt Gade/Republic)

Neighbors still unhappy about smell at Jackrabbit Farms

By Anna Jauhola on Apr 9, 2015 at 5:24 p.m.

Neighbors who live near a corporate hog farm south of Mount Vernon again requested Jackrabbit Farms to do something about an alleged odor from its establishment.

Representatives from Pipestone System, which manages the hog facility, and Jackrabbit Farms met with about 10 neighbors Thursday afternoon at the Davison County Courthouse in Mitchell.

"The microbes in the pit take years to get fully activated, and then the odor will be reduced," said Sean Simpson, general counsel for Pipestone System.

Jackrabbit Family Farm swine production unit is where 5,000 sows are expected to produce up to 3,000 piglets a week when the facility is at full capacity.

Dr. Barry Kerkaert, veterinarian for Jackrabbit Farms, said the company is not satisfied with the odor issue and a major remedy to the situation is to get the enzymes in the manure pits working better to eliminate the odor.

Davison County Commissioner Denny Kiner suggested the company use an additive in the manure pits to increase the enzyme activity.

Large Scale, Corporate Hog Operations: Why rural communities are concerned and what they should do

John Ikerd
Agricultural Economist
University of Missouri, Columbia

I was recently asked by a rural advocacy group in Missouri to list some logical reasons why rural community leaders should be concerned about the impacts of livestock factories on their communities? I considered this to be a reasonable request and thus developed a list of reasons why I think rural residents should question whether or not they want large-scale, corporate hog farms to locate in their communities. Those reasons seem to make a logical starting point for a paper concerning why rural communities are concerned about large-scale corporate hog operations and what they should do about them.

As I indicate in my response to that request, there is no scientific consensus on this issue. Thus, there is no set of scientific "facts" to either prove or disprove the validity of these concerns. Research exists to support many of the concerns on my list, even though they cannot be proven. However, most of the concerns on the list are based primarily on logical reasoning and common sense. Some may dismiss these "logical" concerns as illogical, uninformed, or inconsequential. But, such assessments simply represent differences in "beliefs," not proven facts or some unique knowledge of reality. The people of rural communities have a right and responsibility to weigh the evidence and logic on both sides of this issue and to make their own decisions.

Top ten reasons for rural communities to be concerned about large-scale, CAFOs

A "top ten list" wasn't chosen just to be cute or catchy. Ten is enough to get the point across, but not so many as to overdo discussion of the issue. Also, I wanted to start at the bottom of my list and work my way to the top.

Concern #10. Hogs stink

Odor is at the top of the list for many opponents of large-scale hog farms. The most vocal opponents tend to be those affected most directly – those who wake up most days to the smell of hog manure. To a hog producer, hog manure may "smell like money," but to the neighbors, it just "smells like hog manure." There are legitimate human health concerns associated with air quality surrounding large hog operations. Thus, the odor problem goes beyond the very real nuisance of living with stench in the air. Odors associated with giant hog farms affect the lives of people for "miles around," not just those on adjoining farms. Few would be willing to stay in, or move into, such a community if they have an opportunity to locate elsewhere. Odor ranks only 10 on my list because something could possibly be done to mitigate its impacts, such as using odor-reducing technologies, compensating those most affected and locating facilities so as to minimize impacts of the greater community.

Concern #9. The work is not healthy for people

A large confinement hog facility is not a pleasant place to work. Known health risks are associated with continuously breathing air that arises from manure pits in confinement hog facilities. Health problems cost money in lost wages and health care costs. But more important, an unhealthy workplace can destroy peoples' lives. History has proven that people will choose to work in dangerous work environments when they are desperate for jobs. Health risks can be life threatening, so I rank worker safety above odor problems. But as in the case of odor, health problems can be mitigated by protecting workers from the noxious fumes, by limiting exposure, and by keeping people with other health problems out of confinement facilities.

Concern #8. Piling up too much "stuff" in one-place causes problems

If you spread out the hogs and let hog manure lay where it falls in a pasture, it doesn't bother anyone very much. But if you start collecting it, flushing it, spreading and spraying it around – all normal practices in confinement hog operations – it becomes air pollution. Water pollution also is a symptom of the same basic problem -- too much manure in one place. The difference between the hog lagoon spills, such as those in Missouri and North Carolina, and the normal runoff from a hog pasture is a simple matter of concentration. When you put a lot of hogs in the same place, you have to collect and store the waste. If it gets into the ground water or gets flushed into streams, it kills fish, clogs streams and lakes with algae, feeds water born disease organism, and wreaks havoc in the environment.

In addition, manure on diversified hog farms normally is spread back onto cropland where the feed grain was grown. Most of the nutrients used to grow the crops are returned to the soil. But, when feed grains from specialized crop farms are shipped to distant hog-factories, the nation's future productive capacity is being stacked up and flushed out into places where crops can't grow. We can treat the symptoms – air pollution and water pollution – but the basic problem of piling up too much stuff is inherent within the system of large-scale, concentrated production.

Concern #7. Consumers have little if anything to gain

Large-scale, corporate hog production is frequently justified to the general public as a more efficient, lower cost, means of producing higher quality pork. The facts of the situation simply do not support such a claim. The average consumer spends just over 10 percent, a dime out of each dollar, of their disposable income for food. About 10 percent, a penny out of the dime, is spent for pork. The costs of live hogs make up only about 35 percent of that penny. The rest goes for processing, packaging, advertising, transportation, and other marketing costs.

Farm record data have shown that costs of large-scale hog operations are only slightly lower than costs of "average" commercial hog producers. Even if production costs were five percent less, about $2/cwt of live hog; the "maximum" savings to consumers would be less than two cents per dollar spent for pork at retail. At best, total food costs would be two-tenths of one percent less and consumers on average would spend only "two-one-hundredths of one percent" less of their income for food. Any savings would be lost in rounding error in consumer food cost statistics. With a handful of large hog producers and packers gaining control of the industry, it seems far more likely that in the long run pork prices would go up rather than down as a consequence of further industrialization.

The argument that factory pork would be higher in quality doesn't hold either. Pork would be more uniform because it would all come from the same basic genetic stock, as is currently the case with chickens. However, consumers have different tastes and preferences – different perceptions of quality. Making all pork "the same" would not necessarily please more consumers. Greater profit for producers and processors, not lower costs or higher quality, is the driving force behind the current trend toward industrial hog production. The only ones who really need to shave another penny or two off production costs are those who are trying to export more pork into highly competitive world markets. That doesn't include many hog farmers or pork consumers. So, why should the general public support industrial hog production?

Concern #6. Continuing regulatory problems are inevitable

Without regulations, big hog operations will impose costs on their neighbors – air pollution, water pollution, and others -- that are not part of the historic costs of producing hogs. It will cost money for hog factories to deal with "externalities" such as air and water pollution. No "bottom-line" driven hog operation will incur those costs unless they are forced to do so by government regulations – federal, state, or local.

Family farmers are people with human feelings and values, and most feel some sense of responsibility to their communities and the environment. Family farmers at least have personal incentives to be stewards of the environment and good neighbors, regardless of how they choose to behave. Public corporations have no such incentives. They are not people. Corporations have no heart or soul. Stockholders often are so detached from their investments they don't know or care what stocks they own – just as long as they make money. Local managers and workers may be good people who really care about the community, but when it comes to keeping their job, they must put profits and growth ahead of community. Professed corporate support of local communities, by necessity, can be nothing more than another strategy for profit and growth. Thus, government regulation and continual conflict are an inherent fact of corporate life.

#5. Hog factories destroy public confidence in agriculture

widely recognized as such.

Farmers have been awarded special privileges, exemptions, and variances under a whole host of public policies -- from taxation to environmental regulations -- because they were trusted to behave in the public interest. Support of

"family farms" has been an important part of the rhetoric of every farm bill that has passed congress. Farmers have also enjoyed a special status "as people," apart from any monetary benefits. They have been respected and trusted. However, bad publicity surrounding large-scale, corporate hog production is using up the farmer's stock of public confidence and good will at an alarming rate. Negative stories have appeared on every major television network over the past few years. When Ms. Magazine runs a feature article on the ills of corporate hog farming, as they did in 1997, we can conclude that the story has just about made the full circuit of public opinion shapers. Family farms will be paying for this loss of public trust for decades, if not forever.

Concern #4. Future of the community is turned over to outside interests.

Rural people need to take charge of their own destinies if they expect to sustain a desirable quality of community life for themselves, their children, and future generations of rural Americans. Quality of life is about much more than just creating more jobs and making more money. Quality of life is also about positive moral and social values and being responsible caretakers of the community as a place. Sure, people need jobs and need to make a decent living. But, jobs and high wages didn't save the cities from decline and decay and jobs won't save rural communities either. When an apparent solution to a problem comes from someone else, from outside, you can just about bet that the benefits will be going to someone else from outside as well.

Some rich and powerful outsiders have their own problems, and they have their eyes on rural communities as places to solve them. Sparse population, trusting people, and lack of jobs in rural areas are seen as ideal opportunities. They are looking for someplace to "dump stuff." An Industrial society creates a lot of "trash," whether in the form of garbage, toxic chemicals, or hog manure. Most "outsiders" promoting rural development schemes have something they need to "dump." Jobs just aren't enough compensation for turning a community into a "dump." Rural people need to take control of their own destiny and build the kinds of communities in which their children and their children's children will choose to live and grow. The solutions to the problems of rural Americans are in the hands, hearts, and minds of rural people themselves, not in outside investment and corporate control.

Concern #3. The decision making process can rip communities apart

The process of decision making may be more important than the decision itself. Anyone who has been a part of a family has experienced this first hand. The memory of an act that triggered a family feud has long since faded, but the feud goes on. Feuds result from a loss of confidence and trust, regardless of the context within which the loss takes place. The large-scale, corporate hog farm issue is one of the most contentious issues to confront rural America in recent history.

The social fabric of rural communities has been ripped apart by controversy surrounding the introduction of large-scale, corporate hog operations. There seems to be no middle ground. Some people seem determined to bring in the big hog operations, by almost any means, and others seem just as committed to keep them out, by almost any means. Almost everyone eventually seems to feel obligated to take sides. The larger question in such communities is not whether the hog factories come in or stay out, but can the community ever heal the wound left by the fight?

A healthy, unified community can deal with almost any problem, including a large-scale corporate hog farm on the outskirts of town. A sick, bitterly divided community is incapable of much more than survival, regardless of its other advantages and opportunities. The future of rural America depends on communities of people being able to work together for their common good. The divisiveness of the decision making process, presumably, could be avoided. But, the consequences of failing to do so are so destructive that it ranks near the top of my list.

Concern #2. Hog factories degrade the productive capacities of rural people

Factories "use up" people. Assembly line work is "non-thinking" work. When you work on an assembly line, you simply do what you are told as fast as you can for as long as you can. I know. I have been there. Large-scale hog operations may not be assembly lines, but the principle is the same. Big hog operators do not want people who know anything about raising hogs. They want people who can be trained to do what they are told to do without thinking. An experienced hog farmer might start thinking, asking questions, and mess up their process. Hog factories, like other factories, are looking for people who are dependable, who know how to carry out orders, and will work hard for a little money.

On balance, large-scale, industrial hog operations destroy more jobs than they create. A driving force behind

industrialization is to substitute capital and technology for labor and management – to make it possible for fewer people to produce more. Large-scale hog operations concentrate the jobs created in one place and call it economic development. The jobs lost elsewhere are ignored or denied. The numbers of independent hog farmers displaced elsewhere will be greater than the number of jobs created in new large scale hog operations. Hog factories replace more independent hog farmers with fewer assembly line workers.

Other kinds of factories have come to rural America in the past. When these factories have found people in other regions, or in other countries, who would work even harder for less, they moved on. Corporately owned factories have no roots. They leave behind a workforce that doesn't know how to do anything other than what they are told. Intelligent, thinking, capable, independent people are transformed into detached, non-thinking people who may be psychologically incapable of earning a living without depending on someone else to tell them what to do. Our cities currently are plagued with such people – people whose capacities have been degraded by factories long since gone. It just doesn't seem to make sense to do the same thing to rural people. When we replace independent, family hog farmers with hog factories we are degrading the most valuable resource rural areas have to support future development – rural people.

Concern #1. Tomorrow's problems are disguised as today's solution

My number one concern regarding large-scale, corporate hog operations is that rural communities will see them as "the solution" to today's problems without seeing them as a potential "source" of problems for tomorrow. Maybe there are some communities so desperate for jobs that it makes sense to take the risks. Maybe they feel they have to do something today to give them a chance to do something better tomorrow. But, hog factories are a short-run solution, at best, that may create more long run problems than they solve today. Low-wage, assembly-line-like jobs should be viewed as a stop gap strategy suitable only for communities with no other options. Sooner or later non-thinking jobs will be done somewhere else on the globe, where people will work harder for less money and are accustomed to doing whatever they are told – by those who have no other options. In the longer run, all non-thinking jobs will be done using computers and robots – not by people anywhere.

The real opportunities for people to lead successful lives in the future will be in "thinking" work. The human mind is uniquely capable of complex thought. Almost anyone is "smarter" than a computer. But, people need to develop their unique human abilities to think. We need to accept the responsibility for thinking and for creating thinking jobs for ourselves and for others. As long as rural people think their problems are solved, or will be solved by someone else, they see no incentive to begin doing the things they need to do to ensure the future of their community.

The primary advantages for rural areas in the twenty-first century will be the unique qualities of life associated with open spaces, clean air, clean water, scenic landscapes, and communities of energetic, thinking, caring people. Communities that sacrifice these long run advantages for short run economic gains may have a difficult time surviving in the new century.

Thus, my number one concern is that large-scale, corporate hog operations are tomorrow's problem disguised as today's solution. They may keep rural people from doing the things that need to be done today to ensure the future of their communities. Large-scale, corporate hog operations will not create communities where our children and their children will choose to live and grow. Communities with a future must take positive actions today to ensure a desirable quality of life for themselves, their children, and rural children of future generations.

Why Do Rural Communities Accept Confinement Animal Feeding Operations?

Admittedly, there are reasonable arguments that can be used to support bringing large-scale confinement animal feeding operations (CAFOs) into a rural community. Community leaders who support such operations typically argue that people in their community:

- Need jobs in to replace those lost to globalization,
- Need a higher tax base to provide rural services,
- Need to bolster their declining agricultural economy,
- Know that other communities will accept these operations if they don't,
- Feel that they can't stand in the way of progress,
- Believe big operations can better afford modern pollution prevention technologies,
- Feel that local opposition is just another case of "not in my backyard," thinking.

There are logical responses to each of these arguments, but each also contains elements of truth. One thing nearly all pro-CAFO arguments have in common is their foundation in short-run, self-interest economics. They are based on a deeply held faith that the market place is the best means of allocating resources – whether it is allocation of people among alternative occupations, land among alternative uses, money among investments, or people among communities. Those things possible and profitable shall be done. People have a right to protect themselves and their property from damage caused by others, but beyond that, the economics of the marketplace shall prevail. A community is nothing more than a collection of individuals that happen to be located in geographic proximity to each other. These are typical assumptions of self-interest economics.

After all, corporate investors are putting their money into CAFOs because they expect to make profits. Investments create jobs and enhance the local tax base. If CAFOs are more cost efficient than smaller farming operations, even if marginally so, traditional family farmers will inevitably be forced out of business -- so the argument goes. Why not give local farmers a chance to go to work for a profitable agricultural corporation? We know these Corporations are going to invest somewhere, so it might as well be here. There are always costs associated with anything that generates benefits. The opponents just want someone else to bear those costs.

They reason that if environmental problems arise, it will be easier to work them out with a few large operations than many small ones. The big operations have the money to invest in the modern waste handling facilities that ultimately will be required of everyone. The technology is available, it's profitable, so it's both futile and foolish to stand in the way of economic progress. The people who are opposed to these operations are accused of being out of touch with economic reality. Opponents of CAFOs are labeled as Luddites – as people who oppose progress or just want to keep things as they are.

If self-interest economics prevail, there is every reason to believe that CAFOs eventually will totally dominate animal agriculture in America. And, corporations will locate CAFOs pretty much wherever they choose, regardless of the ecological and social consequences. They will avoid locating them in heavily populated areas to minimize nuisance law suites. But, money invested in CAFOs will seek its place of highest return. The only way to successfully challenge this outcome it to challenge its basic premise – the right of private profits to prevail over public good – and to uphold the rights of people to prevail over the pursuit of profits in protecting their communities and shaping their destinies.

Sustainability: The Challenge to Land Use Economics

Current land use decisions in the United States, including location of large hog operations, have their foundation in economic theory as it relates to the concept of private property. Persons who hold ownership rights to property may do with it pretty much as they see fit, including exchange ownership rights with others, as long as it does not interfere with the private property rights of others. Any restrictions on individual land use are limited to uses that might affect the use rights held by other individuals.

With relatively minor exceptions, land use decisions are determined by the economics of the market place. Provisions are made through laws of eminent domain to acquire private property for public use, without the consent of owners, but not without just economic compensation to current landowners. Land uses of a criminal nature, deemed to be of clear public harm, may be restricted without compensation. Land use zoning may restrict land use as well. But in reality, economic considerations commonly dominate planning and zoning decisions. The question becomes, how can economic development be maximized with the minimum negative impact on community residents. Requests for changes in zoning are typically motivated by a desire to put land to a higher economic use. Opposition to changes typically is motivated by the desire to protect private property rights. It is a rare community that uses the tools of planning and zoning to ensure the long run ecological and social well being of the community as a whole.

So, with minor exceptions, private property may be put to its highest economic use. The concept of highest economic use gives legitimacy to competing private property rights, but commonly ignores or denies any right of the community, or public as a whole, to participate in all land use decisions. Economic theory treats a community as a collection of individuals, not as an entity with rights separate from, or in addition to, those of individuals of which the community is composed. In addition, conventional economics gives no consideration to potential ownership rights of future generations. Rights of intergenerational transfer of ownership are based on the premise that to prohibit or limit such transfers would unjustly restrict current private property rights. Free market economics makes no provision for future generations, other than those reflected in the self-interests of current decision-makers. And economics drives land use decisions.

The question of long run sustainability presents a serious challenge to conventional economic thought as the foundation for land use decisions. Over the past decade, many different people have defined sustainable development, of which sustainable agriculture is but one part, in many ways. However, the underlying theme of nearly all such definitions is one of intergenerational equity – a responsibility to meet the needs of the current generation while leaving equal or better opportunities of those of all generations to follow. In more common language, sustainability development applies the Golden Rule across generations – doing for future generations as we would have them do for us.

The three cornerstones of sustainability are ecological soundness, economic viability, and social justice. The three are not separate goals or objectives, but instead are three separate dimensions of the same whole – as with the three dimensions of a box; height, length, and width. Any object lacking any one of those three dimensions quite simply is not a box. Any system of development that is not ecologically sound *and* economically viable *and* socially just quite simply is not sustainable over time. All are necessary and none alone or any pair is sufficient to ensure sustainability.

Thus, sustainability requires that we look beyond the economics of short-run, self-interest to the broader set of issues affecting quality of life or human well being over time. Sustainability requires that we broaden our economic thinking to consider the long run health and productivity of the natural ecosystem, not just the optimum means by which it may be exploited for our short-run gratification. Sustainability requires that we broaden our economic thinking to consider the well being of the community, or society, as a whole, not just sum the welfare of individuals who make up a community or society. The economics of self-interest is an important dimensions of sustainability, but it is but one among three. Things ecological, social, and economic must be considered as complementing dimensions of the same whole, not as competing objectives that can be pursued separately.

Economic Implications for Sustainable Land Use

The following is a short discourse on the economics of land use under conventional and sustainable economic assumptions. For some readers, this discussion will be unnecessary, and they may feel free to skip to the next section. It is included for the benefit of those who might be skeptical regarding whether or not the conclusions of this paper are based on sound economic logic. They are.

From a short-run economic perspective, production from a given piece of land should continue to be increased as long as the value of additional production exceeds the added cost of creating that production. Land is considered as a *fixed* economic resource – its quantity cannot be increased – and all other inputs such as hogs, feed, and labor are considered to be *variable* – more or less may be used on a given piece of land. The fundamental economic question is; " what quantity of variable inputs should be applied to a given amount of fixed resource?" In terms of hog production, the answer is: the number of hogs or size of production unit, and the number of production units in a given area, should be increased as long as the value of adding one more hog or production unit exceeds their addition to costs.

The economic optimum scale of hog production has increased dramatically over the past few years. New production technologies have allowed hog producers to avoid many of the previous problems of large-scale production – such as disease and labor problems. Changes in the food system have created opportunities for profitable integration of production and marketing activities – favoring large-scale, corporate hog operations over individually owned family farms. Thus, the costs associated with larger scale production have declined and the returns from large-scale, corporate production have increased. There is little doubt that the dramatic increase in large-scale CAFOs has been driven by economics – by corporate greed and the pursuit of profit. However the economic arguments that support CAFOs are valid only from the perspective of economics of short-run, self-interest.

The conclusions are totally different if we instead take a long run, sustainable economics perspective of land use questions associated with large-scale hog operations. In the long run nearly all the agricultural inputs that are *variable* in the short run are *fixed*. For example, fossil fuels, fertilizers and pesticides for feed production, machinery, and many building materials are all derived from finite, non-renewable stocks of natural resources. Thus, their long-run supply is *fixed*, even though their short run use may be *variable*.

In the long run, our only truly *variable* resource is solar energy. Living organisms, including people, represent renewable resources, but living organisms are dependent on finite natural resources as well as solar energy. Every productive resource on earth can realistically be depleted over some finite period of time. But, the continuing supply of energy from the sun is expected to continue for billions of years into the future.

Geographic space is required to capture solar energy, at least for agricultural use. Land represents space. Thus, land – as space – serves as a proxy for solar energy, the only long run, *variable* resource. Of course, land has characteristics other than space -- such as organic matter, texture, and water holding capacity – which may influence its productivity and value. But, these non-spatial aspects of land are finite, and thus, may be depleted over time. Land as space, while fixed in total at any point in time, represents a virtually infinite supply of solar energy that may be utilized in varying quantities over time, and thus, represents a *variable* long run resource.

Ironically, those things that are variable in the short run are fixed over the long run, and the one thing most fixed in the short run, space, represents the only variable long run resource. As we should expected, things that appear to be optimum from a short run perspective are far from optimum when one takes a long run perspective.

Solar energy in not only variable – it is also *free*. The sun is the only resource that we don't have to pay for, by one means of another. Thus, in the long run, land – as space – must be considered as *free*. Economics dictates that we maximize production from free resources if we are to maximize profits. When space is considered to be free, the profit maximizing use of all non-renewable inputs will be at the point of their minimum cost per unit of production. In hog production the optimum would be at the point of maximum production per pound of feed or per hour of labor, not maximum profit from a production unit or for a given corporation.

Maximum production *per unit* of non-renewable input will result in maximum *total* production from a given quantity of input over time – and maximum contribution to sustainable production. If land, as space, is allowed to take on a positive market value, less land will be used relative to other production inputs – feed, labor, capital, and equipment -- resulting in these non-renewable inputs being used up at faster than optimal long run rates. This conclusion is quite different from conventional short-run economics which treats land as a marketable commodity and focuses on maximizing profits for the firm or corporation, rather than maximizing long run benefits to the community or society.

Implications for CAFOs in Rural Communities

So what does all this mean for confinement animal feeding operations in rural communities? It means if short run economics is allowed to prevail, concentration of hogs in a given area will increased as long as each additional unit of production – increase in size or number of CAFOs –adds more to total value of production than it adds to total costs. But, it also means if rural communities want to *sustain* development over the long run they cannot allow short-run economic self-interest to prevail.

Eventually, the size of CAFOs may be limited by rising costs. For very large operations, costs of production may eventually rise because feed and other inputs have to be shipped in and products shipped out from and to increasingly distant locations. But in reality, something other than economic scale of production typically limits the size and number of CAFOs in a given area. Costs associated with such things as foul odors, water pollution, worker health, displaced farmers, degradation of human potential, and destruction of communities are all considered to be "externalities," if considered at all, in short-run, self-interest economics. The limit of size typically is not one of internal economics, but rather one of external pressures.

External costs, by definition, are costs not imposed by the market place. Thus, those who are damaged must impose such costs – through law suites, government regulations, and social pressures from the surrounding community. External costs typically limit the growth of CAFOs within any given area. But, the economics of self-interest provide the constant and relentless motivating force for those who operate CAFOs to do the things that result in law suites, to violate government regulations, and bribe and coerce the community into accepting their presence. CAFOs almost always see opportunities to increase profits if external constraints can be overcome, avoided, or removed.

The existence of externalities cause those who operate CAFOs to choose those areas least willing and able to impose external costs of the corporation, which allows them to operate as near as possible at the short-run, self-interest economic optimum size. The most important spatial requirements for CAFOs at present appear to be space for dispersing foul odors in the air and space for spreading manure on the land. Rural areas are "valued" as dumping grounds for stench and manure – things other people don't want to have around. Thus giant animal feeding factories have consistently located in remote, economically depressed rural areas. It all makes logical short-run, self-interest, economic sense. But, it is all long run, sustainable economic nonsense.

What should rural communities do?

Rural people must become actively involved in shaping the destiny of their communities. They cannot rely on some "invisible hand" of economics to create a positive future. The "invisible hand" has been severely crippled, if not cut off, as an economy made up of small proprietorships has been replaced by an economy dominated by large corporations. Rural people must assert their right put their long run, community interest ahead of the short-run, self-interest of those who invest in and operate CAFOs. Such operations cannot even be justified on economic grounds, when one takes a long-run economic perspective. Nor can the impacts of CAFOs on environmental quality and social justice be tolerated if communities are concerned about their long-run sustainability.

Markets cannot be allowed to allocate the use of land as space. This is the most important conclusion of the foregoing illustration of short run versus long run economics. Markets place positive prices on economic inputs, resources, and products. Those things that are most scarce – that are less available relative to the aggregate desire and ability to posses them – will command the highest market prices. Higher prices both ration the scarce supplies among those who are willing and able to pay and provide an incentive for increased production to reduce the scarcity. But land, as space, cannot be allowed to have a positive price without misallocating its use, and higher land prices quite simply cannot create more space. Land prices guide land use to its highest valued short-run economic alternative – whether for residential developments, hog factories, farming, or wilderness. Those using conventional economic theory have falsely assured us that society will realize the highest total value from a given stock of land by allowing free markets to allocate land use.

Some portion of the total value of land will reflect its inherent productive capacity, whether in agriculture, recreation, or other land-based production processes. That portion of land value can be allocated by market prices. However, much of the value of land represents its value as space -- a geographic place to carry out some activity, or simply as space to be held or controlled. Any market value placed on land as space will cause it to be used too intensively, using too many inputs on too little land, and will deplete resources at a faster than optimum rate. Thus, concern for long run sustainability will require a rethinking of fundamental concepts of private property, specifically of what it means to *own* land.

The first reaction of many will be to rise in defense of "private property rights" – the right to use their land as they see fit. However, when markets are allowed to dictate land use those with less money can easily be deprived of the right to use land as they see fit by those with more money. Those with more money may bid up land prices to the point were current users cannot afford to pay their property taxes or possibly justify not selling out to the highest bidder. The ability of one farmer to use their land may be affected by another's land being purchased by an outside investor – the existence of a large CAFO in a county may bring on regulations that preclude existing hog farmers from further expansion. Farmers who would prefer to be good community citizens and ethical stewards of their land may be forced by competition from outside investors to exploit their community and the their land in order to stay in business. Insisting on unencumbered use of private property may be far more restrictive on use of private property by local landowners than would their participation in a community-based land-use decision making process.

The concept of private property has never meant the right to do whatever one chooses with the property they own. *Conditional ownership* was always implied, if not always stated. A new condition needed to ensure sustainability is one that denies any right to degrade the land or the surrounding community, just because one owns the right to use their land. Thus, the owner of land cannot possess, and thus cannot convey to another, the right to use land is ways that are inconsistent with long run societal well being. If the community, rather than the individual, makes the ultimate decisions regarding how land is used, land as space will have no market value because there will be no right of alternative use for its owner to convey. Its price will reflect only that portion of its value that is associated with its potential productivity in its current use.

What should rural communities do? They should demand their right to be protected against the economic tyranny of the marketplace by making logical, long run land use decision for their communities. They should refuse to allow the long run economic, ecological and social well being of their communities to be degraded in the pursuit of short-run, economic self-interests. They should demand the right to allocate land use within their community by means other than market prices – and to exceed any set of state or national health and environmental standards to protect the community if necessary.

Traditional remedies such as law suites and environmental regulations will not provide lasting solutions. Traditional remedies are based on the principle of conflicting self-interest, rather than the collective interest of the community as a whole. Law suites, at best, only compensate individuals who are damaged by the actions of another – even in the case of class actions. Environmental regulations invariably reflect some compromise among conflicting individual interests,

which settles to some minimum common denominator in a society driven by short-run, self-interest. Communities must find the courage and the means to act as a whole, for the long run well being of the community as a whole, both now and forever. This is not a matter of compromise among conflicts; it is a matter of harmony within.

Communities may use zoning laws to pursue their objectives where they are allowed to do so under current state law. Communities may also use health and environmental regulations to protect the people and the land where such laws at the local level are allowed. In cases where state or national laws prevent a community from protecting itself from exploitation, the laws must be changed. But, all current restraints on CAFOs are only "band aid" treatments for a potentially fatal disease. Those with the greatest economic interests ultimately will prevail. New means must be found for allocating land use that will remove any economic incentive for degrading the land. Land must be treated as a commonly managed natural resource, rather than an economic commodity that can be bought and sold to the highest bidder.

The inherent common property nature of land as space certainly is not a new concept. In 1796 revolutionary writer Thomas Paine, in his paper, Agrarian Justice, pointed out that all land was initially held in common. Thus, the previous removal of land from the commons deprived those of later generations of their common birthright – the right of access to land. Initially, land could only be removed from the commons if as much land and as good of land was left for any others who chose to claim it. Consequently, land taken from the commons had no market value – by definition, it could not be scarce. A similar argument can be made to support the rights of future generations to as much land as good of land as we have today. And to protect this right, land as space cannot be allowed to have a market value.

Economist, Henry George in his 1879 book, "Progress and Poverty" proposed that all use value of land be taxed away to prevent the pricing of land as a market commodity. A more logical approach today might be devise a policy for capturing any increases in land values attributable to rezoning for higher market valued uses in order to compensate those whose land is rezoned to lower-valued uses. This would remove any economic incentive for current of future owners to rezone land to either higher or lower valued uses, and would make it much easier for the community as a whole to make logical long run land use decisions. A similar capturing of capital gains in land values attributable to growing population demands would remove speculative incentives for land ownership and would generate public funds to sustain and enhance the productivity capacity of land.

Sustainable development ultimately will require that land use decisions be made by means that find harmony among long-run economic, social, and ethical or moral concerns. It makes no more sense to buy and sell the right to *misuse* land than to buy and sell the right to misuse another person. Land, particularly land as space, is a fundamental resource upon which all life depends. It cannot be allowed to belong to anyone individually or to us in total as a collection of individuals – just as people cannot belong to other people. Land belongs to the earth just as people belong to the earth, to the collective *us* as a whole – inseparable, indivisible, across all generations.

We may logically buy and sell those things that enhance the productivity of land – for those uses with impacts that fall within the realm of legitimate self-interest. But we cannot allow markets to allocate the use of land as space. We may logically decide some land use issues by a vote of the people – for those uses with impacts that fall within the realm of the community of interest. But, many uses of land as space have impacts on future generations, and future generations cannot vote. Such land use decisions must reflect our fundamental values concerning the responsibilities of being human. Such issues cannot be resolved by economics or politics, they rest on a fundamental code of ethics or morality. They arise out of a consensus of what is fundamentally right and wrong.

Many issues concerning the natural environment are fundamentally moral or ethical issues. We should not be buying and selling pollution rights, because no individual has the moral right to pollute in the first place, and thus, has no right to sell it. Businesses may argue that society has given them that right, through the political process. But, no society has the right to pollute, so it cannot convey that right to a business or anyone else. Pollution of the environment is fundamentally, morally wrong, the same as it is morally wrong to kill, to steal, or enslave. The environment can assimilate some level of waste, as society can tolerate certain amounts or kinds of killing, stealing, or enslaving. But, those things are still morally and ethically wrong, regardless of the ability of society to survive them. We don't condone or encourage them by allowing people to openly buy or sell the right to enslave another person, nor vote on whether one person should be allowed to kill another for personal reasons. We cannot prevent pollution, but is always morally wrong to degrade the natural environment.

It is also morally wrong for one person to exploit another person for personal, economic gain. The short-run economics of self-interest makes no provision for avoiding such exploitation. Those who have fewer opportunities are forced to do

the jobs that others can avoid at wages lower than others would be willing to accept. Pursuit of short-run profit dictates that people be hired to works as hard as they can be made to work at wages as low as they will accept. There is not short run economic incentive for businesses to invest in improving the productive capacity of people if there are already people available who possess the skills and abilities needed. But, communities have a very large stake in maintaining the productive capacities of their members. In essence, a community *is* the collective whole of its people. If we allow the people of our community to be degraded, our community is degraded. If we allow our communities to be degraded, human society will be degraded.

No one has the wisdom to plot a true course toward a sustainable human society. At this point in time, we simply don't know how we can meet the needs of the current generation while leaving equal or better opportunities for those of future generations. But, we are beginning to learn some things that we cannot do. We cannot allow the economics of short-run, self-interest to determine the *use of our land and our people*. We know that the relentless pursuit of profits and growth will degrade both our natural and human resources, and will not leave as much and as good as we have today for those of future generations.

We also know that we cannot allow large, corporate organizations, such as those operating CAFOs, to do whatever they want to do wherever they have the money and/or can buy the votes to do it. Rural America may well be the place where America makes a historic stand for sustainability – just as the cities of the South gave birth to the Civil Rights movement. The first rural community to declare and defend the fundamental moral and ethical right of its people to determine how land is used may be remembered much as Rosa Parks is remembered for refusing to move to the back of the bus in Montgomery.

The most significant long-run social, economic, and cultural impacts of CAFOs on rural communities could well be the beginning of a new revolution – a revolution that ultimately will discard the outdated paradigm of short-run, self-interest economics for a new paradigm of sustainable economic, ecological, and social development.

Examples of Properties Devalued by Factory Farms

Studies & Reports

In describing the economic costs of CAFOs to rural communities, the recent Union of Concerned Scientists report stated that "because property values are reduced near CAFOs, the residential tax base may suffer as well."
~ Doug Gurian-Sherman, Union of Concerned Scientists, *CAFOs Uncovered: The Untold Costs of Confined Animal Feeding Operations,* at 61 (April 2008).

The recent Pew Commission report on industrial farm animal production described the various negative impacts that factory farm facilities have on the environment, public health, animal welfare, and rural communities. The report did not directly address declining property values, but did note the negative influence factory farms have on rural social capital and the rights of neighbors to enjoy their own properties.
~ Pew Commission on Industrial Farm Animal Production, *Putting Meat on the Table: Industrial Farm Animal Production in America,* at 40-49 (April 2008).

A 2012 report by Dr. John Kilpatrick of Greenfield Advisors evaluates a Colorado property and the impacts a nearby CAFO has on its value. The report explains that the principles within the report would be applicable to the appraisal of any property near a CAFO.
~ John A. Kilpatrick, *In re: Delta County* (Aug. 22, 2012).

This report was prepared to assist local boards of health who have concerns about CAFOs in their communities and to help them "understand their role in developing ways to mitigate potential problems associated with CAFOs." The report states that "[t]he most certain fact regarding CAFOs and property values are that the closer a property is to a CAFO, the more likely it will be that the value of the property will drop." It also noted that "[d]ecreases in property values can . . . cause property tax rates to drop, which can place stress on local government budgets."
~ Carrie Hribar, National Association of Local Boards of Health, *Understanding Concentrated Animal Feeding Operations and Their Impact on Communities,* at III, 11 (2010).

A technical report for the Pew Commission report discussed various CAFO studies and found that: "Industrialization of animal agriculture leads to the reduced enjoyment of property and the deterioration of the surrounding landscape, which are reflected in declining home values and lowering of property tax assessments. Recurrent strong odors, the degradation of water bodies, and increased populations of flies are among the problems caused by CAFOS that make it intolerable for neighbors and their guests to participate in normal outdoor recreational activities or normal social activities in and around their homes."
~ Pew Commission on Industrial Farm Animal Production, *Community and Social Impacts of Concentrated Animal Feeding Operations,* at 31.

The National Association of Realtors has put together a "field guide" that explains what CAFOs are and how they can impact property values. The guide lists several studies and notes that, while a few studies have found a positive impact, "most studies have found a negative relationship between feedlots and property values."
~ National Association of Realtors, *Field Guide to Impacts of Animal Feedlots on Property Values* (Sept. 2013).

www.cdc.gov/nceh/ehs/docs/understanding (CAFO)

In Iowa, one 1996 study found that proximity to a hog CAFO decreased neighboring property values in the following order: 40% within ½ mile; 30% within 1 mile; 20% within 1.5 miles, and; 10% within 2 miles.

~ William J. Weida, *The CAFO: Implications for Rural Economies in the U.S.* 1 (Colo. College & GRACE Factory Farm Project 2004) (citing Padgett & Johnson).

Another Iowa study found that there may be a 1-10% reduction in property values of residences upwind of new CAFO facilities, and that the drop in value "helps explain opposition by rural residents to large-scale feeding operations."

~ Joseph A. Herriges et al., *Living with Hogs in Iowa: The Impact of Livestock Facilities on Rural Residential Property Values* 19-20 (Iowa State Univ. Ctr. for Agric. Dev. Working Paper 03-WP 342 (Aug. 2003)).

A 1999 study in Missouri found that the average loss of land value within three miles of a CAFO was $112/acre.

~ Mubarak Hamed et al., *The Impacts of Animal Feeding Operations on Rural Land Values* 2 (Cmty. Policy Analysis Ctr., Univ. of Mo., May 1999) (finding that "there is a relationship between proximity to a CAFO and the value of property").

Studies cited by Dakota Rural Action found that property within a 3-mile radius of a CAFO loses 6.6% in property valuation, and property within 0.10 mile of a CAFO loses up to 88% in property valuation.

~ Dakota Rural Action, *CAFO Economic Impact* (June 2006) (citing North Central Regional Center for Rural Development (1999:46); Siepel et al. (1998)).

A Sierra Club study reported that county assessors in at least eight states lowered property taxes for neighbors of factory farms.

~ William J. Weida, *Nutrient Management Issues* (GRACE Factory Farm Project, Apr. 4, 2001) (citing Sierra Club, *Property Tax Reductions* (Mar. 13, 2000)).

A study in Berks County, Pennsylvania evaluated the impact of potential local disamenities on neighboring properties. It found that the impacts of CAFOs on neighboring property values did not vary significantly by species or by differences in the sizes of the operations.

~ Richard Ready & Charles Abdalla, *The Impact of Open Space and Potential Local Disamenities on Residential Rural Property Values in Berks County, Pennsylvania* i (Penn. State Univ., Staff Paper No. 363, June 2003).

This study evaluated the influence of proximity to swine facilities on the sale price of residential properties, using a GIS-based hedonic model. The study reported that "[r]esults indicate a negative and significant impact on property value from hog operations." The study also found that the modeling "may be a promising technique for establishing setback guidelines, for assessing property value damages resulting from animal operations, and for evaluating potential property value impacts to surrounding properties when siting a new CAFO."

~ Milla et al., *Evaluating the Effect of Proximity to Hog Farms on Residential Property Values: A GIS-Based Hedonic Price Model Approach*, 17 URISA Journal 27, 30–31 (2005).

A Putnam County, Missouri study found a $58/acre loss of value for properties within 1.5 miles of a CAFO facility.

~ William J. Weida, *The Evidence for Property Devaluation Due to the Proximity to CAFOs* 6 (Col. College & GRACE Factory Farm Project, Jan. 21, 2002).

Three different North Carolina studies, described in a presentation at the University of Kentucky, found that proximity and animal density have significant, negative impacts on the market values of residential properties.
~ Michael Thomas et al., *A Comparison of Three Recent Hedonic Models of Hog Farm Discommodity in Coastal North Carolina: Evidence of Diseconomies of Scale and Brown Zones* (May 2003) (citing studies of Bruton, Ansine etl al., and Kim).

A 2008 University of Northern Iowa study analyzed house sales in Black Hawk County, Iowa to determine the effect of hog CAFOs on property values. It found "large adverse impacts suffered by houses that are very close (within 3 miles) to and directly downwind from a CAFO."
~ H. Isakson & M. D. Ecker, *An Analysis of the Impact of Swine CAFOs on the Value of Nearby Houses* 19 (Univ. of N. Iowa Technical Report, July 23, 2008).

A 1996 newsletter from EPA's National Center for Environmental Economics reported on an early North Carolina State University study that used hedonic analysis to make various findings on factory farms and their negative impacts on residential land values.
~ USEPA, National Center for Environmental Economics, *Effects of Hog Operations on Residential Property Values*, 3:12 Newsletter (Dec. 1996).

A recent white paper by the Institute of Science, Technology and Public Policy reported on the negative impacts hog CAFOs have in Iowa, including "marked[] and consistent[]" decreases in land values and quality of life in areas near CAFOs. The report noted a study finding that "[p]roximity to a CAFO can reduce the value of a home by 40%."
~ Institute of Science, Technology and Public Policy, *Concentrated Animal Feeding Operations (CAFOs): Assessment of Impacts on Health, Local Economies, and the Environment with Suggested Alternatives* 3, 6 (post February 2007) (citing study of Park, Lee, and Seidl).

Articles

This 2001 article in the *Appraisal Journal* explains how CAFOs can negatively impact proximate property values, and lists several factors that should be considered in valuing those properties.
~ John A. Kilpatrick, *Concentrated Animal Feeding Operations and Proximate Property Values*, 39:3 Appraisal J. 301 (2001).

A 2012 press release reported that property owners in Illinois were awarded a 12.5% reduction in their property value based on the effects of a neighboring swine CAFO. The reduction applied retroactively from the time the CAFO was constructed.
~ CRAPC & ICCAW, *Neighbors of Illinois Swine CAFO Claim Victory in Property Tax Appeal* (Sept. 6, 2012).

A 2007 article in the *Agriculture and Human Values* journal evaluated studies on industrialized farming and community impacts from the 1930s forward. It reported predominantly detrimental effects, including a decline in real estate values for residences close to hog CAFOs.
~ Lobao & Stofferahn, *The Community Effects of Industrialized Farming: Social Science Research and Challenges to Corporate Farming Laws*, Agric. & Human Values (2007).

In Waseca County, Minnesota, a county assessor designed a "smell location chart" to determine reductions in values of properties near feedlots. Factors in the percentage of reduction allowed included the proximity to the feedlot, the number of animals, and the presence of a manure lagoon.
~ Douglas Clement, *Knee Deep in Feedlot Feuds*, FedGazette, July 2001.

In January 2007, Indiana residents turned out to testify before the state legislature on a CAFO moratorium bill. One woman testified that a businessman was "'driven to suicidal thoughts because he was unable to sell his home after six years because of the odor from a nearby CAFO.'" Another testified that "'[d]ecreased property value because of CAFOs mean [sic] decreased revenue from property taxes, which means less money for our schools.'"
~ Jondi Schmitt, *Hoosiers Voice CAFO Concerns: Proposed Bill Would Put Three-Year Moratorium on Start of Construction,* South Bend Tribune, Jan. 30, 2007.

The Indiana House passed a bill in February 2007 that would prohibit new CAFOs within 1 mile of cities, towns, schools, and health facilities. One representative who supported the bill said he "want[ed] the pork industry to grow" in Indiana, but that growth could happen "while having respect to our neighbors." "CAFOs do decrease property values," he said.
~ Niki Kelly, *General Assembly: House Restricts Feed Farms*, The Journal Gazette, Feb. 22, 2007.

A Michigan Land Use article reported that a tax tribunal reduced the assessments for properties adjacent to CAFOs. It ordered local officials to reduce the taxable values of at least five rural homes by 35% based on problems with stench from a hog livestock factory, and on "slim sale chances" for the homes.
~ Patty Cantrell, *Michigan Tax Tribunal Recognizes Hog Factory Stench* (Mich. Land Use Inst., Dec. 7, 1999).

This 2004 paper debunked assumptions underlying CAFO-proponent arguments, including those regarding CAFOs and property use. It noted: "CAFOs generate odor, air and water pollution, all of which have a direct impact on neighboring properties. The closer the neighboring property, the more severe the impact is likely to be. . . . The resulting loss of exclusive use by neighboring properties lowers their values and ultimately also lowers the taxes generated from these properties. Suing the offending party for these nuisance activities could potentially compensate the neighboring property owners. To prevent this, factory farming interests have attempted to sponsor legislation to prohibit nuisance suits for agricultural pollution."
~ William J. Weida, *Considering the Rationales for Factory Farming* (for presentation) 10 (Mar. 5, 2004).

Clark County, Illinois established assessment abatements for fifty residential homes around a hog CAFO in the following order: 30% reduction within ½ mile; 25% reduction within ¾ mile; 20% reduction within 1 mile; 15% reduction within 1 ¼ miles; 10% reduction with 1 ½ miles.
~ William J. Weida, *The Evidence for Property Devaluation Due to the Proximity to CAFOs* 6 (Col. College & GRACE Factory Farm Project, Jan. 21, 2002).

A 2006 article in the *Journal of Ecological Anthropology* recognized the ill effects of factory farms on neighboring properties: "In addition to their negative effects on the local economy and tax base, large corporate operations are the source of environmental issues that threaten the property values of rural and urban residents. This strains the economic base and places higher burdens of taxation on remaining residents."
~ Barbara J. Dilly, *Tax Policy and Swine Production in Iowa,* United States, 10 J. Ecological Anthropology 45, 48 (2006).

A Peoria, Illinois newspaper reported that county officials lowered property values for at least 20 people with homes within two miles of a large sow farm and its odor. The tax board decreased assessments by 30% for neighbors with 1 ½ miles of the operation, and 10% for those within 2 miles of the facility.
~ *Board Smells Lower Land Values near Hog Farm*, The Journal Star, May 6, 1998, at A1.

An Iowa paper reported on the results of the University of Northern Iowa study mentioned above. One interviewee said that his neighbor had been offered $1 million for his land before plans for a hog lot were announced, but that after the announcement, "the would-be buyer walked away." "'He lost almost $1 million right there . . . . And it's not necessarily smell. It's psychological . . . . They don't want anything to do with them (hog lots) if they see them.'" Another interviewee, who had recently bought land in the area, said she "'would not have bought the house and all the surrounding property . . . at above market value . . . if a CAFO was going to be built a mile away. . . . And to tell you the truth, I'll sell my property at a huge loss to move away if they build these things."

~ *UNI Study: Hog Lot Cuts up to 15% off Nearby Home Values*, Waterloo Courier, Mar. 12, 2007.

A 2006 Letter to the Editor in opposition to proposed legislation that would weaken Michigan's environmental laws described the "severe pollution" that CAFOs cause. The author explained that the growing number of CAFOs in Michigan was "threatening our public health, our rural communities and the viability of Michigan's 52,000 farms." She also noted that "[t]he stench from CAFOs has led to reductions in property values of up to 70 percent by the Michigan Tax Tribunal for nearby residents no longer able to enjoy or sell their homes."

~ Anne Woiwode Letter to the Editor, *Animal Sewage from Livestock Farms Threatens Communities*, Kalamazoo Gazette, May 15, 2006.

In February 1998, residents of Caribou, Maine petitioned the city council for a temporary ban on factory pig farms. Among concerns were "strong odor from waste, surface and ground water contamination and plummeting property values."

~ Gloria Flannery, *Caribou Councilors Seek Ban on Piggery; Fears of Pollution, Odor Lead to Ordinance Proposal*, Bangor Daily News, Feb. 25, 1998.

In an article summarizing newspaper coverage of concerns about large-scale swine facilities (LSSF) in Illinois, a "distinct undercurrent" of claims against the facilities was that they were "difficult for communities." Specifically, "[s]ources were concerned that LSSF were socially disruptive: they went against traditional community values, destroyed the community's history, violated ethics of neighborliness, and created community conflict. In addition, they were concerned that the community would have to develop infrastructure capacity to handle the effects of LSSF, paying for social services, schools, and health care for migrant workers and cleaning up spills and abandoned lagoons. Those opposed to LSSF also maintained that the large-scale operations had no overall economic benefit for communities because they displaced more jobs than they created, decreased property values and made alternative industries, such as tourism, less viable."

~ A.E. Reisner, *Newspaper Coverage of Controversies about Large-Scale Swine Facilities in Rural Communities in Illinois*, 83:11 J. Animal Sci. (Nov. 1, 2005).

Coverage of the 2007 Food and Family Farm Presidential Summit in Iowa noted that "many neighbors say the [CAFOs] stink up the air and foul the water, devastate their property values, and drive small farmers out of business."

~ Jennifer Jacobs, *Candidates Tout Their Farm Credentials*, Des Moines Register, Nov. 11, 2007.

Cases

In a 2013 decision by the Idaho Board of Tax Appeals, a property owner was awarded a 20% reduction in his residential property assessment due to his property's proximity to a CAFO. As evidence, the

property owner explained that his property was and would be negatively impacted by the CAFO because of dust and odors, impaired views, nearby (or migrating) contamination and disease, loud noises, etc. He also presented an appraiser working paper that summarized CAFO impacts on nearby property values, a summary of a study done in a neighboring county that quantified property value decreases based on proximity to CAFOs, and a real estate broker's letter that estimated a decrease in his property's value of 20-30%. The Board found that the County should have made appraisal adjustments based on these factors, and ordered a 20% reduction relying primarily on the neighboring county study, the appraisal paper, and the real estate broker's statement.
~ *In the Matter of the Appeals of Joe Morton*, Nos. 12-A-1377 & 12-A-1379 (Idaho Bd. of Tax Appeals, April 22, 2013).

In a 1997 Indiana Tax Court case, property owners asserted that a state board did not adequately consider the negative effects a proximate hog operation had on their neighborhood when assessing their property. To support their claim that odors from the operation impaired the enjoyment of their property, the plaintiffs presented two jars of air taken from their yard to the hearing officer. The Tax Court held that the plaintiffs met their burden of proving their assessment was incorrect based on the proximate hog operation's effect on the desirability of their neighborhood. Relevant evidence that the plaintiffs presented included the two jars of air "redolent with swine" (though unopened, the hearing officer conceded they would smell bad), and verbal testimony about how the odor impaired the enjoyment of their property (they were unable to play tennis, open windows, or hang clothes out).
~ Corey v. State Bd. of Tax Comm'rs, 674 N.E.2d 1062, 1063, 1065-66 (Ind. Tax. Ct. 1997) (reversing state board's assessment on these grounds).

In a case before Indiana's Court of Appeals that was basically a zoning challenge to a proposed CAFO, some people who lived near the proposed CAFO presented evidence that their property values would decline if the CAFO were built. They presented testimony by their Township Assessor, who said:

> The first thing that has to happen if this hog operation goes in, is the neighborhood value will have to be lowered from a good to a fair or a poor . . . . [T]here's some houses like Flynns [sic], Bowmans and Jerry Marsh's, David Helt's there's some of them that the Sexton's house, there's two of them there that are pretty new houses, Steve Bowman's sister just built a new house up there. I wouldn't be surprised if they wouldn't drop 30 percent, I don't think it would be out of the question. So the property values will decrease in this area.

The Court held that the testimony was enough to show that the people near the proposed CAFO would "suffer a pecuniary loss" if the CAFO permit were granted.
~ *Sexton v. Jackson County Bd. of Zoning Appeals,* 884 N.E.2d 889, 893-94 (Ind. App. 2008).

In 2002, a Nebraska Court held that a tax commission should have considered the effect of a nearby factory farm on a taxpayer's property value. The taxpayer presented evidence from an appraiser who "considered that a potential buyer would take into account the odor produced by the hog farrowing facility," and adjusted the property's value downward for that and other reasons. The Court made several strong statements illustrating its conviction that factory farms impact neighboring property values:

> In the context of negotiations between a willing buyer and seller to arrive at fair market value, the neighboring hog facility and the house's location would unquestionably affect the market value of Livingston's house. Any other conclusion would mean that two identical houses, one

> located next to the railroad switching yard and the other next to the country club golf course, have identical values – an obviously arbitrary and illogical conclusion that no reasonable person would reach. . . .
>
> That many potential buyers would not look favorably upon the hog facility, and judge the home's value with reference thereto, is demonstrated by some well-known Nebraska cases in which homeowners have successfully sued hog facility owners for damages caused by interference with the use of their nearby homes. . . .
> No reasonable fact finder could conclude that in the real estate marketplace, a potential buyer would not notice, and react economically, to having a large hog facility very nearby while living in a remote location.

~*Livingston v. Jefferson County Bd. of Equalization,* 640 N.W.2d 426, 431, 437 (Neb. Ct. App. 2002).

In another Nebraska tax case, the state Supreme Court held that an assessor's valuation was "arbitrary and unreasonable" because it did not apply external/locational depreciation to a home that was near a cattle feedlot. The property owner provided testimony about problems with dust, trucks, and flies from the nearby feedlot. In addition, the well for the home was connected to the cattle-watering facility.
~ *Darnall Ranch, Inc. v. Banner County Bd. of Equalization,* 753 N.W.2d 819, 830-32 (Neb. 2008).

In a 1999 South Dakota case, the Court upheld the decision of a land commission to deny a permit for the siting of a hog confinement facility based on, among other things, devaluation of surrounding real estate.
~ Coyote Flats, LLC v. Sanborn County Comm'n, 596 N.W.2d 347, 352, 356 (S.D. 1999).

An appellate court in Illinois has recognized that factory farms can decrease neighboring property values. In *Nickels v. Burnett,* the Court upheld a preliminary injunction against building an 8,000-head hog CAFO based in part on "extensive evidence in the form of affidavits and scholarly articles authored by the expert affiants demonstrating that, if the hog facility were to begin operation, plaintiffs would experience substantially harmful health effects and a significant loss of value to their land." The Court found the "harms described were substantially certain to occur should the hog facility begin operations in its present proposed location."

The neighboring plaintiffs alleged that the facility would devalue their properties (among other things). The plaintiffs introduced the affidavit of a professional appraiser, who stated that neighboring property values would be reduced by 18-35%. They also presented affidavits from two doctors who concluded, respectively, that "years of downwind exposure to Hydrogen Sulfide even in low doses can cause permanent brain damage and . . . any exposure must be avoided;" and that "locating the proposed hog facility 3/4 of a mile or less away from homes is likely to cause medical and psychological symptoms to the people living in those homes." Another expert opined that "subjecting the Schmidt and Klein families (the families living closest to the site of the proposed hog operation), to the hog operation odors will significantly increase the likelihood that the two families will experience health problems and that it will cause significant detrimental effects on the quality of their lives." In his opinion, "subjecting the other 13 families, whose homes are located within 3/4 of a mile from the proposed hog operation, to the emissions generated by the proposed hog operation will increase their risk of health problems."
~ *Nickels v. Burnett,* 798 N.E.2d 817, 820, 826 (Ill. App. Ct. 2003); Brief of Appellees at 7-10.

In Pasco, Washington, an appraisal done for litigation purposes found an over 50% reduction in value of a family farm impacted by neighboring CAFO dust, flies, fecal matter, and odor. The CAFO settled the lawsuit by relocating the plaintiffs and buying their farm.
~ John A. Kilpatrick, *Concentrated Animal Feeding Operations and Proximate Property Values*, 39:3 Appraisal J. 301, 305 (2001).

In Michigan, a horse farm appealed its property tax assessment because it was located near a large scale pork processing facility. The horse farm got a 50% reduction based on airborne externalities and flies.
~ John A. Kilpatrick, *Concentrated Animal Feeding Operations and Proximate Property Values*, 39:3 Appraisal J. 301, 305 (2001).

In a 2002 Iowa nuisance case, the Court ordered a pork company to pay $100,000 to homeowners when their home dropped $50,000 in value after a nearby CAFO was built. The plaintiffs had alleged that the CAFO attracted bugs and harmed their physical and emotional health.
~ Associated Press, *Judge Awards Iowa Couple $100,000 in Hog Lot Lawsuit,* Amarillo Globe-News, Jan. 12, 2002.

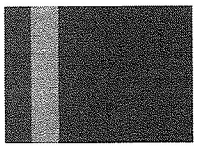
In 1998 in Cedar County, Nebraska, property owners received an assessment reduction based on a neighboring CAFO. On the protest form to the tax board, the property owners stated: "Our neighbor has built a hog confinement and lagoon across the road from our house. This same neighbor has runoff from his cattle yards in to the road ditch 100ft from
our well. The nitrates in our water ha[ve] increased making it not safe to drink. We feel a valuation increase of $35,340 is unfair." The board looked at the property and decided to assess a 25% locational depreciation.
~ Great Plains Environmental Law Center, Case Studies, Cedar County, Property Valuation Protest Form (1998).

In January 2002, in Calhoun County, Iowa, a jury awarded $76,400 in damages to four property owners who claimed a 4,000-hog operation within a mile of their properties diminished their property values. In another Iowa county, a Court had recently awarded $100,000 to other property owners for decreased property values from a nearby hog feeding operation.
~ Jerry Perkins, *Jury Sides against Hog-lot Firm: A Total of $76,400 Will Go to Residents Near the Facility*, Jan. 26, 2002.

A 1998 newsblurb from Kansas reported that a jury awarded $15,000 to retired farmers who live near a feedlot for diminished property values and loss of peace of mind.
~ *Across the USA: News from Every State*, USA Today, June 22, 1998.

This document does not contain legal advice.
Please consult a licensed attorney if you wish to obtain legal advice.

Tracie Zaun
304 Wilcox Ave N Buffalo, ND 58011
701-361-1699 tracie.zaun@corelinksolutions.com



RECEIVED
JAN 2 3 2016
DIV. OF WATER QUALITY

January 21, 2016

North Dakota Department of Health
Division of Water Quality
600 E Boulevard Ave
Bismarck, ND 58505

To whom it may concern,

As you are aware, there is a lot of concern stemming from the community meeting in Buffalo, ND on January 18th regarding Rolling Green Family Farms moving in a hog farm operation. I am writing a letter of concern due to medical reasons.

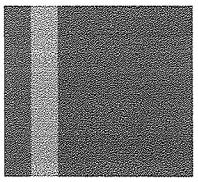
I am a 40 year old female that has been dealing with a compromised immune system, I have Lupus. As you are well aware, when someone has a compromised immune system, they have a harder time fighting off viruses, bacteria and germs. I have days where I feel "normal" but I also have days that make it difficult to leave my house.

When I heard about a hog farm coming to our community, I had immediate concerns for my health and others in the community that also suffer from autoimmune diseases and other health issues. One of my biggest concerns that I have is zoonotic disease transmission especially MRSA. In some of the research that I have looked at, people who live within a mile of a hog operation are nearly 3 times more likely to carry MRSA in their noses than the general population (McKenna, 2014) and also another MRSA study conducted in Pennsylvania in 2013 (Joan A. Casey, Frank C. Curriero, Sara E. Cosgrove, Keeve E. Nachman, & Brian S. Schwartz, 2013) found that people who live near fields treated with industrially farmed hog manure are "significantly" more likely to be treated for infections, and that people who live near hog operations showed a "similar but weaker association" with MRSA infection rates. With this being said, those that have weakened immune systems are at an increased risk for developing staph infections, including MRSA.

Thank you for taking the time to listen to my concerns regarding my health and those that live in the community as there are elderly folks that live in this community that could also be affected.

Sincerely,
Tracie Zaun

Vincent Larson
14029 35th St. SE
Buffalo, ND 58011



RECEIVED
JAN 2[illegible] 2016
DIV. OF WATER QUALITY

January 20, 2016

ND Dept. of Heath, Div. of Water Quality
918 East Divide Ave.
Bismarck, ND 58501-1947

Dear Committee Members

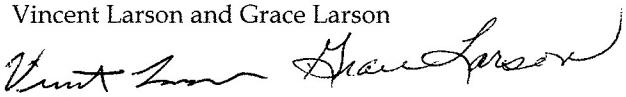
We understand that we are to submit our comments to you about the proposed hog farm in the Buffalo area.

Our home is 1 ½ miles radius from the proposed site. We do not wish to undermine legitimate farming enterprises, but do have a concern about the amount of smell that could be generated. Hog manure has a particularly pungent odor so we are afraid SE winds could bring it to our home. SE winds occur numerous times during a year.

Thank you for being thoughtful of our concerns.

Warm regards,

Vincent Larson and Grace Larson



Strommen, Rachel A.

From: Lang, Jeremiah M.
Sent: Monday, February 01, 2016 10:13 AM
To: Strommen, Rachel A.
Subject: FW: I support approval for Rolling Green

-----Original Message-----
From: Darren Olafson [mailto:olafsonenterprises@polarcomm.com]
Sent: Monday, February 01, 2016 10:03 AM
To: Lang, Jeremiah M.
Subject: I support approval for Rolling Green

Dear Environmental Engineer Lang,

As a farmer and business owner in North Dakota, I strongly urge the DOH to approve the Rolling Green Family Farms new hog facility near Buffalo. It appears that they are following the rule of law and we need more operations in the state that are good stewards and can help us stay strong in the world of animal agriculture.
This "Not in my Backyard" approach is quite sickening. It smacks of jealousy and opponents are attempting to use environmental issues to convince people from an emotional level to help stop this development, to stop progress. I would hope that in North Dakota we can rely on common sense as opposed to emotional filibustering to make decisions that impact our future. I ask of the DOH to make sure to follow the facts and the rule of law to make sure that everyone is treated fairly. We cannot allow a precedent to be set here that puts animal agriculture in the state of North Dakota at risk.
Thank you for taking the time to read this and I trust that the department will do the right thing.

Sincerely,

Darren Olafson
420 Main Ave
Edinburg, ND 58227

Strommen, Rachel A.

From: Lang, Jeremiah M.
Sent: Monday, January 25, 2016 7:42 AM
To: Strommen, Rachel A.
Cc: Rockeman, Karl H.
Subject: FW: Proposed Buffalo hog farm

Rachel,

Here's another one for the file.

Jeremy

From: Glenn Muske [mailto:gamuske@gmail.com]
Sent: Sunday, January 24, 2016 12:41 PM
To: Lang, Jeremiah M.
Subject: Proposed Buffalo hog farm

I recently read about this proposed hog operation near Buffalo, ND. I would oppose granting a permit for this business at this time.

I don't live near it but was a citizen of OK for a number of years when they saw hog operations as a big economic driver. In hind sight, there are many that supported them initially that wish they would have taken a harder look at what the operation would bring

Also it is interesting that a large confinement operation is proposed when industries such as poultry are looking to return more to a more animal-friendly environment.

Yes, ag is a big ND economic driver but we need to move slowly down this slippery slope. We could have another oil situation on our hands.

Glenn Muske

Strommen, Rachel A.

From: Lang, Jeremiah M.
Sent: Thursday, February 04, 2016 7:26 AM
To: Strommen, Rachel A.
Subject: FW: I support approval of the pig farm

-----Original Message-----
From: John Jacobson [mailto:johnj14@invisimax.com]
Sent: Wednesday, February 03, 2016 7:57 AM
To: Lang, Jeremiah M.
Subject: I support approval of the pig farm

Dear Environmental Engineer Lang,

We have a tremendous economic opportunity in the state of North Dakota in regard to livestock expansion. Growth in this area can provide opportunity for our rural communities in terms of economic growth directly from the activities of the farm and indirectly to crop farms in terms of a more competitive basis.

These farms must go through the process and meet the requirements of the Department of Health and should not be stopped because of rhetoric and fear.

I support the proposed pig farm near buffalo.

John Jacobson

Sincerely,

John Jacobson
14115 14th St NE
Hatton, ND 58240

Strommen, Rachel A.

From: Lang, Jeremiah M.
Sent: Monday, February 01, 2016 11:51 AM
To: Strommen, Rachel A.
Subject: FW: I support approval of the pig farm

-----Original Message-----
From: Nathan Fegley [mailto:nfegley@srt.com]
Sent: Monday, February 01, 2016 11:19 AM
To: Lang, Jeremiah M.
Subject: I support approval of the pig farm

Dear Environmental Engineer Lang,

I support the proposed hog farm in Buffalo because I know that with proper oversight of construction and management that there are very little environmental impacts. The hog farm will have a tremendous economic impact on the area and spur other positive growth to the agriculture industry in North Dakota.

Sincerely,

Nathan Fegley
10701 240th St NW
Berthold, ND 58718

From: Rockeman, Karl H.
Sent: Wednesday, January 20, 2016 8:11 AM
To: Strommen, Rachel A.; Lang, Jeremiah M.; Espe, Brady L.
Cc: Haroldson, Marty R.; Olson, Margaret I.
Subject: FW: Large scale hog production

Another comment for the record.

This is a new one. Maggie, any idea on what he's referring to?

Karl Rockeman, P.E.
Director
Division of Water Quality
North Dakota Department of Health
(701)328-5210

From: -Info-Dept. of Health
Sent: Wednesday, January 20, 2016 8:03 AM
To: Rockeman, Karl H.
Cc: Glatt, Dave D.
Subject: FW: Large scale hog production

FYI
Londa

From: Sandy Azure [mailto:sandyazure12@gmail.com]
Sent: Wednesday, January 20, 2016 6:20 AM
To: -Info-Dept. of Health
Subject: Large scale hog production

The state of ND is currently not taking into consideration titleV1 in allowing large scale hog farms. The state regulations are to weak and oversite is severely under- reserved to address the adverse impacts of industrial swine production. The EPA and the state must take seriously the potential for discrimination. I ask the state to hold public hearings on all large scale hog production permit's to address this issue. I ask the state to take another look at its permitting policy to better confirm to title V1 . Paul Azure 499 14 th st n apt 101 wahpeton nd 58075

Strommen, Rachel A.

From: Lang, Jeremiah M.
Sent: Monday, February 01, 2016 9:31 AM
To: Strommen, Rachel A.
Subject: FW: I support approval of the pig farm

-----Original Message-----
From: Rachel Bina [mailto:rachelbina@gmail.com]
Sent: Monday, February 01, 2016 9:25 AM
To: Lang, Jeremiah M.
Subject: I support approval of the pig farm

Dear Environmental Engineer Lang,

Thank you for working with Rolling Green Family Farms on this project. I understand the public concern, but if implemented correctly, can be a success story for North Dakota agriculture. I am a grain farmer, very concerned about growing domestic uses of the feed grain crops grown in North Dakota. If we can feed our grain crops to our animals locally, it is a win-win for our local economy. If this farm can meet the implementation standards, then please continue to support this project. Regards,

Sincerely,

Rachel Bina
6588 Highway 32
Park River, ND 58270

Strommen, Rachel A.

From: Lang, Jeremiah M.
Sent: Tuesday, February 09, 2016 1:31 PM
To: Strommen, Rachel A.
Subject: FW: I support approval of the pig farm

-----Original Message-----
From: Gregory Mostad [mailto:gregory_mostad@hotmail.com]
Sent: Tuesday, February 09, 2016 12:43 PM
To: Lang, Jeremiah M.
Subject: I support approval of the pig farm

Dear Environmental Engineer Lang,

I am a life long resident of North Dakota and supporter of agriculture. From my days growing up on a farm, being involved in FFA in high school, and to my career working in agriculture, I am very passionate about preserving our agricultural roots in North Dakota.

I support business growth and diversification in North Dakota. It's good for our economy. And a livestock farm is a business just like any other, so I support the proposed pig farm planned for Buffalo, North Dakota.

For the future of North Dakota, it's important that young people have the opportunity to begin farming and ranching. If we are going to shut down livestock expansion at the whim of the Not In My Backyard crowd, how will young people ever get started in agriculture? I support the proposed pig farm near Buffalo, it's the right thing to do for the future of North Dakota.

I'm in favor of the proposed pig farm near Buffalo that was in the news this week. If the family has met all the requirements of the Health Department, they should be able to grow their business.

If a new plastics manufacturer was looking to move to Buffalo, N.D., I doubt if they would face any opposition, so it's wrong for people to oppose expansion of another business, just because it happens to be a pig farm. Business is business, and I support the proposed pig farm.

Why are people opposed to this pig farm in Buffalo? They are working with the health department to meet all the requirements for public health and safety. There is no reason fear-mongering should stop this farm moving forward.

Livestock expansion is good for North Dakota. It's good for the grain farmers too, and I think we should welcome the pig farm near Buffalo.

I'm in favor of the proposed new hog farm in Buffalo. It's good for our rural communities to have growth, and growing livestock farms helps the other farmers in the area too. Since the family involved is meeting Health Department requirements, why should anybody be allowed to stand in their way?

Please take into consideration my comments. I don't write public comments very often, but I feel very passionate about this issue and I want to support these people.

Sincerely,

Gregory Mostad
1935 Queensbury St
West Fargo, ND 58078

RECEIVED
JAN 25 2016
DIV. OF WATER QUALITY

ND Department of Public Health

My name is Deb Miller. I live on a farm outside of Buffalo with my two daughters. I am writing about the proposed large hog farm operation on schedule to be built near my home. Permit # ND-2015-019

I have lived her for 18 years. My husband and I built the home my girls and I still live in. We don't want to move; we are established. I've heard stories about people moving near a railroad or airport and complaining about the noise. It can be said they shouldn't have moved to an area that has a railroad track or where an airport was already established. We here in Buffalo can say the opposite, we are established, we should have a say in the building of something that could potentially change the status of our current living situation. We have a right to know the potential changes or consequences of such a large hog operation moving in close to our town and next to our friends and neighbors.

My questions are will this affect the re-sale value of my home, will the water table be affected. Where will all the waste be dumped, can I count on smelling the hog farm throughout the year? If the plan is to use the waste as fertilizer is any of the farmland it will be used on near a river where possible pollution can occur?

I understand they plan to bring people from out of state to run the hog farm. Bringing people in from out of state hasn't resulted in a positive situation for the native North Dakotans in the Western half of the state. That makes me nervous, especially when I think of raising my daughters here.

I realize the proper line of paper work has been followed, legally things are correct. Announcing the operation to the locals here has been last minute, and I want to know why? Is there something so bad that we would fight tooth and nail to stop it? I am established here, I don't want to move out of our home, out of our school district. I want to know if this hog farm operation will make me want to move. I have a right, we as all have a right to know how things may change.

Debora Miller

Debora Miller
13887 39th St. S.E.
Buffalo, ND 58011

ND Department of Health
Division of Water Quality
918 East Divide Avenue
Bismarck, ND 58501

RECEIVED
JAN 25 2016
DIV. OF WATER QUALITY

Dear ND Department of Health and Division of Water Quality Board members,

We are writing this letter in response to the very recent news that a swine farm was on the agenda for approval near Buffalo, ND. We are suspicious as to why this information wasn't made public until the very last minute. Being born and raised in North Dakota, we were both brought up in farming communities. We question why a local farmer would sell his land to a large corporation and the news didn't become public until now. The whole thing smells like a shady deal. If it were such a great project, then why all the secrecy? We read the articles in the Fargo Forum along with the news video presentations from the meeting in Tower City.

We own 2 quarters of land ½ mile south of the site of the proposed swine operation in Buffalo, ND. Our land is on the south side of Interstate 94. This land was originally homesteaded by Nelson and Jane Nudell and bought by their son Lorne and Helen Nudell. The land went into a trust to my brothers and me (Kim). We then bought the land from my brothers, Keith Nudell and Kent Nudell. We currently rent our farm land to the Buhr Brothers of Buffalo, ND. It is our hope to pass this land on to our two sons, Seth Webster and Jared Webster. Custer, SD is where we live and are retired from the teaching profession. We have connections in Buffalo, ND and visit up there to check on the land numerous times.

We are concerned because there is a drainage system that flowed from the land north of Interstate 94 to our land directly south of Interstate 94. We are concerned about the drainage that might affect water quality, the spread of disease, and the odor. We are equally concerned about the value of the land as this pig operation emits toxics into the water drainage and land. Does this corporation have a plan for disposal of dead animals and the placentas? Would these be a source for flies and possible disease? We have so many questions and are feeling rushed about getting this letter sent to you in time for your deadline meeting! We plan to be in ND for spring planting on our land in Ellendale, ND in May and would gladly come up for meetings at that time.

This sounds like a rush deal. We would hope you would give the farmers and the community more time to gather their research and answer their questions before you make a hasty decision that has the possibility of hurting a lot of people's livelihoods and the town's peacefulness. We would hate to see a large corporation take away from the livelihood of the farming community of Buffalo. We doubt this corporation is going to support the local businesses. **We strongly urge you to give the citizens of Buffalo more time to gather information.**

Sincerely, A+K 1-21-16
Alan and Kim Webster
25278 Grey Rocks Road
Custer, SD 57730

RECEIVED
JAN 21 2016
DIV. OF WATER QUALITY

January 16, 2016

ND Department of Health
Division of Water Quality
918 East Divide Ave.
Bismarck, ND 58501-1947

Re: Public Notice ND-2015-019

To Whom It May Concern;

We have just been informed of this public notice. We are genuinely concerned about the establishment of the Rolling Green Family Farms RE,LLC Livestock facility located in SE ¼ of the NW1/4 section 4 Township 139 N, Range 54W, in Cass County North Dakota. Specifically, we are concerned about the quality of life due to the odor, the environmental impact on the water and devaluation of property values.

Respectfully;

John Sproul John Sproul
Gregory Sproul Gregory Sproul
Susan Sproul Susan Sproul
Robin Sproul Robin Sproul

cc: Antoinette Babcock
Mayor, Buffalo North Dakota

RECEIVED
JAN 2 1 2016
DIV. OF WATER QUALITY

January 19, 2016

ND Dept of Health
Div of Water Quality
918 E Divide Ave
Bismarck, ND 58501-1947

RE: Rolling Hills Hog Farm in Buffalo, ND

Dear Sirs:

I am a 4th Generation Wheat Farmer from Ayr. Our home is 9 miles north of this propossed site. I am concerned over the amount of traffic this operation will bring to our road. Also the wear and tear on the road, the township will not have resources to repair roads. This could be a very danagerous situation with the added semis as my family and I use this road regularly.

My neighbor ran a 300 sow confinement operation, less than a quarter mile away. We regularly could not enjoy the outdoors due to smell. I do worry about air quality due to this operation. My neighbor has passed on ....due to lung and heart disease. His family believes was caused from working in the hog barns for years and years. I myself worked for him one winter, the two other workers and myself developed a severe cough. I am very concerned with air quality.

I was raised on the family farm, we raised sheep, cattle, pigs and horses. We treated our animals like family, we had love and respect for our animals. I believe that confinement of any animal is inhumane.

I am very concerned with the lagoons/manure being stored underground, who will monitor this. Will the ground water be contaminated, what about runoff.

We are very much opposed to Rolling Greens opening a hog confinement in Buffalo, it will disrupt my familys quality of life, along with the many residence of Buffalo.

Sincerely,

Ron Punton Candace Punton

Ron and Candace Punton

RECEIVED
JAN 21 2016
DIV. OF WATER QUALITY

January 16, 2016

ND Department of Health
Division of Water Quality
918 East Divide Ave.
Bismarck, ND 58501-1947

Re: Public Notice ND-2015-019

To Whom It May Concern:

We have just been informed of this public notice. We are genuinely concerned about the establishment of the Rolling Green Family Farms, RE, LLC Livestock facility located in the SE ¼ of the NW ¼ Section 4 Township 139N, Range 54W, in Cass County, North Dakota. Specifically, we are concerned about the quality of life due to the odor, the environmental impact on the water and the devaluation of property values.

Respectfully,

Susan Sproul

Susan Sproul

Lang, Jeremiah M.

From: Pat Faul [pfaul@westriv.com]
Sent: Sunday, February 21, 2016 8:08 AM
To: Lang, Jeremiah M.
Subject: I support approval of the pig farm

Dear Environmental Engineer Lang,

I am in favor of the pig farm, any advancement in animal agriculture benefits farmers statewide. It also provides economic development for their community. Rules are being followed, get it going!

Sincerely,

pat
980 Highway 200 NE
McClusky, ND 58463

January 20, 2015

RECEIVED
JAN 2 5 2016
DIV. OF WATER QUALITY

Ashley Moyer
N208 Eastowne Lane
Appleton, WI 54915

North Dakota Department of Health,
Division of Water Quality,
918 East Divide Avenue
Bismarck, North Dakota 58501-1947

To Whom It May Concern:

I am writing this letter in regards to the proposed 9,000 confined pig operation near Buffalo, North Dakota. This operation is being proposed 1.5 miles from where I grew up. My families' land is .5 miles away. I would like to voice my opposition to this operation for many reasons.

This operation will not be built in "the middle of nowhere" as many may believe. There are many homes, small farms, and small towns within a 5-15 mile radius of where they want to build this. There are many other places in the United States that do not have families living within this 5-15 mile radius. These types of operations will produce a lot of manure which contain many pathogens that can cause cancer and many other health concerns. My cousin and his wife just built a brand new house 1.5 miles away from this proposed operation. They will be able to see it from their backyard and the smell will most certainly affect them (and everyone else who lives nearby). What's worse is they are expecting their first baby this year and that little one will be exposed to these dangerous pathogens.

Fecal wastes from these animals will be applied to the soil surface and to varying extents are then incorporated into the soil. These fecal wastes can also enter our water systems by direct contamination of the water or through seepage or surface runoff. This not only affects members of our community, but the wildlife as well. There is a creek that runs behind my childhood home and there are many ducks, geese, pheasants and deer who call this home. They will be impacted by this runoff as well.

As someone who will inherit the land .5 miles away from this proposed operation, the value of this land will be greatly affected. Studies have found that the average loss of land value within three miles of a CAFO was $112/acre. My families land and home value will all plummet if this operation is built. This also will affect the neighbors as well. If land and home value plummet so does the property tax revenue.

I would encourage you to really look over the pros and cons of what this operation will do to the small community I grew up in and where so many people still call home. With diligent research, you will find that the cons far outweigh the pros. I am very much against this operation being built on the proposed location. Please deny a permit for this to be built. Thank you for your time.

Sincerely,

Ashley Moyer

To the No. Dak Health Dept.

It's not so much about the Hog Farm. It's more so the people of Buffalo, that has lived there for most or all there life. Don't like new comers or changes in there town. We have a Dairy Farm just outside of town. It gets some strong, if the Wind is at the Right Derection. But I lives with it, we Been here for 23-yrs. If you are having a vote on it all vote for it.

RECEIVED
FEB 22 2016
DIV. OF WATER QUALITY

Ms. Marlene Hermanson
PO Box 17
Casselton, ND 58012

FARGO ND 581
20 FEB 2016 PM 1 T

North Dakota Dept of Health Division
of Water Quality
918-E. Divide Ave.
Bismarck, N. Dak

Letters To The Editor

TO THE EDITOR:

This is in response to Bil[illegible] ... Barnesville MN

TO THE EDITOR:

After researching the public health and environmental nightmares that 30 U.S. states, including Minnesota and North Dakota, as well as our neighbor, Canada, have suffered, due to pollution accidents and deliberate violations by large hog, cow and poultry "farmers", it is an outrage that on June 26 the Clay County Board of Commissioners voted to deny a one-year feedlot moratorium and a public town hall meeting for the county's rural and city dwellers to voice their public health and pollution opinions and concerns.

"Are we doing the level of inspections we should be? No," said Mark Steuart of the Minnesota Pollution Control Agency (MPCA) at a recent educational meeting called for by the Clay County Planning Commission, featuring four experts on the mega-sized animal factory issues. The MPCA only has four feedlot officers to inspect and enforce our pollution laws and regulations over a vast 21 county area. "It's purely random," he said.

Regarding the lifespan of a hog manure concrete pit, Steuart said, "If man built it, it WILL break. SOMEtime." He accentuated the words "will" and "some". Commissioner Roland Holm replied, "Concrete IS porous - over a period of time," and then went on to say that some of the chemicals in the manure weakens the rebar beneath it. Steuart tentatively answered, "Yeah ... particularly if there's honeycombing. Yeah ... there's a lifespan, and I'm not sure if it's 20 years or 25 years, but..." his voice trailed off - leaving citizens stunned.

County-delegated feedlot officers, something many of the county's commissioners said they are highly in favor of as a solution to the pollution and public health problems, also are proven to not work. "In the spring of 2007, we probably had more spreading violations, than I've had in a number of years," said George Leary, delegated feedlot officer for Blue Earth County. He admitted he only has time to inspect one-third of his county's feedlots yearly.

Can engineers be counted on to do a top-notch job, during construction of animal factories' manure pits to pass inspection, and are sites properly inspected before, during and after the concrete is poured? No! Chairman Commissioner Greg Anderson asked the MPCA, "Then, you may or may not be inspecting the rebars before the pour and after the pour - there's no way to tell with the rebars?" Steuart answered, "Right."

Steuart also admitted, "Not all engineers are created equal." And Leary agreed, "Not all engineering firms are going to do, um, an adequate job." Leary then discussed a particular bad engineer he'd just dealt with the previous day.

Moreover, enforcement of pollution violators is sorely lacking. Leary said he's only turned over two violators to the DNR and county attorney in the past seven years he's had his job. "And that's not to say that we've not had complaints for spills or anything like that because we have had ... but if it's not a serious violation - a letter of warning put in their file - I believe -is adequate," he said.

He then told of a dairy operator who had violated the state's 300-foot tile setback law in 2003. Leary sent him a warning letter. In 2005, he sent him another warning letter for the exact same pollution violation. In the spring of 2007, Leary finally turned the case over to the DNR for the exact same pollution violation. Sooo ... even repeat warning letters, obviously, do not work!

Steuart admitted the MPCA does not even know exactly where all of Minnesota's feedlots are or how many there really are because some of them fail to legally register. He then recounted a feedlot operator who "never did register initially in 2001 - he didn't register in 2005 - he didn't sign up for the open lot agreement." Steuart then added that guy gets to have one more year to run his operation.

Robert Sip of the Minnesota Department of Agriculture provided a slide-tape show at that meeting, which showed each county's number of registered feedlots. His map listed 200 registered feedlots in Blue Earth County and 131 in Clay County. However, Leary corrected Sip's information with, "... we actually have 445 feedlots in the county." Bringing inaccurate information to that important meeting, which was specifically held to provide decision-makers and the public with all of the facts before vital decisions are voted on is, in my book, inexcusable!

Inspections and enforcement are not being carried out properly at local levels, as is painfully true by Steuart's and Leary's own admissions - even more were stated than this letter can hold! The Clay County Board of Commissioners really should have voted for a moratorium, if not an outright permanent ban on any feedlot with more than 300 animal units, including expansions of current feedlots.

Equally shocking is the fact that not all of the citizen-elected Board members even bothered going to that educational meeting, and two who did actually left early, so how could they possibly cast an intelligent, well-informed vote?

At the very least, the Board should have voted for a town hall meeting to give all county citizens a forum to voice their concerns about animal factory issues and Clay County's future water, air, soil, and public health. The commissioners need to remember that hogs don't vote ... people do.

(published 7-2-07 B'ville paper)

Barbara Kay Carlisle
- Barnesville, MN

We eventually won. (thanks to public letters...)
Google: Living a Nightmare! Animal Factories in Michigan
Watch the teaser, & Part I, & Part II of this short documentary.

This public letter is peppered with "officials" quotes...
please read!

Division of Wa...
North Dakota Public Health Dept. — I implore you to deny any more factory farms. Please read my letter & watch doc.

PS ~ I've been pondering moving to N.D., but if the State values Money over

RECEIVED
FEB 29 2016
DIV. OF WATER QUALITY

To Whom it May Concern:n

I am writing to ask for help for our community in Buffalo in regards to the hog farm that wants to build here. To give you a background on me, I am new to the community. We just moved here the end of October.

When my husband and I first heard about the hog farm, we were not overly concerned since we both grew up on farms and our families raised animals. I actually didn't even know about the community meeting that was held that Pipestone attended. I saw the Fargo Forums article on Facebook since a friend happened to have liked it. I then started to google and search for all the different news organizations and what they were reporting. When I heard the Joel Heitkamp interview with the mayor of Buffalo I was very upset by how the community was treated. I had been told by someone in town enough of what happened at the meeting to make me believe that this interview is accurate. Who gives this company the right to come to our community and to treat our people this way? You don't heckle people when they are asking question that you don't like, and you don't have jobs threatened when someone is saying something that you don't like. I then once again saw a Forum article that was liked by a friend that was from Wayne Trottier saying how he was discouraged that we don't want the hog farm here. I was so upset that I sent him an email telling him that I didn't think that he had the right to write a letter like that when he doesn't even know what is going on in this community. Mr Trottier is very quick to email me back with his questions, but never really answers any of my questions.

Buffalo has formed a group of concerned citizens that met last week and they invited a few people that have hog farms near their homes. After coming home from that meeting, I have to tell you I am scared. Pipestone's last hog farm that they opened up is near one of the speaker's home. She said that they came in and promised them the same thing that they are promising us, but they lied. She said that they have seen no economic impact from this farm coming to their town, only problems. She is from an area that has several commercial dairy farms and they do not have issues with them. She said that they bring in the contractor from Morris MN and all of the building supplies came out of state as well. She said that the local lumber company and electrician asked to bid on the new buildings and they were not allowed to see the plans. All of the feed and supplies are not bought locally. She said that they were promised that they would use the most effective filters and they are trying to save money by making their own. The real ones are too costly.

At the SD hog farm they have already have had one family move out of the area and they had to sell their property for quite a bit less than what it had been worth. She said another one will be moving soon if they are not able to get the company to decrease the hog smell. She said that these people are about a mile away. People are having to stay in their houses and the smell is still coming in the house. Per the South Dakota newspaper, people are starting to have health issues. This company told them that they would only smell the hogs 2 percent of the time. Of course, now they are saying that they never said this in the first place. Why is it ok for them to come in and wreck our quality of life? Why don't our lives matter? Is making money more important to these people then us humans?

I then go and spend 10 minutes googling CAFO hog farms and found articles from other states. I can honestly say that no one is saying anything good about these places other than it makes the owners money. I am now concerned about my heath since I have asthma. I know that one of my neighbors is

contracted to spread manure and I don't know how much this will impact my health. One report that I read said that the air quality can affect you up to 5 miles away. I believe that I live about 2 ½ miles away as the crow files from the hog farm.

I called the ND Public Heath department and spoke to Jeremy. He told me that they have received a lot of letters from citizens regarding this issue. I told him my story and asked him if they have called the other state health departments and talked to them since I was told that this company was turned down from SD and MN before heading to ND. He said that he has been talking to them. I asked him why they would even think about letting a company come in that causes respiratory health issues and he said that he had not heard that the hog farms did. I told him that he couldn't have don't very much research since I have only looked online for 10 minutes. He said that they would have the meeting March 17th and that they would review everything and as along as the company meet all the requirements they would receive the permit. Even though they have received a ton of letters and I am talking to him about the health issues that this type of farm creates, he is telling me that isn't enough!

Terry Dwelle, the State Health Officer has on YOUR website that YOU are committed to safeguarding the health of every North Dakotan. How can you approve this permit if that is true?

We were told that this business plan has been around for many years. They like to go into a small community near the edge of a county. They come in and say they are opening one, than they open two and pretty soon you are to hog county. If one county says no to them, then they go to the next county. They said that the type of people that usually work here are transit people and it puts a burden on the school systems since they then have to hire bilingual teachers. The lady from SD said that she wasn't sure where their workers came from, just that there were a bunch of cars with MN plates. The township will not see additional money since the wear and tear on the roads will actually cost them more to upkeep. The state will see more wear and tear on Interstate which will in turn cost all of ND tax payers.

So where is the benefit? Who is getting the money other than the land owner who is selling the land and Pipestone? Which state officials or politicians are getting special favors? Why is the health of our people not the number one priority? Why does it have to be this land, why not build where we are not going to hurt anyone's health? Maybe the workers need to be required to wear respiratory gear so they do not have long term health problems. Maybe we need to fund the family farmers to raise our pigs in smaller quantities so there are not so many health risks. One of the articles that I read stated that even though there are more CAFO's that animal production is not any higher than when family farms raised the pigs. The big corporations just ran the small farmer out of business.

If this is such a great thing for us, why was this hidden from the public for over a year? The only way Buffalo residents found out about it was because the ND Public Health Dept had to print a notice in the Fargo Forum by law. Thankfully someone saw it since we all know most people don't read them! If it is so great, why does the corporation bring their people to a meeting and plant them in the crowd as spectators and have them heckle people.

When we heard about it we were told by the ND Public Health Department that we had to write letters in a very short amount of time and get them to the health department and our reason for not wanting the hog farm could not be because of odor. Thankfully the community was able to comply and get the hearing/meeting for March otherwise the Health Department would have just approved the permit.

I told Jeremy at the health department that I have asthma and asked him if he understood that it was odors that activated asthma symptoms like mine. I told him that the reason that there is an order is that there is something in the air. So if something is in the air that is harmful to us, why is that not a reason for us not to want the facility located here?

Why does Pipestone have a new company name for each facility that they build? If they were a proud and honest company then they would stick with one name that everyone would recognize. But if you have a different company set up for each location, you can walk away when you want to and leave all of your problems behind. What happens if they get a disease in the building that they can't get rid of? It will than become the township, county and the states problem. They will file for bankruptcy and they will walk away.

I have been more focused on the respiratory issues, but research also shows that these CAFO's are harmful to the land and our water. Why are we willing to put our nature at risk? Does it really matter that our state does not raise a lot of pigs? It is worth the cost of having to clean up the companies mess when they leave.

The ND Health Department needs to remember that the health of the ND people are the first priority, not weather a company meets requirements or not. If other states are not allowing these people in, they are doing it for a reason. They have learned that these type of facilities are not good for the people or the land. If they do have to build they need to build further away from people in a more rural community.

Sincerely,

Linda Wendel

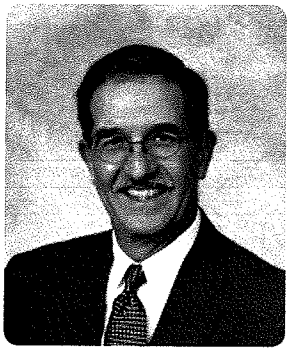
Linda Wendel

3395 143rd Ave SE

Buffalo

NORTH DAKOTA
DEPARTMENT *of* HEALTH (/)

Search



Welcome to the North Dakota Department of Health website. It's amazing how public health affects our lives every day. We breathe clean air and drink safe, sparkling water. Our garbage is disposed of properly. We can do our jobs in smoke-free workplaces and feel confident that the food we eat in restaurants is safe. Our children are immunized against many diseases that struck fear into the heart of every parent just a few decades ago. These accomplishments and more are due to the efforts of public health at the state and local level.

To see how public health affects your life every day, click here: A Day in Your Life Thanks to Public Health .

All of us at the Department of Health are committed to safeguarding the health of every North Dakotan. We look forward to continuing our service to you.
Terry Dwelle, M.D., M.P.H.T.M.
State Health Officer

Health Indicator Dashboard (/StrategicPlanning/)

(/StrategicPlanning/)

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(/EHS/Spills/)

Health Topics A-Z (/DoH/TopicsAtoZ.aspx)

Navigate the website by topic (/DoH/TopicsAtoZ.aspx)

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Twitter (http://twitter.com/nddoh)

Frequently Requested

Current Issues

Operating Status: Normal (DoHStatus.aspx)

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Email: health@nd.gov (mailto:health@nd.gov)

Intranet (https://www.ndhealth.gov/intranet/)

1320 AM · 107.9 FM

Do you want to restore the youthful, healthy glow of your skin?
Make the beautiful choice.
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Plastic Surgery Associates
OF SOUTH DAKOTA LTD

Rural Davison County residents irked at hog farm odors

Wednesday, October 07, 2015 9:52 a.m. CDT by Jack Taylor

farm

Commissioner Denny Kiner, Da...
(Download MP3)

Marilyn Reimnitz (Download MP3)

SIOUX FALLS, S.D. (KELO AM) - Neighbors of a large hog farm in Davison County are angered over the facility's odors and complained to the Commission yesterday.

But Commissioner Denny Kiner says there's only so much the county can do.

Jackrabbit has spent $30,000 on bio filters but residents say they're not effective.

Marilyn Reimnitz lives south of Mount Vernon. She says some of her neighbors, "the people near and dear to my heart," are sick and complain about headaches and breathing problems that they didn't have before the plant moved in.

Representatives from Pipestone System, which manages Jackrabbit, are invited to address concerns at future Davison County Commission meeting.

(Thanks Billy Lurken, KMIT Mitchell)

INSTITUTE of SCIENCE, TECHNOLOGY AND PUBLIC POLICY

Concentrated Animal Feeding Operations (CAFOs)

ASSESSMENT OF IMPACTS ON HEALTH, LOCAL ECONOMIES, AND THE ENVIRONMENT

WITH SUGGESTED ALTERNATIVES

INSTITUTE OF SCIENCE, TECHNOLOGY AND PUBLIC POLICY
Maharishi University of Management
1000 North Fourth Street
Fairfield, Iowa 52556

EXECUTIVE SUMMARY

The state of Iowa raises more hogs than any state in the country — 17.2 million as of December 2006 — generating $3.65 billion a year in revenues.[1]

Yet today, although Iowa produces roughly the same amount of pork it did a century ago, the number of hog farmers in the state has dropped dramatically. In the past 25 years alone, the number of Iowa farms with pigs has declined 83% — from 59,134 farms in 1978 to 10,205 farms in 2002.[2] Why?

Most of the 17 million Iowa hogs today are raised in factory farms, large facilities known as Concentrated Animal Feeding Operations or CAFOs, where thousands of hogs are contained before being shipped to the meatpacking plant. The corporations that derive economic benefit from these CAFOs assert that this industrialized farming method is the future of agriculture and a boon to rural regions. Research studies indicate, however, that CAFOs are causing measurable harm across a broad range of environmental, biological, and economic parameters.

These studies have found that factory farms present a variety of problems:

- Significant amounts of toxic animal waste are released into water and air without environmental controls in place, causing pollution to air, soil, and the water supply.
- This pollution, in turn, appears to be a causative factor in the increased illness rates observed among people who live near CAFO facilities.
- The widespread, routine administration of antibiotics to confined hogs increases bacterial drug resistance and thereby endangers public health.
- Land values and quality of life in areas near CAFOs have been shown to decrease markedly and consistently.
- The local economy suffers rather than improves, and small-scale farming declines.

This report examines the impact of CAFOs on health, the economy, and the environment. It highlights how factory farms have impacted Jefferson County in particular, and explains the laws relevant to construction of these facilities and how citizens can get involved in this issue. It also presents viable alternatives to farmers and communities so that the livestock industry can continue to prosper while safeguarding and sustaining a community's health, economic vitality, and environmental resources.

PUBLIC HEALTH IMPACT

How can a CAFO affect my health?

The health threats from a hog factory are due to the tremendous amounts of manure generated in one place by a large number of hogs, whose waste is dropped into anaerobic "pits" that, lacking oxygen, putrefy the matter quickly. A typical swine livestock factory of 10,000 hogs will create as much waste as 25,000 to 50,000 humans.[3]

Hog waste contains viruses, parasites, and bacteria, including bacteria that can contribute to antibiotic resistance in humans. This waste is often contained in large cesspools called lagoons, from which it is applied to surrounding land or sprayed into the air.

Hog waste contains viruses, parasites, and bacteria, including bacteria that can contribute to antibiotic resistance in humans.

The air around CAFOs can contain unhealthy concentrations of hydrogen sulfide, ammonia, inhalable particulate matter, and endotoxin.[4,5]

What are the physical symptoms and illnesses CAFOs can cause?

In addition to nausea, headache, and vomiting, more than 25%–30% of employees working in CAFO facilities report serious respiratory problems,[6,7] some of which are due to toxins (e.g., endotoxin, glucans) from inhaled microbes. One study found that Iowans living within a two-mile radius of a 4,000-hog unit reported more respiratory and other symptoms than a control group of Iowans not living near a CAFO.[8]

Iowans living within a two-mile radius of a 4,000-hog unit reported more respiratory and other symptoms than a control group of Iowans not living near a CAFO.

Hydrogen sulfide gas is known to be a potent neurotoxin that can cause damage to the brain and nervous system. People exposed to atmospheric concentrations of even 0.1–1 part per million (ppm) display neurobehavioral dysfunction, including abnormal balance and delays in verbal recall.[9]

Another study showed that people living near North Carolina hog CAFOs reported more confusion, tension, depression, and fatigue than did those not living nearby.[10]

University of Iowa scientists released a study in June 2006 showing that children who attend school near CAFOs may be at higher risk for asthma. Students at the study school, located ½ mile from a CAFO in northeast Iowa, showed a prevalence of physician-diagnosed asthma in 19.7% of cases; only 7.3% exhibited asthma from the control school more than 10 miles from a CAFO.[11]

The American Public Health Association (APHA), in a 2004 resolution, urged federal, state, and local governments to impose a moratorium on new CAFOs until additional scientific data has been collected. This resolution was based on an analysis of the health and economic impacts of CAFOs on workers, children, and CAFO neighbors from exposure to large concentrations of manure, dust, toxins, microbes, antibiotics, and pollutants.[12]

Is the odor from CAFOs harmful, or merely unpleasant?

Odor pollution, even at low concentrations, can cause gastrointestinal, stress-related, and respiratory symptoms, and may negatively impact the brain and organ systems.[13,14]

How can the antibiotics fed to hogs threaten my health and the health of my community?

An estimated 70% of the antimicrobial drugs used in the U.S. are fed to nondiseased livestock in order to promote growth and to compensate for the stress and health risks of CAFO confinement.[15] This widespread use of antimicrobials by CAFOs contributes to the evolution and global increase of antibiotic-resistant bacteria, which transmit their resistance to humans typically (but not only) via contaminated food.[16] Since the drugs used in human medicine are identical or very similar to the antimicrobials used by CAFOs,[17] humans infected by antibiotic-resistant bacteria can no longer be treated effectively by standard antibiotics. Consequently, the widespread use of antimicrobials by CAFOs directly jeopardizes public health.

CAFO-raised hogs contain not only more antibiotics but also more hormones, which have been administered to enhance growth. The animals also produce increased adrenaline and other chemicals due to the stressful environment in which they are raised, potentially causing the meat to be less healthy for human ingestion. These chemicals are not usually found in low-stress livestock situations.

Do CAFOs affect the social health of a community?

Studies indicate that CAFOs disrupt the quality of life for neighboring residents. The rural lifestyle, which has always prized outdoor activities and visits from friends and family, is threatened when homeowners need to protect themselves from the air and manure coming from the CAFO. Social capital declines, and deep-seated rifts often arise between CAFOs and their neighbors.[18,19]

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ECONOMIC IMPACT

Prior to their construction, CAFOs are often promoted locally through claims that they will bring economic vitality to the area. However, the research conducted after operations begin indicates otherwise. The evidence shows a loss of jobs, depressed property values, loss of income for local businesses, and a huge drain on county resources resulting from CAFOs

coming into a rural area. A significant cost to counties lies in the road and bridge upgrades and repairs necessitated by hog and manure transport traffic.

Do factory farms bring jobs?

A farmer who contracts with a corporation to build and operate a CAFO actually ends up being more like a facilities manager than a farmer. Instead of being independent entrepreneurs, many hog farmers are now contract growers. Every CAFO worker replaces nearly three independent family farmers.[20] CAFO crews are often made up of itinerant workers who spend little money in the communities where they work. A Congressional Research Report also found that communities with industrial animal facilities had higher unemployment rates.[21]

Studies show that independent family farmers offer far more benefits to rural communities: 10% more permanent jobs, 20% more local retail sales, and a 30% increase in per capita income.[22]

The evidence shows a loss of jobs, depressed property values, loss of income for local businesses, and a huge drain on county resources resulting from CAFOs coming into a rural area.

Do hog confinements generate additional county tax revenue?

CAFOs actually appear to place a burden on county governments. Proximity to a CAFO can reduce the value of a home by 40%, an Iowa study found.[23] This loss in value affects tax assessments and therefore county tax revenues.

In addition, the confinements do not pay for the damage they cause to county roads and infrastructure — or for health costs, accidents, and environmental monitoring. One Iowa community estimated that costs for gravel-road upkeep increased about 40% due to truck traffic to industrial hog confinements. The annual estimated cost of local road upkeep around a 20,000 hog confinement is $6,447 per mile due to truck traffic.[24]

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CAFOs are also eligible for tax write-offs that can decrease the amounts of taxes paid locally.[25]

Will a CAFO increase economic development in my county?

Unlikely. Large corporate agribusiness giants are vertically integrated, traditionally owning the hogs from before birth to post-market. These companies often contract with meatpacking plants to take the hogs (sometimes they own both the hogs and the packing plant), effectively shutting out the small family farmer from earning a living. Partly in response to this shift in production, the number of independent small farmers has decreased dramatically in the last two decades.[26]

CAFO operations with gross incomes in excess of $900,000 spend less than 20% locally, while farms with incomes under $100,000 spend 95% locally.[27]

Because of the undesirable aspects of living close to CAFOs, including the odor, exposure

to toxins, and polluted groundwater, hog confinements effectively *preclude* new businesses from relocating to a county. Studies have indicated that concentration and industrialization of agriculture have been associated with economic decline, both locally and regionally.[28]

The cost of cleaning up the air and water pollution caused by CAFOs rests on local taxpayers, not on the CAFO, thereby increasing its costs locally. Essentially, local economies seem to subsidize the operations of CAFOs and their large out-of-state corporations.

ENVIRONMENTAL IMPACT

Are CAFOs harming the environment?

Manure spills, leaking pits, spreading during inappropriate climatic conditions, and the overspreading of manure are major threats to Iowa's water sources. According to a report by the Environmental Integrity Project, there were 329 documented manure spills from livestock facilities from 1992 to 2002, killing over 2.6 million fish and contaminating groundwater.[29]

In 1995, in the biggest environmental spill in U.S. history — more than twice as big as the Exxon Valdez oil spill — a 120,000 square foot manure lagoon in North Carolina ruptured, releasing 25.8 million gallons of effluvium into the New River. Every living creature in the river died, including fish by the millions.[30]

Researchers at the Centers for Disease Control and Prevention said contaminants including pathogens, metals, antibiotics, bacteria, nitrates (cancer-causing agents), and parasites were found in manure lagoons and surrounding wells, drainage ditches, and underground water.[31]

Tetracycline-resistant genes have been found in lagoons and groundwater underlying swine CAFOs; also, 25%–75% of antimicrobials given to CAFO livestock pass unchanged into manure waste and may contaminate soil and water.[32]

Millions of fish have been killed and drinking wells have been contaminated in the over 140 manure spills reported in Iowa and three surrounding states in the past two years.

77% of all Iowans want to buy humanely raised, environmentally soundly produced pork.

What is the future for CAFOs?

Some researchers see a shift taking place away from industrial agriculture and back to family farms:

- A consumer trend toward natural, organic, and locally grown food is stimulating a resurgence of small family farms.
- The markets for sustainable/local meats and milk are the fastest growing sectors of the meat and dairy markets.
- A poll by the Humane Society of the United States found that 77% of all Iowans want to buy humanely raised, environmentally soundly produced pork.[33]

In light of the hazardous health problems pertaining to CAFOs, the influence of environmental and economic concerns, and the increasing reluctance of workers to spend time in a CAFO, it seems prudent to examine other ways to raise livestock.

Indeed, studies at Iowa State University have shown that hogs can be produced in hoop houses just as efficiently as in CAFOs.[34]

Most CAFO hogs in Jefferson County are not owned by county farmers.

From 1980 to 2003, the ten to fifteen counties in Iowa with the largest reduction in population were also counties with the largest number of hog confinements.

CAFO SITUATION IN JEFFERSON COUNTY

How many hogs live in Jefferson County?

Currently 34 CAFOs are located in Jefferson County, with most of these containing just under 2,500 hogs. A conservative estimate brings the total hog count in the county to about 60,000.

According to Jim Rubis, former head librarian at Fairfield Public Library and president of Jefferson County Farmers and Neighbors (JFAN), since 1980 the number of hogs in the state has remained stable while the number of producers has dropped sharply — significantly fewer people are involved in the livestock industry. As the CAFO industry has centralized, more control has been held outside the county; for instance, most CAFO hogs in Jefferson County are not owned by county farmers.

How have CAFOs affected nearby counties?

From 1980 to 2003, the ten to fifteen counties in Iowa with the largest reduction in population were also counties with the largest number of hog confinements. As CAFOs have proliferated, counties have been negatively impacted; not only has a positive economic impact been missing, but illness and social discord have been common.

Davis County in particular has noticed an impact. In Davis County, directly southwest of Jefferson County, the hog population has grown in the last decade from about 10,000 head to about 150,000–200,000 head. In addition to noxious odors affecting citizens living close to CAFOS, the factory farm proliferation has caused social disruption, as some residents have experienced that once amicable neighbors and cooperating farmers have turned against one another over issues stemming from CAFOs.[35]

Washington County, Jefferson's neighbor to the northeast, now has over 500,000 hogs.

What do Iowa laws have to say regarding CAFOs?

Lobbying efforts by the pork industry over the last two decades have had an impact on legislation, and state laws are now in effect that prevent counties from regulating local agriculture — including hog production.

In 1995, for example, the Iowa legislature passed House File 519, which prohibited local control over any land zoned for agriculture. Consequently, counties and local areas no longer have input over whether or where a CAFO is built.

A poll published by the *Des Moines Register* on February 5, 2007, indicated that 64% of Iowans now want more of a voice in how livestock operations are sited in their counties.

In November 2006, research scientists at the University of Iowa and the University of North Carolina called for a moratorium on livestock confinement construction and called for local control legislation. Minnesota, the third largest pork producer in the nation, and Missouri both have local control legislation in place, which has not negatively impacted hog revenues.

At the same time, the Department of Natural Resources (DNR) has seen a challenge to its power to regulate CAFOs. Bills have been introduced (none have passed) in the past year to minimize the DNR's regulatory power over factory farms.

At this point, a SAFO (Small Animal Feeding Operation) with fewer than 1,250 hogs could be built within the city limits of Fairfield with very few regulations, and manure from a confinement could be applied right up to the city limits. A CAFO housing between 1,250 and 2,499 hogs could be built 1,875 feet from the city.

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What recent CAFO-related activities have affected Jefferson County?

- A proposed 5,900-head sow confinement in Batavia, which would create 6 million gallons of toxic manure a year, seems to be permanently stalled. Citizen action helped forestall the construction: Batavia homeowners and farmers were given a grant by Jefferson County Farmers and Neighbors (JFAN) to assist them in legally protecting their homes from the impact of this CAFO. This sow confinement could also have affected the county's waterways, particularly Cedar Creek, which runs northwest to southeast in Jefferson County.
- In a rare decision, a 4,300-sow facility proposed for Farson, just across the line from northwest Jefferson County, was denied a permit by the DNR because of a weak manure-management plan.
- In February 2006, landowners who had proposed a CAFO on Pleasant Plain Road across from the new Cambridge Investment Research building decided not to build, after lengthy legal discussion with opponents.
- In May 2006, the Pleasant Plain Property Association filed a lawsuit against a confinement proposed near Pleasant Plain Road and 167th Street.
- As of February 2007, six 4,800-unit CAFOs have been proposed for construction near

Martinsburg in Keokuk County, which is just over the border from Jefferson County. Two of these have already secured permits. (For five to six CAFOs of this size, nearly 5,000 acres are needed for manure application.)

- In addition to the odor nuisance, Jefferson County could be affected if the CAFO operators arrange to have manure from these facilities applied to Jefferson County farms. (Many farmers are eager to receive the free manure and use it as fertilizer, which significantly reduces their corn production costs.)

A record number of requests for CAFO permits were filed in 2006, catapulting the CAFO issue to the forefront of recent political elections.

What are the key strategies currently being pursued in the CAFO debate?

Key strategies include communicating with local government officials about CAFO concerns and the desire for local control; holding discussions with farmers or individuals who may be planning to erect a CAFO nearby (and pursuing litigation if necessary); and following the Good Neighbor Guidelines outlined by JFAN to promote openness between farmers and residents in working out logistics concerning confinement facilities.

A record number of requests for CAFO permits were filed in 2006, catapulting the CAFO issue to the forefront of recent political elections.

Various organizations have arisen across the state, on a grassroots level, to monitor the spread of CAFOs.

ALTERNATIVES TO FACTORY FARMS

Is there a less harmful yet viable way for Iowa farmers to produce hogs?

Iowa can raise hogs profitably, sustainably, and humanely without incurring the costs that now burden county governments.

It is important to realize that Iowa can raise hogs profitably, sustainably, and humanely without incurring the costs that now burden county governments. Iowa has over 1,000 hoop structures that raise hogs on deep-bedded straw without resorting to inhumane confinement, industrial manure disposal, and tax breaks.

Iowa independent hog producers also raise hogs for natural livestock producers such as Niman Ranch, Organic Valley, Patchwork Farms, Eden Pork, and a number of other "alternative" and "niche market" hog brands. With the consumer trend toward natural and organic foods, farmers can see a profit while employing sustainable practices that have minimal negative environmental impact.

Another option is the creation of small farm cooperatives or regional coops, such as Country Natural Beef of Oregon and Good Natured Family Farms of Kansas. Diversification

— having three or four income-producing enterprises stemming from the same farm — is another practical way to protect against a fluctuating hog market.[36]

As noted earlier, a Humane Society of the United States poll found that 77% of all Iowans want to buy humanely raised, environmentally soundly produced pork.

Iowa has always been a key center of agriculture for the country. Perhaps it is now appropriate for the state, situated in the middle of the trend toward high-tech agriculture, to begin to seek alternatives in farming so that a sustainable solution can be reached, one that nourishes everyone over the long term — the farmer, local residents, consumers, and the earth.

CONCLUSION: PUTTING CAFOs IN PERSPECTIVE

Pigs were once viewed positively in Iowa, a key piece of the bucolic, rural farm life. With the monopoly of confinement facilities, raising hogs now ranks very low on the list of desirable rural developments.[37]

Kendall Thu, Ph.D., of Northern Illinois University, who specializes in food systems and their relationship to the health of rural communities, presented this summation of confinement operations for livestock:

> This industrialized form of agriculture tends to become disarticulated from surrounding communities, resulting in social inequities, poverty and a range of attendant social, economic and environmental pathologies. . . . A whole generation of research has demonstrated that it is simply better for the social and economic fabric of rural communities to have more farmers providing food than to have production concentrated in the hands of a few.[38]

"A whole generation of research has demonstrated that it is simply better for the social and economic fabric of rural communities to have more farmers providing food than to have production concentrated in the hands of a few."
— Kendall Thu, Ph.D., Northern Illinois University

Iowa has always been a key center of agriculture for the country. Perhaps it is now appropriate for the state, situated in the middle of the trend toward high-tech agriculture, to begin to seek alternatives in farming so that a sustainable solution can be reached, one that nourishes everyone over the long term — the farmer, local residents, consumers, and the earth.

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Large Scale, Corporate Hog Operations:
Why rural communities are concerned and what they should do

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I was recently asked by a rural advocacy group in Missouri to list some logical reasons why rural community leaders should be concerned about the impacts of livestock factories on their communities? I considered this to be a reasonable request and thus developed a list of reasons why I think rural residents should question whether or not they want large-scale, corporate hog farms to locate in their communities. Those reasons seem to make a logical starting point for a paper concerning why rural communities are concerned about large-scale corporate hog operations and what they should do about them.

As I indicate in my response to that request, there is no scientific consensus on this issue. Thus, there is no set of scientific "facts" to either prove or disprove the validity of these concerns. Research exists to support many of the concerns on my list, even though they cannot be proven. However, most of the concerns on the list are based primarily on logical reasoning and common sense. Some may dismiss these "logical" concerns as illogical, uninformed, or inconsequential. But, such assessments simply represent differences in "beliefs," not proven facts or some unique knowledge of reality. The people of rural communities have a right and responsibility to weigh the evidence and logic on both sides of this issue and to make their own decisions.

Top ten reasons for rural communities to be concerned about large-scale, CAFOs

A "top ten list" wasn't chosen just to be cute or catchy. Ten is enough to get the point across, but not so many as to overdo discussion of the issue. Also, I wanted to start at the bottom of my list and work my way to the top.

Concern #10. Hogs stink

Odor is at the top of the list for many opponents of large-scale hog farms. The most vocal opponents tend to be those affected most directly – those who wake up most days to the smell of hog manure. To a hog producer, hog manure may "smell like money," but to the neighbors, it just "smells like hog manure." There are legitimate human health concerns associated with air quality surrounding large hog operations. Thus, the odor problem goes beyond the very real nuisance of living with stench in the air. Odors associated with giant hog farms affect the lives of people for "miles around," not just those on adjoining farms. Few would be willing to stay in, or move into, such a community if they have an opportunity to locate elsewhere. Odor ranks only 10 on my list because something could possibly be done to mitigate its impacts, such as using odor-reducing technologies, compensating those most affected and locating facilities so as to minimize impacts of the greater community.

Concern #9. The work is not healthy for people

A large confinement hog facility is not a pleasant place to work. Known health risks are associated with continuously breathing air that arises from manure pits in confinement hog facilities. Health problems cost money in lost wages and health care costs. But more important, an unhealthy workplace can destroy peoples' lives. History has proven that people will choose to work in dangerous work environments when they are desperate for jobs. Health risks can be life threatening, so I rank worker safety above odor problems. But as in the case of odor, health problems can be mitigated by protecting workers from the noxious fumes, by limiting exposure, and by keeping people with other health problems out of confinement facilities.

Concern #8. Piling up too much "stuff" in one-place causes problems

If you spread out the hogs and let hog manure lay where it falls in a pasture, it doesn't bother anyone very much. But if you start collecting it, flushing it, spreading and spraying it around – all normal practices in confinement hog operations – it becomes air pollution. Water pollution also is a symptom of the same basic problem -- too much manure in one place. The difference between the hog lagoon spills, such as those in Missouri and North Carolina, and the normal runoff from a hog pasture is a simple matter of concentration. When you put a lot of hogs in the same place, you have to collect and store the waste. If it gets into the ground

water or gets flushed into streams, it kills fish, clogs streams and lakes with algae, feeds water born disease organism, and wreaks havoc in the environment.

In addition, manure on diversified hog farms normally is spread back onto cropland where the feed grain was grown. Most of the nutrients used to grow the crops are returned to the soil. But, when feed grains from specialized crop farms are shipped to distant hog-factories, the nation's future productive capacity is being stacked up and flushed out into places where crops can't grow. We can treat the symptoms – air pollution and water pollution – but the basic problem of piling up too much stuff is inherent within the system of large-scale, concentrated production.

Concern #7. Consumers have little if anything to gain

Large-scale, corporate hog production is frequently justified to the general public as a more efficient, lower cost, means of producing higher quality pork. The facts of the situation simply do not support such a claim. The average consumer spends just over 10 percent, a dime out of each dollar, of their disposable income for food. About 10 percent, a penny out of the dime, is spent for pork. The costs of live hogs make up only about 35 percent of that penny. The rest goes for processing, packaging, advertising, transportation, and other marketing costs.

Farm record data have shown that costs of large-scale hog operations are only slightly lower than costs of "average" commercial hog producers. Even if production costs were five percent less, about $2/cwt of live hog; the "maximum" savings to consumers would be less than two cents per dollar spent for pork at retail. At best, total food costs would be two-tenths of one percent less and consumers on average would spend only "two-one-hundredths of one percent" less of their income for food. Any savings would be lost in rounding error in consumer food cost statistics. With a handful of large hog producers and packers gaining control of the industry, it seems far more likely that in the long run pork prices would go up rather than down as a consequence of further industrialization.

The argument that factory pork would be higher in quality doesn't hold either. Pork would be more uniform because it would all come from the same basic genetic stock, as is currently the case with chickens. However, consumers have different tastes and preferences – different perceptions of quality. Making all pork "the same" would not necessarily please more consumers. Greater profit for producers and processors, not lower costs or higher quality, is the driving force behind the current trend toward industrial hog production. The only ones who really need to shave another penny or two off production costs are those who are trying to export more pork into highly competitive world markets. That doesn't include many hog farmers or pork consumers. So, why should the general public support industrial hog production?

Concern #6. Continuing regulatory problems are inevitable

Without regulations, big hog operations will impose costs on their neighbors – air pollution, water pollution, and others -- that are not part of the historic costs of producing hogs. It will cost money for hog factories to deal with "externalities" such as air and water pollution. No "bottom-line" driven hog operation will incur those costs unless they are forced to do so by government regulations – federal, state, or local.

Family farmers are people with human feelings and values, and most feel some sense of responsibility to their communities and the environment. Family farmers at least have personal incentives to be stewards of the environment and good neighbors, regardless of how they choose to behave. Public corporations have no such incentives. They are not people. Corporations have no heart or soul. Stockholders often are so detached from their investments they don't know or care what stocks they own – just as long as they make money. Local managers and workers may be good people who really care about the community, but when it comes to keeping their job, they must put profits and growth ahead of community. Professed corporate support of local communities, by necessity, can be nothing more than another strategy for profit and growth. Thus, government regulation and continual conflict are an inherent fact of corporate life.

Concern #5. Hog factories destroy public confidence in agriculture

Over the decades, family farmers have built up a vast treasure of public confidence and good will. Many people in the cities either grew up on farms or have parents or other close relatives whom either now are or once were family farmers. The "farm family" conjured up images of people who are hard working, moral, honest, solid,

dependable, trustworthy, caring, and responsible. These images have been a valuable source of wealth for farmers – although not widely recognized as such.

Farmers have been awarded special privileges, exemptions, and variances under a whole host of public policies -- from taxation to environmental regulations -- because they were trusted to behave in the public interest. Support of "family farms" has been an important part of the rhetoric of every farm bill that has passed congress. Farmers have also enjoyed a special status "as people," apart from any monetary benefits. They have been respected and trusted. However, bad publicity surrounding large-scale, corporate hog production is using up the farmer's stock of public confidence and good will at an alarming rate. Negative stories have appeared on every major television network over the past few years. When Ms. Magazine runs a feature article on the ills of corporate hog farming, as they did in 1997, we can conclude that the story has just about made the full circuit of public opinion shapers. Family farms will be paying for this loss of public trust for decades, if not forever.

Concern #4. Future of the community is turned over to outside interests.

Rural people need to take charge of their own destinies if they expect to sustain a desirable quality of community life for themselves, their children, and future generations of rural Americans. Quality of life is about much more than just creating more jobs and making more money. Quality of life is also about positive moral and social values and being responsible caretakers of the community as a place. Sure, people need jobs and need to make a decent living. But, jobs and high wages didn't save the cities from decline and decay and jobs won't save rural communities either. When an apparent solution to a problem comes from someone else, from outside, you can just about bet that the benefits will be going to someone else from outside as well.

Some rich and powerful outsiders have their own problems, and they have their eyes on rural communities as places to solve them. Sparse population, trusting people, and lack of jobs in rural areas are seen as ideal opportunities. They are looking for someplace to "dump stuff." An Industrial society creates a lot of "trash," whether in the form of garbage, toxic chemicals, or hog manure. Most "outsiders" promoting rural development schemes have something they need to "dump." Jobs just aren't enough compensation for turning a community into a "dump." Rural people need to take control of their own destiny and build the kinds of communities in which their children and their children's children will choose to live and grow. The solutions to the problems of rural Americans are in the hands, hearts, and minds of rural people themselves, not in outside investment and corporate control.

Concern #3. The decision making process can rip communities apart

The process of decision making may be more important than the decision itself. Anyone who has been a part of a family has experienced this first hand. The memory of an act that triggered a family feud has long since faded, but the feud goes on. Feuds result from a loss of confidence and trust, regardless of the context within which the loss takes place. The large-scale, corporate hog farm issue is one of the most contentious issues to confront rural America in recent history.

The social fabric of rural communities has been ripped apart by controversy surrounding the introduction of large-scale, corporate hog operations. There seems to be no middle ground. Some people seem determined to bring in the big hog operations, by almost any means, and others seem just as committed to keep them out, by almost any means. Almost everyone eventually seems to feel obligated to take sides. The larger question in such communities is not whether the hog factories come in or stay out, but can the community ever heal the wound left by the fight?

A healthy, unified community can deal with almost any problem, including a large-scale corporate hog farm on the outskirts of town. A sick, bitterly divided community is incapable of much more than survival, regardless of its other advantages and opportunities. The future of rural America depends on communities of people being able to work together for their common good. The divisiveness of the decision making process, presumably, could be avoided. But, the consequences of failing to do so are so destructive that it ranks near the top of my list.

Concern #2. Hog factories degrade the productive capacities of rural people

Factories "use up" people. Assembly line work is "non-thinking" work. When you work on an assembly line, you simply do what you are told as fast as you can for as long as you can. I know. I have been there. Large-scale hog operations may not be assembly lines, but the principle is the same. Big hog operators do not want people who know anything about raising hogs. They want people who can be trained to do what they are told to do without thinking. An experienced hog farmer might start thinking, asking questions, and mess up their process. Hog factories, like other factories, are looking for people who are dependable, who know how to carry out orders, and will work hard for a little money.

On balance, large-scale, industrial hog operations destroy more jobs than they create. A driving force behind industrialization is to substitute capital and technology for labor and management – to make it possible for fewer people to produce more. Large-scale hog operations concentrate the jobs created in one place and call it economic development. The jobs lost elsewhere are ignored or denied. The numbers of independent hog farmers displaced elsewhere will be greater than the number of jobs created in new large scale hog operations. Hog factories replace more independent hog farmers with fewer assembly line workers.

Other kinds of factories have come to rural America in the past. When these factories have found people in other regions, or in other countries, who would work even harder for less, they moved on. Corporately owned factories have no roots. They leave behind a workforce that doesn't know how to do anything other than what they are told. Intelligent, thinking, capable, independent people are transformed into detached, non-thinking people who may be psychologically incapable of earning a living without depending on someone else to tell them what to do. Our cities currently are plagued with such people -- people whose capacities have been degraded by factories long since gone. It just doesn't seem to make sense to do the same thing to rural people. When we replace independent, family hog farmers with hog factories we are degrading the most valuable resource rural areas have to support future development – rural people.

Concern #1. Tomorrow's problems are disguised as today's solution

My number one concern regarding large-scale, corporate hog operations is that rural communities will see them as "the solution" to today's problems without seeing them as a potential "source" of problems for tomorrow. Maybe there are some communities so desperate for jobs that it makes sense to take the risks. Maybe they feel they have to do something today to give them a chance to do something better tomorrow. But, hog factories are a short-run solution, at best, that may create more long run problems than they solve today. Low-wage, assembly-line-like jobs should be viewed as a stop gap strategy suitable only for communities with no other options. Sooner or later non-thinking jobs will be done somewhere else on the globe, where people will work harder for less money and are accustomed to doing whatever they are told – by those who have no other options. In the longer run, all non-thinking jobs will be done using computers and robots – not by people anywhere.

The real opportunities for people to lead successful lives in the future will be in "thinking" work. The human mind is uniquely capable of complex thought. Almost anyone is "smarter" than a computer. But, people need to develop their unique human abilities to think. We need to accept the responsibility for thinking and for creating thinking jobs for ourselves and for others. As long as rural people think their problems are solved, or will be solved by someone else, they see no incentive to begin doing the things they need to do to ensure the future of their community.

The primary advantages for rural areas in the twenty-first century will be the unique qualities of life associated with open spaces, clean air, clean water, scenic landscapes, and communities of energetic, thinking, caring people. Communities that sacrifice these long run advantages for short run economic gains may have a difficult time surviving in the new century.

Thus, my number one concern is that large-scale, corporate hog operations are tomorrow's problem disguised as today's solution. They may keep rural people from doing the things that need to be done today to ensure the future of their communities. Large-scale, corporate hog operations will not create communities where our children and their children will choose to live and grow. Communities with a future must take positive actions today to ensure a desirable quality of life for themselves, their children, and rural children of future generations.

Why Do Rural Communities Accept Confinement Animal Feeding Operations?

Admittedly, there are reasonable arguments that can be used to support bringing large-scale confinement animal feeding operations (CAFOs) into a rural community. Community leaders who support such operations typically argue that people in their community:

- Need jobs in to replace those lost to globalization,
- Need a higher tax base to provide rural services,
- Need to bolster their declining agricultural economy,
- Know that other communities will accept these operations if they don't,
- Feel that they can't stand in the way of progress,
- Believe big operations can better afford modern pollution prevention technologies,
- Feel that local opposition is just another case of "not in my backyard," thinking.

There are logical responses to each of these arguments, but each also contains elements of truth. One thing nearly all pro-CAFO arguments have in common is their foundation in short-run, self-interest economics. They are based on a deeply held faith that the market place is the best means of allocating resources – whether it is allocation of people among alternative occupations, land among alternative uses, money among investments, or people among communities. Those things possible and profitable shall be done. People have a right to protect themselves and their property from damage caused by others, but beyond that, the economics of the marketplace shall prevail. A community is nothing more than a collection of individuals that happen to be located in geographic proximity to each other. These are typical assumptions of self-interest economics.

After all, corporate investors are putting their money into CAFOs because they expect to make profits. Investments create jobs and enhance the local tax base. If CAFOs are more cost efficient than smaller farming operations, even if marginally so, traditional family farmers will inevitably be forced out of business -- so the argument goes. Why not give local farmers a chance to go to work for a profitable agricultural corporation? We know these Corporations are going to invest somewhere, so it might as well be here. There are always costs associated with anything that generates benefits. The opponents just want someone else to bear those costs.

They reason that if environmental problems arise, it will be easier to work them out with a few large operations than many small ones. The big operations have the money to invest in the modern waste handling facilities that ultimately will be required of everyone. The technology is available, it's profitable, so it's both futile and foolish to stand in the way of economic progress. The people who are opposed to these operations are accused of being out of touch with economic reality. Opponents of CAFOs are labeled as Luddites – as people who oppose progress or just want to keep things as they are.

If self-interest economics prevail, there is every reason to believe that CAFOs eventually will totally dominate animal agriculture in America. And, corporations will locate CAFOs pretty much wherever they choose, regardless of the ecological and social consequences. They will avoid locating them in heavily populated areas to minimize nuisance law suites. But, money invested in CAFOs will seek its place of highest return. The only way to successfully challenge this outcome it to challenge its basic premise – the right of private profits to prevail over public good – and to uphold the rights of people to prevail over the pursuit of profits in protecting their communities and shaping their destinies.

Sustainability: The Challenge to Land Use Economics

Current land use decisions in the United States, including location of large hog operations, have their foundation in economic theory as it relates to the concept of private property. Persons who hold ownership rights to property may do with it pretty much as they see fit, including exchange ownership rights with others, as long as it does not interfere with the private property rights of others. Any restrictions on individual land use are limited to uses that might affect the use rights held by other individuals.

With relatively minor exceptions, land use decisions are determined by the economics of the market place. Provisions are made through laws of eminent domain to acquire private property for public use, without the consent of owners, but not without just economic compensation to current landowners. Land uses of a criminal nature, deemed to be of clear public harm, may be restricted without compensation. Land use zoning may restrict land use as well. But in reality, economic considerations commonly dominate planning and zoning decisions. The question becomes, how can economic development be maximized with the minimum negative

impact on community residents. Requests for changes in zoning are typically motivated by a desire to put land to a higher economic use. Opposition to changes typically is motivated by the desire to protect private property rights. It is a rare community that uses the tools of planning and zoning to ensure the long run ecological and social well being of the community as a whole.

So, with minor exceptions, private property may be put to its highest economic use. The concept of highest economic use gives legitimacy to competing private property rights, but commonly ignores or denies any right of the community, or public as a whole, to participate in all land use decisions. Economic theory treats a community as a collection of individuals, not as an entity with rights separate from, or in addition to, those of individuals of which the community is composed. In addition, conventional economics gives no consideration to potential ownership rights of future generations. Rights of intergenerational transfer of ownership are based on the premise that to prohibit or limit such transfers would unjustly restrict current private property rights. Free market economics makes no provision for future generations, other than those reflected in the self-interests of current decision-makers. And economics drives land use decisions.

The question of long run sustainability presents a serious challenge to conventional economic thought as the foundation for land use decisions. Over the past decade, many different people have defined sustainable development, of which sustainable agriculture is but one part, in many ways. However, the underlying theme of nearly all such definitions is one of intergenerational equity – a responsibility to meet the needs of the current generation while leaving equal or better opportunities of those of all generations to follow. In more common language, sustainability development applies the Golden Rule across generations – doing for future generations as we would have them do for us.

The three cornerstones of sustainability are ecological soundness, economic viability, and social justice. The three are not separate goals or objectives, but instead are three separate dimensions of the same whole -- as with the three dimensions of a box; height, length, and width. Any object lacking any one of those three dimensions quite simply is not a box. Any system of development that is not ecologically sound *and* economically viable *and* socially just quite simply is not sustainable over time. All are necessary and none alone or any pair is sufficient to ensure sustainability.

Thus, sustainability requires that we look beyond the economics of short-run, self-interest to the broader set of issues affecting quality of life or human well being over time. Sustainability requires that we broaden our economic thinking to consider the long run health and productivity of the natural ecosystem, not just the optimum means by which it may be exploited for our short-run gratification. Sustainability requires that we broaden our economic thinking to consider the well being of the community, or society, as a whole, not just sum the welfare of individuals who make up a community or society. The economics of self-interest is an important dimensions of sustainability, but it is but one among three. Things ecological, social, and economic must be considered as complementing dimensions of the same whole, not as competing objectives that can be pursued separately.

Economic Implications for Sustainable Land Use

The following is a short discourse on the economics of land use under conventional and sustainable economic assumptions. For some readers, this discussion will be unnecessary, and they may feel free to skip to the next section. It is included for the benefit of those who might be skeptical regarding whether or not the conclusions of this paper are based on sound economic logic. They are.

From a short-run economic perspective, production from a given piece of land should continue to be increased as long as the value of additional production exceeds the added cost of creating that production. Land is considered as a *fixed* economic resource -- its quantity cannot be increased -- and all other inputs such as hogs, feed, and labor are considered to be *variable* – more or less may be used on a given piece of land. The fundamental economic question is; " what quantity of variable inputs should be applied to a given amount of fixed resource?" In terms of hog production, the answer is: the number of hogs or size of production unit, and the number of production units in a given area, should be increased as long as the value of adding one more hog or production unit exceeds their addition to costs.

The economic optimum scale of hog production has increased dramatically over the past few years. New production technologies have allowed hog producers to avoid many of the previous problems of large-scale production – such as disease and labor problems. Changes in the food system have created opportunities for

profitable integration of production and marketing activities – favoring large-scale, corporate hog operations over individually owned family farms. Thus, the costs associated with larger scale production have declined and the returns from large-scale, corporate production have increased. There is little doubt that the dramatic increase in large-scale CAFOs has been driven by economics – by corporate greed and the pursuit of profit. However the economic arguments that support CAFOs are valid only from the perspective of economics of short-run, self-interest.

The conclusions are totally different if we instead take a long run, sustainable economics perspective of land use questions associated with large-scale hog operations. In the long run nearly all the agricultural inputs that are *variable* in the short run are *fixed*. For example, fossil fuels, fertilizers and pesticides for feed production, machinery, and many building materials are all derived from finite, non-renewable stocks of natural resources. Thus, their long-run supply is *fixed*, even though their short run use may be *variable*.

In the long run, our only truly *variable* resource is solar energy. Living organisms, including people, represent renewable resources, but living organisms are dependent on finite natural resources as well as solar energy. Every productive resource on earth can realistically be depleted over some finite period of time. But, the continuing supply of energy from the sun is expected to continue for billions of years into the future.

Geographic space is required to capture solar energy, at least for agricultural use. Land represents space. Thus, land – as space – serves as a proxy for solar energy, the only long run, *variable* resource. Of course, land has characteristics other than space – such as organic matter, texture, and water holding capacity – which may influence its productivity and value. But, these non-spatial aspects of land are finite, and thus, may be depleted over time. Land as space, while fixed in total at any point in time, represents a virtually infinite supply of solar energy that may be utilized in varying quantities over time, and thus, represents a *variable* long run resource.

Ironically, those things that are variable in the short run are fixed over the long run, and the one thing most fixed in the short run, space, represents the only variable long run resource. As we should expected, things that appear to be optimum from a short run perspective are far from optimum when one takes a long run perspective.

Solar energy in not only variable – it is also *free*. The sun is the only resource that we don't have to pay for, by one means of another. Thus, in the long run, land – as space – must be considered as *free*. Economics dictates that we maximize production from free resources if we are to maximize profits. When space is considered to be free, the profit maximizing use of all non-renewable inputs will be at the point of their minimum cost per unit of production. In hog production the optimum would be at the point of maximum production per pound of feed or per hour of labor, not maximum profit from a production unit or for a given corporation.

Maximum production *per unit* of non-renewable input will result in maximum *total* production from a given quantity of input over time – and maximum contribution to sustainable production. If land, as space, is allowed to take on a positive market value, less land will be used relative to other production inputs – feed, labor, capital, and equipment – resulting in these non-renewable inputs being used up at faster than optimal long run rates. This conclusion is quite different from conventional short-run economics which treats land as a marketable commodity and focuses on maximizing profits for the firm or corporation, rather than maximizing long run benefits to the community or society.

<u>Implications for CAFOs in Rural Communities</u>

So what does all this mean for confinement animal feeding operations in rural communities? It means if short run economics is allowed to prevail, concentration of hogs in a given area will increased as long as each additional unit of production – increase in size or number of CAFOs –adds more to total value of production than it adds to total costs. But, it also means if rural communities want to *sustain* development over the long run they cannot allow short-run economic self-interest to prevail.

Eventually, the size of CAFOs may be limited by rising costs. For very large operations, costs of production may eventually rise because feed and other inputs have to be shipped in and products shipped out from and to increasingly distant locations. But in reality, something other than economic scale of production typically limits the size and number of CAFOs in a given area. Costs associated with such things as foul odors, water pollution, worker health, displaced farmers, degradation of human potential, and destruction of communities are

all considered to be "externalities," if considered at all, in short-run, self-interest economics. The limit of size typically is not one of internal economics, but rather one of external pressures.

External costs, by definition, are costs not imposed by the market place. Thus, those who are damaged must impose such costs – through law suites, government regulations, and social pressures from the surrounding community. External costs typically limit the growth of CAFOs within any given area. But, the economics of self-interest provide the constant and relentless motivating force for those who operate CAFOs to do the things that result in law suites, to violate government regulations, and bribe and coerce the community into accepting their presence. CAFOs almost always see opportunities to increase profits if external constraints can be overcome, avoided, or removed.

The existence of externalities cause those who operate CAFOs to choose those areas least willing and able to impose external costs of the corporation, which allows them to operate as near as possible at the short-run, self-interest economic optimum size. The most important spatial requirements for CAFOs at present appear to be space for dispersing foul odors in the air and space for spreading manure on the land. Rural areas are "valued" as dumping grounds for stench and manure – things other people don't want to have around. Thus giant animal feeding factories have consistently located in remote, economically depressed rural areas. It all makes logical short-run, self-interest, economic sense. But, it is all long run, sustainable economic nonsense.

What should rural communities do?

Rural people must become actively involved in shaping the destiny of their communities. They cannot rely on some "invisible hand" of economics to create a positive future. The "invisible hand" has been severely crippled, if not cut off, as an economy made up of small proprietorships has been replaced by an economy dominated by large corporations. Rural people must assert their right put their long run, community interest ahead of the short-run, self-interest of those who invest in and operate CAFOs. Such operations cannot even be justified on economic grounds, when one takes a long-run economic perspective. Nor can the impacts of CAFOs on environmental quality and social justice be tolerated if communities are concerned about their long-run sustainability.

Markets cannot be allowed to allocate the use of land as space. This is the most important conclusion of the foregoing illustration of short run versus long run economics. Markets place positive prices on economic inputs, resources, and products. Those things that are most scarce – that are less available relative to the aggregate desire and ability to posses them – will command the highest market prices. Higher prices both ration the scarce supplies among those who are willing and able to pay and provide an incentive for increased production to reduce the scarcity. But land, as space, cannot be allowed to have a positive price without misallocating its use, and higher land prices quite simply cannot create more space. Land prices guide land use to its highest valued short-run economic alternative – whether for residential developments, hog factories, farming, or wilderness. Those using conventional economic theory have falsely assured us that society will realize the highest total value from a given stock of land by allowing free markets to allocate land use.

Some portion of the total value of land will reflect its inherent productive capacity, whether in agriculture, recreation, or other land-based production processes. That portion of land value can be allocated by market prices. However, much of the value of land represents its value as space -- a geographic place to carry out some activity, or simply as space to be held or controlled. Any market value placed on land as space will cause it to be used too intensively, using too many inputs on too little land, and will deplete resources at a faster than optimum rate. Thus, concern for long run sustainability will require a rethinking of fundamental concepts of private property, specifically of what it means to *own* land.

The first reaction of many will be to rise in defense of "private property rights" – the right to use their land as they see fit. However, when markets are allowed to dictate land use those with less money can easily be deprived of the right to use land as they see fit by those with more money. Those with more money may bid up land prices to the point were current users cannot afford to pay their property taxes or possibly justify not selling out to the highest bidder. The ability of one farmer to use their land may be affected by another's land being purchased by an outside investor – the existence of a large CAFO in a county may bring on regulations that preclude existing hog farmers from further expansion. Farmers who would prefer to be good community citizens and ethical stewards of their land may be forced by competition from outside investors to exploit their community and the their land in order to stay in business. Insisting on unencumbered use of private property

may be far more restrictive on use of private property by local landowners than would their participation in a community-based land-use decision making process.

The concept of private property has never meant the right to do whatever one chooses with the property they own. *Conditional ownership* was always implied, if not always stated. A new condition needed to ensure sustainability is one that denies any right to degrade the land or the surrounding community, just because one owns the right to use their land. Thus, the owner of land cannot possess, and thus cannot convey to another, the right to use land is ways that are inconsistent with long run societal well being. If the community, rather than the individual, makes the ultimate decisions regarding how land is used, land as space will have no market value because there will be no right of alternative use for its owner to convey. Its price will reflect only that portion of its value that is associated with its potential productivity in its current use.

What should rural communities do? They should demand their right to be protected against the economic tyranny of the marketplace by making logical, long run land use decision for their communities. They should refuse to allow the long run economic, ecological and social well being of their communities to be degraded in the pursuit of short-run, economic self-interests. They should demand the right to allocate land use within their community by means other than market prices – and to exceed any set of state or national health and environmental standards to protect the community if necessary.

Traditional remedies such as law suites and environmental regulations will not provide lasting solutions. Traditional remedies are based on the principle of conflicting self-interest, rather than the collective interest of the community as a whole. Law suites, at best, only compensate individuals who are damaged by the actions of another – even in the case of class actions. Environmental regulations invariably reflect some compromise among conflicting individual interests, which settles to some minimum common denominator in a society driven by short-run, self-interest. Communities must find the courage and the means to act as a whole, for the long run well being of the community as a whole, both now and forever. This is not a matter of compromise among conflicts; it is a matter of harmony within.

Communities may use zoning laws to pursue their objectives where they are allowed to do so under current state law. Communities may also use health and environmental regulations to protect the people and the land where such laws at the local level are allowed. In cases where state or national laws prevent a community from protecting itself from exploitation, the laws must be changed. But, all current restraints on CAFOs are only "band aid" treatments for a potentially fatal disease. Those with the greatest economic interests ultimately will prevail. New means must be found for allocating land use that will remove any economic incentive for degrading the land. Land must be treated as a commonly managed natural resource, rather than an economic commodity that can be bought and sold to the highest bidder.

The inherent common property nature of land as space certainly is not a new concept. In 1796 revolutionary writer Thomas Paine, in his paper, Agrarian Justice, pointed out that all land was initially held in common. Thus, the previous removal of land from the commons deprived those of later generations of their common birthright – the right of access to land. Initially, land could only be removed from the commons if as much land and as good of land was left for any others who chose to claim it. Consequently, land taken from the commons had no market value -- by definition, it could not be scarce. A similar argument can be made to support the rights of future generations to as much land as good of land as we have today. And to protect this right, land as space cannot be allowed to have a market value.

Economist, Henry George in his 1879 book, "Progress and Poverty" proposed that all use value of land be taxed away to prevent the pricing of land as a market commodity. A more logical approach today might be devise a policy for capturing any increases in land values attributable to rezoning for higher market valued uses in order to compensate those whose land is rezoned to lower-valued uses. This would remove any economic incentive for current of future owners to rezone land to either higher or lower valued uses, and would make it much easier for the community as a whole to make logical long run land use decisions. A similar capturing of capital gains in land values attributable to growing population demands would remove speculative incentives for land ownership and would generate public funds to sustain and enhance the productivity capacity of land.

Sustainable development ultimately will require that land use decisions be made by means that find harmony among long-run economic, social, and ethical or moral concerns. It makes no more sense to buy and sell the right to *misuse* land than to buy and sell the right to misuse another person. Land, particularly land as space, is a fundamental resource upon which all life depends. It cannot be allowed to belong to anyone individually or to

us in total as a collection of individuals – just as people cannot belong to other people. Land belongs to the earth just as people belong to the earth, to the collective *us* as a whole – inseparable, indivisible, across all generations.

We may logically buy and sell those things that enhance the productivity of land -- for those uses with impacts that fall within the realm of legitimate self-interest. But we cannot allow markets to allocate the use of land as space. We may logically decide some land use issues by a vote of the people -- for those uses with impacts that fall within the realm of the community of interest. But, many uses of land as space have impacts on future generations, and future generations cannot vote. Such land use decisions must reflect our fundamental values concerning the responsibilities of being human. Such issues cannot be resolved by economics or politics, they rest on a fundamental code of ethics or morality. They arise out of a consensus of what is fundamentally right and wrong.

Many issues concerning the natural environment are fundamentally moral or ethical issues. We should not be buying and selling pollution rights, because no individual has the moral right to pollute in the first place, and thus, has no right to sell it. Businesses may argue that society has given them that right, through the political process. But, no society has the right to pollute, so it cannot convey that right to a business or anyone else. Pollution of the environment is fundamentally, morally wrong, the same as it is morally wrong to kill, to steal, or enslave. The environment can assimilate some level of waste, as society can tolerate certain amounts or kinds of killing, stealing, or enslaving. But, those things are still morally and ethically wrong, regardless of the ability of society to survive them. We don't condone or encourage them by allowing people to openly buy or sell the right to enslave another person, nor vote on whether one person should be allowed to kill another for personal reasons. We cannot prevent pollution, but is always morally wrong to degrade the natural environment.

It is also morally wrong for one person to exploit another person for personal, economic gain. The short-run economics of self-interest makes no provision for avoiding such exploitation. Those who have fewer opportunities are forced to do the jobs that others can avoid at wages lower than others would be willing to accept. Pursuit of short-run profit dictates that people be hired to works as hard as they can be made to work at wages as low as they will accept. There is not short run economic incentive for businesses to invest in improving the productive capacity of people if there are already people available who possess the skills and abilities needed. But, communities have a very large stake in maintaining the productive capacities of their members. In essence, a community *is* the collective whole of its people. If we allow the people of our community to be degraded, our community is degraded. If we allow our communities to be degraded, human society will be degraded.

No one has the wisdom to plot a true course toward a sustainable human society. At this point in time, we simply don't know how we can meet the needs of the current generation while leaving equal or better opportunities for those of future generations. But, we are beginning to learn some things that we cannot do. We cannot allow the economics of short-run, self-interest to determine the *use of our land and our people*. We know that the relentless pursuit of profits and growth will degrade both our natural and human resources, and will not leave as much and as good as we have today for those of future generations.

We also know that we cannot allow large, corporate organizations, such as those operating CAFOs, to do whatever they want to do wherever they have the money and/or can buy the votes to do it. Rural America may well be the place where America makes a historic stand for sustainability – just as the cities of the South gave birth to the Civil Rights movement. The first rural community to declare and defend the fundamental moral and ethical right of its people to determine how land is used may be remembered much as Rosa Parks is remembered for refusing to move to the back of the bus in Montgomery.

The most significant long-run social, economic, and cultural impacts of CAFOs on rural communities could well be the beginning of a new revolution -- a revolution that ultimately will discard the outdated paradigm of short-run, self-interest economics for a new paradigm of sustainable economic, ecological, and social development.

What's that Smell? A CAFO Near You

January 2, 2008 by GAVIN OFF Environment & Climate, CAFOs vs. Free Range

But industry leaders say many complaints come from people opposed to factory farming, not because of excessive odor

GREEN CITY - In a place where strangers wave to each other through the passing windshields of their pickups and neighbors tend to their neighbors' crops for no more than a thank you, finding an unwelcome guest in this quiet town might seem unimaginable.

But several families in Green City, a blink-and-you-missed-it town surrounded by farms and wild sunflower fields in Sullivan County, say they've been fighting an obnoxious guest for 13 years.

Some residents have moved.

Others have complained.

Since 2000, the Missouri Department of Natural Resources has received more than 1,700 odor complaints against concentrated animal feeding operations, according to a Missourian analysis of records held by the state agency. Missouri is home to 450 of these operations, including 21 large enough to have their odors regulated.

Residents of Sullivan County in north central Missouri have registered more than one-third of the complaints against the feeding operations, which typically house thousands of animals.

"Hope you had a good Thanksgiving," read a 2004 complaint. "Be glad you're not here this morning. The hog odor would about bring your turkey back to life."

Animal farm odors present the state with one of its most complicated environmental problems, said Leanne Tippett Mosby, deputy division director of the DNR's Division of Environmental Quality.

The state must protect the interest of animal producers, who provide jobs, economic benefits and food for hundreds of residents. Meanwhile, it must also protect the interests of their neighbors, who say farm odors cause health problems and simply make their lives miserable.

"I know it's a political hot potato," said Mark Fohey, vice-chairman of the Missouri Air Conservation Commission. "You can do whatever you want, and you're basically going to piss off one or the other."

Complaints registered

Of the more than 1,700 odor complaints since 2000, residents filed nearly 1,400 of them -- about 80 percent - against Premium Standard Farms, according to the state database of complaints. Premium Standard, a pork-producing heavyweight, operates in five northern Missouri counties.

Small-farm owner Rolf Christen, 53, and his family have filed about 400 complaints against

Premium Standard in 6 1/2 years - the rough equivalent of one every six days.

Christen's home outside Green City sits four miles south of Premium Standard's Green Hills farm and eight miles northwest of Premium Standard's Valley View farm. Combined, they house some 200,000 hogs.

According to statistics from the U.S. Department of Agriculture and the National Resource Conservation Service, 200,000 hogs produce about 650 tons of feces a year.

Winds carry the rotten egg-like smell across town, residents say.

A couple times a week, Christen said, the stench blows across picturesque corn, hay and soybean fields to his small home under towering maple trees.

"People move from the city to the country because of clean air and clean water," Christen said. "Right now we live in the middle of a cesspool."

Christen is one of about 270 Missouri residents mentioned in two ongoing odor nuisance lawsuits against Premium Standard Farms.

"Ill-smelling odors, hazardous substances and/or contaminated wastewater have escaped and continue to escape from the defendant's swine factories onto the plaintiffs' properties and thus have substantially impaired and continue to impair the plaintiff's use and quiet enjoyment of their properties," the lawsuits read.

According to the lawsuits, filed in Jackson County Circuit Court, odors from the feeding operations can cause nausea, vomiting, headaches, breathing difficulties and irritated eyes, noses and throats.

A January report released by the Missouri Department of Health and Senior Services says some studies have shown that odors exacerbate the pre-existing health problems of nearby residents while affecting their overall quality of life.

The U.S. Environmental Protection Agency reported in 1996 that the odors could affect a person's mood and physical well-being.

"To me, that suggests it's something we should be concerned with because as a society we want to protect all our people," said Peter Thorne, professor with the University of Iowa's

Department of Occupational and Environmental Health.

Full Story: http://www.columbiamissourian.com/stories/2008/01/02/whats-smell-neighbors-complain-factory-hog-farms-a/

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By Mayo Clinic Staff

It isn't clear why some people get asthma and others don't, but it's probably due to a combination of environmental and genetic (inherited) factors.

Asthma triggers

Exposure to various irritants and substances that trigger allergies (allergens) can trigger signs and symptoms of asthma. Asthma triggers are different from person to person and can include:

- Airborne allergens, such as pollen, animal dander, mold, cockroaches and dust mites
- Respiratory infections, such as the common cold
- Physical activity (exercise-induced asthma)
- Cold air
- Air pollutants and irritants, such as smoke
- Certain medications, including beta blockers, aspirin, ibuprofen (Advil, Motrin IB, others) and naproxen (Aleve)
- Strong emotions and stress
- Sulfites and preservatives added to some types of foods and beverages, including shrimp, dried fruit, processed potatoes, beer and wine
- Gastroesophageal reflux disease (GERD), a condition in which stomach acids back up into your throat

Symptoms Risk factors

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ENVIRONMENTAL HEALTH

Understanding Concentrated Animal Feeding Operations and Their Impact on Communities

N A L B O H
National Association of Local Boards of Health

Understanding Concentrated Animal Feeding Operations and Their Impact on Communities

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Foreword

The National Association of Local Boards of Health (NALBOH) is pleased to provide *Understanding Concentrated Animal Feeding Operations and Their Impact on Communities* to assist local boards of health who have concerns about concentrated animal feeding operations (CAFOs) or large industrial animal farms in their communities. The Environmental Health Services Branch of the Centers for Disease Control and Prevention (CDC), National Center for Environmental Health (NCEH) encouraged the development of this product and provided technical oversight and financial support. This publication was supported by Cooperative Agreement Number 5U38HM000512. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the CDC.

The mission of NALBOH is to strengthen boards of health, enabling them to promote and protect the health of their communities, through education, technical assistance, and advocacy. Boards of health are responsible for fulfilling three public health core functions: assessment, policy development, and assurance. For a health agency, this includes overseeing and ensuring that there are sufficient resources, effective policies and procedures, partnerships with other organizations and agencies, and regular evaluation of an agency's services.

NALBOH is confident that *Understanding Concentrated Animal Feeding Operations and Their Impact on Communities* will help local board of health members understand their role in developing ways to mitigate potential problems associated with CAFOs. We trust that the information provided in this guide will enable board of health members to develop and sustain monitoring programs, investigate developing policy related to CAFOs, and create partnerships with other local and state agencies and officials to improve the health and well-being of communities everywhere.

A special thanks to Jeffrey Neistadt (NALBOH's Director – Education and Training), NALBOH's Environmental Health subcommittee, and any local board of health members and health department staff who were contacted during the development of this document for their contributions and support.

Introduction

Livestock farming has undergone a significant transformation in the past few decades. Production has shifted from smaller, family-owned farms to large farms that often have corporate contracts. Most meat and dairy products now are produced on large farms with single species buildings or open-air pens (MacDonald & McBride, 2009). Modern farms have also become much more efficient. Since 1960, milk production has doubled, meat production has tripled, and egg production has quadrupled (Pew Commission on Industrial Animal Farm Production, 2009). Improvements to animal breeding, mechanical innovations, and the introduction of specially formulated feeds and animal pharmaceuticals have all increased the efficiency and productivity of animal agriculture. It also takes much less time to raise a fully grown animal. For example, in 1920, a chicken took approximately 16 weeks to reach 2.2 lbs., whereas now they can reach 5 lbs. in 7 weeks (Pew, 2009).

New technologies have allowed farmers to reduce costs, which mean bigger profits on less land and capital. The current agricultural system rewards larger farms with lower costs, which results in greater profit and more incentive to increase farm size.

AFO vs. CAFO

A CAFO is a specific type of large-scale industrial agricultural facility that raises animals, usually at high-density, for the consumption of meat, eggs, or milk. To be considered a CAFO, a farm must first be categorized as an animal feeding operation (AFO). An AFO is a lot or facility where animals are kept confined and fed or maintained for 45 or more days per year, and crops, vegetation, or forage growth are not sustained over a normal growing period (Environmental Protection Agency [EPA], 2009). CAFOs are classified by the type and number of animals they contain, and the way they discharge waste into the water supply. CAFOs are AFOs that contain at least a certain number of animals, or have a number of animals that fall within a range and have waste materials that come into contact with the water supply. This contact can either be through a pipe that carries manure or wastewater to surface water, or by animal contact with surface water that runs through their confined area. (See Appendix A)

History

AFOs were first identified as potential pollutants in the 1972 Clean Water Act. Section 502 identified "feedlots" as "point sources" for pollution along with other industries, such as fertilizer manufacturing. Consequently, a permit program entitled the National Pollutant Discharge Elimination System (NPDES) was created which set effluent limitation guidelines and standards (ELGs) for CAFOs. CAFOs have since been regulated by NPDES or a state equivalent since the mid-1970s. The definitions of what was considered an AFO or CAFO were created by the EPA for the NPDES process in 1976. These regulations remained in effect for more than 25 years, but increases and changes to farm size and production methods required an update to the permit system.

The regulations guiding CAFO permits and operations were revised in 2003. New inclusions in the 2003 regulations were that all CAFOs had to apply for a NPDES permit even if they only discharged in the event of a large storm. Large poultry operations were included in the regulations, regardless of their waste disposal system, and all CAFOs that held a NPDES permit were required to develop and implement a nutrient management plan. These plans had CAFOs identify ways to treat or process waste in a way that maintained nutrient levels at the appropriate amount.

The 2003 CAFO rule was subsequently challenged in court. A Second Circuit Court of Appeals decision required alteration to the CAFO permitting system. In *Water Keeper et al. vs. the EPA*, the court directed the EPA to remove the requirement for all CAFOs to apply for NPDES. Instead, the court required that nutrient management plans be submitted with the permit application, reviewed by officials and the public, and the terms of the plan be incorporated into the permit.

As a result of this court decision, the CAFO rule was again updated. The current final CAFO rule, which was revised in 2008, requires that only CAFOs which discharge or propose to discharge waste apply for permits. The EPA has also provided clarification in the discussion surrounding the rule on how CAFOs should assess whether they discharge or propose to discharge. There is also the opportunity to receive a no discharge certification for CAFOs that do not discharge or propose to discharge. This certification demonstrates that the CAFO is not required to acquire a permit. And while CAFOs were required to create nutrient management plans under the 2003 rule, these plans were now included with permit applications, and had a built-in time period for public review and comment.

Benefits of CAFOs

When properly managed, located, and monitored, CAFOs can provide a low-cost source of meat, milk, and eggs, due to efficient feeding and housing of animals, increased facility size, and animal specialization. When CAFOs are proposed in a local area, it is usually argued that they will enhance the local economy and increase employment. The effects of using local materials, feed, and livestock are argued to ripple throughout the economy, and increased tax expenditures will lead to increase funds for schools and infrastructure.

Environmental Health Effects

The most pressing public health issue associated with CAFOs stems from the amount of manure they produce. CAFO manure contains a variety of potential contaminants. It can contain plant nutrients such as nitrogen and phosphorus, pathogens such as *E. coli*, growth hormones, antibiotics, chemicals used as additives to the manure or to clean equipment, animal blood, silage leachate from corn feed, or copper sulfate used in footbaths for cows.

Depending on the type and number of animals in the farm, manure production can range between 2,800 tons and 1.6 million tons a year (Government Accountability Office [GAO], 2008). Large farms can produce more waste than some U.S. cities—a feeding operation with 800,000 pigs could produce over 1.6 million tons of waste a year. That amount is one and a half times more than the annual sanitary waste produced by the city of Philadelphia, Pennsylvania (GAO, 2008). Annually, it is estimated that livestock animals in the U.S. produce each year somewhere between 3 and 20 times more manure than people in the U.S. produce, or as much as 1.2–1.37 billion tons of waste (EPA, 2005). Though sewage treatment plants are required for human waste, no such treatment facility exists for livestock waste.

While manure is valuable to the farming industry, in quantities this large it becomes problematic. Many farms no longer grow their own feed, so they cannot use all the manure they produce as fertilizer. CAFOs must find a way to manage the amount of manure produced by their animals. Ground application of untreated manure is one of the most common disposal methods due to its low cost. It has limitations, however, such as the inability to apply manure while the ground is frozen. There are also limits as to how many nutrients from manure a land area can handle. Over application of livestock wastes can overload

soil with macronutrients like nitrogen and phosphorous and micronutrients that have been added to animal feed like heavy metals (Burkholder et al., 2007). Other manure management strategies include pumping liquefied manure onto spray fields, trucking it off-site, or storing it until it can be used or treated. Manure can be stored in deep pits under the buildings that hold animals, in clay or concrete pits, treatment lagoons, or holding ponds.

Animal feeding operations are developing in close proximity in some states, and fields where manure is applied have become clustered. When manure is applied too frequently or in too large a quantity to an area, nutrients overwhelm the absorptive capacity of the soil, and either run off or are leached into the groundwater. Storage units can break or become faulty, or rainwater can cause holding lagoons to overflow. While CAFOs are required to have permits that limit the levels of manure discharge, handling the large amounts of manure inevitably causes accidental releases which have the ability to potentially impact humans.

The increased clustering and growth of CAFOs has led to growing environmental problems in many communities. The excess production of manure and problems with storage or manure management can affect ground and surface water quality. Emissions from degrading manure and livestock digestive processes produce air pollutants that often affect ambient air quality in communities surrounding CAFOs. CAFOs can also be the source of greenhouse gases, which contribute to global climate change.

All of the environmental problems with CAFOs have direct impact on human health and welfare for communities that contain large industrial farms. As the following sections demonstrate, human health can suffer because of contaminated air and degraded water quality, or from diseases spread from farms. Quality of life can suffer because of odors or insect vectors surrounding farms, and property values can drop, affecting the financial stability of a community. One study found that 82.8% of those living near and 89.5% of those living far from CAFOs believed that their property values decreased, and 92.2% of those living near and 78.9% of those living far from CAFOs believed the odor from manure was a problem. The study found that real estate values had not dropped and odor infestations were not validated by local governmental staff in the areas. However, the concerns show that CAFOs remain contentious in communities (Schmalzried and Fallon, 2007). CAFOs are an excellent example of how environmental problems can directly impact human and community well-being.

Groundwater

Groundwater can be contaminated by CAFOs through runoff from land application of manure, leaching from manure that has been improperly spread on land, or through leaks or breaks in storage or containment units. The EPA's 2000 National Water Quality Inventory found that 29 states specifically identified animal feeding operations, not just concentrated animal feeding operations, as contributing to water quality impairment (Congressional Research Service, 2008). A study of private water wells in Idaho detected levels of veterinary antibiotics, as well as elevated levels of nitrates (Batt, Snow, & Alga, 2006). Groundwater is a major source of drinking water in the United States. The EPA estimates that 53% of the population relies on groundwater for drinking water, often at much higher rates in rural areas (EPA, 2004). Unlike surface water, groundwater contamination sources are more difficult to monitor. The extent and source of contamination are often harder to pinpoint in groundwater than surface water contamination. Regular testing of household water wells for total and fecal coliform bacteria is a crucial element in monitoring groundwater quality, and can be the first step in discovering contamination issues related to CAFO discharge. Groundwater contamination can also affect surface water (Spellman &

Whiting, 2007). Contaminated groundwater can move laterally and eventually enter surface water, such as rivers or streams.

When groundwater is contaminated by pathogenic organisms, a serious threat to drinking water can occur. Pathogens survive longer in groundwater than surface water due to lower temperatures and protection from the sun. Even if the contamination appears to be a single episode, viruses could become attached to sediment near groundwater and continue to leach slowly into groundwater. One pollution event by a CAFO could become a lingering source of viral contamination for groundwater (EPA, 2005).

Groundwater can still be at risk for contamination after a CAFO has closed and its lagoons are empty. When given increased air exposure, ammonia in soil transforms into nitrates. Nitrates are highly mobile in soil, and will reach groundwater quicker than ammonia. It can be dangerous to ignore contaminated soil. The amount of pollution found in groundwater after contamination depends on the proximity of the aquifer to the CAFO, the size of the CAFO, whether storage units or pits are lined, the type of subsoil, and the depth of the groundwater.

If a CAFO has contaminated a water system, community members should be concerned about nitrates and nitrate poisoning. Elevated nitrates in drinking water can be especially harmful to infants, leading to blue baby syndrome and possible death. Nitrates oxidize iron in hemoglobin in red blood cells to methemoglobin. Most people convert methemoglobin back to hemoglobin fairly quickly, but infants do not convert back as fast. This hinders the ability of the infant's blood to carry oxygen, leading to a blue or purple appearance in affected infants. However, infants are not the only ones who can be affected by excess nitrates in water. Low blood oxygen in adults can lead to birth defects, miscarriages, and poor general health. Nitrates have also been speculated to be linked to higher rates of stomach and esophageal cancer (Bowman, Mueller, & Smith, 2000). In general, private water wells are at higher risk of nitrate contamination than public water supplies.

Surface Water

The agriculture sector, including CAFOs, is the leading contributor of pollutants to lakes, rivers, and reservoirs. It has been found that states with high concentrations of CAFOs experience on average 20 to 30 serious water quality problems per year as a result of manure management problems (EPA, 2001). This pollution can be caused by surface discharges or other types of discharges. Surface discharges can be caused by heavy storms or floods that cause storage lagoons to overfill, running off into nearby bodies of water. Pollutants can also travel over land or through surface drainage systems to nearby bodies of water, be discharged through manmade ditches or flushing systems found in CAFOs, or come into contact with surface water that passes directly through the farming area. Soil erosion can contribute to water pollution, as some pollutants can bond to eroded soil and travel to watersheds (EPA, 2001). Other types of discharges occur when pollutants travel to surface water through other mediums, such as groundwater or air.

Contamination in surface water can cause nitrates and other nutrients to build up. Ammonia is often found in surface waters surrounding CAFOs. Ammonia causes oxygen depletion from water, which itself can kill aquatic life. Ammonia also converts into nitrates, which can cause nutrient overloads in surface waters (EPA, 1998). Excessive nutrient concentrations, such as nitrogen or phosphorus, can lead to eutrophication and make water inhabitable to fish or indigenous aquatic life (Sierra Club Michigan Chapter, n.d.). Nutrient over-enrichment causes algal blooms, or a rapid increase of algae growth in an aquatic environment (Science Daily, n.d.). Algal blooms can cause a spiral of environmental problems to an aquatic system. Large groups of algae can block sunlight from underwater plant life, which are

habitats for much aquatic life. When algae growth increases in surface water, it can also dominate other resources and cause plants to die. The dead plants provide fuel for bacteria to grow and increased bacteria use more of the water's oxygen supply. Oxygen depletion once again causes indigenous aquatic life to die. Some algal blooms can contain toxic algae and other microorganisms, including *Pfiesteria*, which has caused large fish kills in North Carolina, Maryland, and the Chesapeake Bay area (Spellman & Whiting, 2007). Eutrophication can cause serious problems in surface waters and disrupt the ecological balance.

Water tests have also uncovered hormones in surface waters around CAFOs (Burkholder et al., 2007). Studies show that these hormones alter the reproductive habits of aquatic species living in these waters, including a significant decrease in the fertility of female fish. CAFO runoff can also lead to the presence of fecal bacteria or pathogens in surface water. One study showed that protozoa such as *Cryptosporidium parvum* and *Giardia* were found in over 80% of surface water sites tested (Spellman & Whiting, 2007). Fecal bacteria pollution in water from manure land application is also responsible for many beach closures and shellfish restrictions.

Air Quality

In addition to polluting ground and surface water, CAFOs also contribute to the reduction of air quality in areas surrounding industrial farms. Animal feeding operations produce several types of air emissions, including gaseous and particulate substances, and CAFOs produce even more emissions due to their size. The primary cause of gaseous emissions is the decomposition of animal manure, while particulate substances are caused by the movement of animals. The type, amount, and rate of emissions created depends on what state the manure is in (solid, slurry, or liquid), and how it is treated or contained after it is excreted. Sometimes manure is "stabilized" in anaerobic lagoons, which reduces volatile solids and controls odor before land application.

The most typical pollutants found in air surrounding CAFOs are ammonia, hydrogen sulfide, methane, and particulate matter, all of which have varying human health risks. Table 1 on page 6 provides information on these pollutants.

Most manure produced by CAFOs is applied to land eventually and this land application can result in air emissions (Merkel, 2002). The primary cause of emission through land application is the volatilization of ammonia when the manure is applied to land. However, nitrous oxide is also created when nitrogen that has been applied to land undergoes nitrification and denitrification. Emissions caused by land application occur in two phases: one immediately following land application and one that occurs later and over a longer period as substances in the soil break down. Land application is not the only way CAFOs can emit harmful air emissions—ventilation systems in CAFO buildings can also release dangerous contaminants. A study by Iowa State University, which was a result of a lawsuit settlement between the Sierra Club and Tyson Chicken, found that two chicken houses in western Kentucky emitted over 10 tons of ammonia in the year they were monitored (Burns et al., 2007).

Most studies that examine the health effects of CAFO air emissions focus on farm workers, however some have studied the effect on area schools and children. While all community members are at risk from lowered air quality, children take in 20-50% more air than adults, making them more susceptible to lung disease and health effects (Kleinman, 2000). Researchers in North Carolina found that the closer children live to a CAFO, the greater the risk of asthma symptoms (Barrett, 2006). Of the 226 schools that were included in the study, 26% stated that there were noticeable odors from CAFOs outdoors, while 8% stated

Table 1 Typical pollutants found in air surrounding CAFOs.

CAFO Emissions	Source	Traits	Health Risks
Ammonia	Formed when microbes decompose undigested organic nitrogen compounds in manure	Colorless, sharp pungent odor	Respiratory irritant, chemical burns to the respiratory tract, skin, and eyes, severe cough, chronic lung disease
Hydrogen Sulfide	Anaerobic bacterial decomposition of protein and other sulfur containing organic matter	Odor of rotten eggs	Inflammation of the moist membranes of eye and respiratory tract, olfactory neuron loss, death
Methane	Microbial degradation of organic matter under anaerobic conditions	Colorless, odorless, highly flammable	No health risks. Is a greenhouse gas and contributes to climate change.
Particulate Matter	Feed, bedding materials, dry manure, unpaved soil surfaces, animal dander, poultry feathers	Comprised of fecal matter, feed materials, pollen, bacteria, fungi, skin cells, silicates	Chronic bronchitis, chronic respiratory symptoms, declines in lung function, organic dust toxic syndrome

they experience odors from CAFOs inside the schools. Schools that were closer to CAFOs were often attended by students of lower socioeconomic status (Mirabelli, Wing, Marshall, & Wilcosky, 2006).

There is consistent evidence suggesting that factory farms increase asthma in neighboring communities, as indicated by children having higher rates of asthma (Sigurdarson & Kline, 2006; Mirabelli et al., 2006). CAFOs emit particulate matter and suspended dust, which is linked to asthma and bronchitis. Smaller particles can actually be absorbed by the body and can have systemic effects, including cardiac arrest. If people are exposed to particulate matter over a long time, it can lead to decreased lung function (Michigan Department of Environmental Quality [MDEQ] Toxics Steering Group [TSG], 2006). CAFOs also emit ammonia, which is rapidly absorbed by the upper airways in the body. This can cause severe coughing and mucous build-up, and if severe enough, scarring of the airways. Particulate matter may lead to more severe health consequences for those exposed by their occupation. Farm workers can develop acute and chronic bronchitis, chronic obstructive airways disease, and interstitial lung disease. Repeated exposure to CAFO emissions can increase the likelihood of respiratory diseases. Occupational asthma, acute and chronic bronchitis, and organic dust toxic syndrome can be as high as 30% in factory farm workers

(Horrigan, Lawrence, & Walker, 2002). Other health effects of CAFO air emissions can be headaches, respiratory problems, eye irritation, nausea, weakness, and chest tightness.

There is evidence that CAFOs affect the ambient air quality of a community. There are three laws that potentially govern CAFO air emissions—the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, also known as the Superfund Act), the Emergency Planning & Community Right to Know Act (EPCRA), and the Clean Air Act (CAA). However, the EPA passed a rule that exempts all CAFOs from reporting emissions under CERCLA. Only CAFOs that are classified as large are required to report any emission event of 100 pounds of ammonia or hydrogen sulfide or more during a 24-hour period locally or to the state under EPCRA (Michigan State University Extension, n.d.). The EPA has also instituted a voluntary Air Quality Compliance Agreement in which they will monitor some CAFO air emissions, and will not sue offenders but instead charge a small civil penalty. These changes have attracted criticism from environmental and community leaders who state that the EPA has yielded to influence from the livestock industry. The changes also leave ambiguity as to whether emission standards and air quality near CAFOs are being monitored.

Greenhouse Gas and Climate Change

Aside from the possibility of lowering air quality in the areas around them, CAFOs also emit greenhouse gases, and therefore contribute to climate change. Globally, livestock operations are responsible for approximately 18% of greenhouse gas production and over 7% of U.S. greenhouse gas emissions (Massey & Ulmer, 2008). While carbon dioxide is often considered the primary greenhouse gas of concern, manure emits methane and nitrous oxide which are 23 and 300 times more potent as greenhouse gases than carbon dioxide, respectively. The EPA attributes manure management as the fourth leading source of nitrous oxide emissions and the fifth leading source of methane emissions (EPA, 2009).

The type of manure storage system used contributes to the production of greenhouse gases. Many CAFOs store their excess manure in lagoons or pits, where they break down anaerobically (in the absence of oxygen), which exacerbates methane production. Manure that is applied to land or soil has more exposure to oxygen and therefore does not produce as much methane. Ruminant livestock, such as cows, sheep, or goats, also contribute to methane production through their digestive processes. These livestock have a special stomach called a rumen that allows them to digest tough grains or plants that would otherwise be unusable. It is during this process, called enteric fermentation, that methane is produced. The U.S. cattle industry is one of the primary methane producers. Livestock production and meat and dairy consumption has been increasing in the United States, so it can only be assumed that these greenhouse gas emissions will also rise and continue to contribute to climate change.

Odors

One of the most common complaints associated with CAFOs are the odors produced. The odors that CAFOs emit are a complex mixture of ammonia, hydrogen sulfide, and carbon dioxide, as well as volatile and semi-volatile organic compounds (Heederik et al., 2007). These odors are worse than smells formerly associated with smaller livestock farms. The anaerobic reaction that occurs when manure is stored in pits or lagoons for long amounts of time is the primary cause of the smells. Odors from waste are carried away from farm areas on dust and other air particles. Depending on things like weather conditions and farming techniques, CAFO odors can be smelled from as much as 5 or 6 miles away, although 3 miles is a more common distance (State Environmental Resource Center, 2004).

Because CAFOs typically produce malodors, many communities want to monitor emissions and odors. Quantifying odor from industrial farming can be challenging because it is a mixture of free and particle-bound compounds, which can make it hard to identify what specifically is causing the odor. Collecting data on specific gases, such as hydrogen sulfide, can be used as a proxy for odor levels.

CAFO odors can cause severe lifestyle changes for individuals in the surrounding communities and can alter many daily activities. When odors are severe, people may choose to keep their windows closed, even in high temperatures when there is no air conditioning. People also may choose to not let their children play outside and may even keep them home from school. Mental health deterioration and an increased sensitization to smells can also result from living in close proximity to odors from CAFOs. Odor can cause negative mood states, such as tension, depression, or anger, and possibly neurophysciatric abnormalities, such as impaired balance or memory. People who live close to factory farms can develop CAFO-related post traumatic stress disorder, including anxiety about declining quality of life (Donham et al., 2007).

Ten states use direct regulations to control odors emitted by CAFOs. They prohibit odor emissions greater than a set standard. States with direct regulations use scentometers, which measure how many times an odor has to be doused with clean air before the smell is undetectable. An additional 34 states have indirect methods to reduce CAFO odors. These include: setbacks, which specify how far CAFO structures have to be from other buildings; permits, which are the most typical way of regulating CAFOs; public comment or involvement periods; and operator or manure placement training.

Insect Vectors

CAFOs and their waste can be breeding grounds for insect vectors. Houseflies, stable flies, and mosquitoes are the most common insects associated with CAFOs. Houseflies breed in manure, while stable and other flies breed in decaying organic material, such as livestock bedding. Mosquitoes breed in standing water, and water on the edges of manure lagoons can cause mosquito infestations to rise. Flies can change from eggs to adults in only 10 days, which means that substances in which flies breed need to be cleaned up regularly.

Flies are typically considered only nuisances, although insects can agitate livestock and decrease animal health. The John Hopkins Bloomberg School of Public Health found evidence that houseflies near poultry operations may contribute to the dispersion of drug-resistant bacteria (Center for Livable Future, 2009). Since flies are attracted to and eat human food, there is a potential for spreading bacteria or pathogens to humans, including microbes that can cause dysentery and diarrhea (Bowman et al., 2000). Mosquitoes spread zoonotic diseases, such as West Nile virus, St. Louis encephalitis, and equine encephalitis.

Residences closest to the feeding operations experience a much higher fly population than average homes. To lower the rates of insects and any accompanying disease threats, standing water should we cleaned or emptied weekly, and manure or decaying organic matter should be removed twice weekly (Purdue Extension, 2007). For more specific insect vector information, please refer to NALBOH's vector guide (*Vector Control Strategies for Local Boards of Health*).

Pathogens

Pathogens are parasites, bacterium, or viruses that are capable of causing disease or infection in animals or humans. The major source of pathogens from CAFOs is in animal manure. There are over 150 pathogens in manure that could impact human health. Many of these pathogens are concerning because

they can cause severe diarrhea. Healthy people who are exposed to pathogens can generally recover quickly, but those who have weakened immune systems are at increased risk for severe illness or death. Those at higher risk include infants or young children, pregnant women, the elderly, and those who are immunosuppressed, HIV positive, or have had chemotherapy. This risk group now roughly compromises 20% of the U.S. population.

Table 2 Select pathogens found in animal manure.

Pathogen	Disease	Symptoms
Bacillus anthracis	Anthrax	Skin sores, headache, fever, chills, nausea, vomiting
Escherichia coli	Colibacilosis, Coliform mastitis-metris	Diarrhea, abdominal gas
Leptospira pomona	Leptospirosis	Abdominal pain, muscle pain, vomiting, fever
Listeria monocytogenes	Listerosis	Fever, fatigue, nausea, vomiting, diarrhea
Salmonella species	Salmonellosis	Abdominal pain, diarrhea, nausea, chills, fever, headache
Clostirdum tetani	Tetanus	Violent muscle spasms, lockjaw, difficulty breathing
Histoplasma capsulatum	Histoplasmosis	Fever, chills, muscle ache, cough rash, joint pain and stiffness
Microsporum and *Trichophyton*	Ringworm	Itching, rash
Giardia lamblia	Giardiasis	Diarrhea, abdominal pain, abdominal gas, nausea, vomiting, fever
Cryptosporidium species	Cryptosporidosis	Diarrhea, dehydration, weakness, abdominal cramping

Sources of infection from pathogens include fecal-oral transmission, inhalation, drinking water, or incidental water consumption during recreational water activities. The potential for transfer of pathogens among animals is higher in confinement, as there are more animals in a smaller amount of space. Healthy or asymptomatic animals may carry microbial agents that can infect humans, who can then spread that infection throughout a community, before the infection is discovered among animals.

When water is contaminated by pathogens, it can lead to widespread outbreaks of illness. Salmonellosis, cryptosporidiosis, and giardiasis can cause nausea, vomiting, fever, diarrhea, muscle pain, and death, among other symptoms. *E.coli* is another serious pathogen, and can be life-threatening for the young, elderly, and immunocompromised. It can cause bloody diarrhea and kidney failure. Since many CAFO use sub-therapeutic antibiotics with their animals, there is also the possibility that disease-resistant bacteria can emerge in areas surrounding CAFOs. Bacteria that cannot be treated by antibiotics can have very serious effects on human health, potentially even causing death (Pew Charitable Trusts, n.d.).

There is also the possibility of novel (or new) viruses developing. These viruses generate through mutation or recombinant events that can result in more efficient human-to-human transmission. There has been some speculation that the novel H1N1 virus outbreak in 2009 originated in swine CAFOs in Mexico. However, that claim has never been substantiated. CAFOs are not required to test for novel viruses, since they are not on the list of mandatory reportable illness to the World Organization for Animal Health.

Antibiotics

Antibiotics are commonly administered in animal feed in the United States. Antibiotics are included at low levels in animal feed to reduce the chance for infection and to eliminate the need for animals to expend energy fighting off bacteria, with the assumption that saved energy will be translated into growth. The main purposes of using non-therapeutic doses of antimicrobials in animal feed is so that animals will grow faster, produce more meat, and avoid illnesses. Supporters of antibiotic use say that it allows animals to digest their food more efficiently, get the most benefit from it, and grow into strong and healthy animals.

The trend of using antibiotics in feed has increased with the greater numbers of animals held in confinement. The more animals that are kept in close quarters, the more likely it is that infection or bacteria can spread among the animals. Seventy percent of all antibiotics and related drugs used in the U.S. each year are given to beef cattle, hogs, and chickens as feed additives. Nearly half of the antibiotics used are nearly identical to ones given to humans (Kaufman, 2000).

There is strong evidence that the use of antibiotics in animal feed is contributing to an increase in antibiotic-resistant microbes and causing antibiotics to be less effective for humans (Kaufman, 2000). Resistant strains of pathogenic bacteria in animals, which can be transferred to humans thought the handling or eating of meat, have increased recently. This is a serious threat to human health because fewer options exist to help people overcome disease when infected with antibiotic-resistant pathogens. The antibiotics often are not fully metabolized by animals, and can be present in their manure. If manure pollutes a water supply, antibiotics can also leech into groundwater or surface water.

Because of this concern for human health, there is a growing movement to eliminate the non-therapeutic use of antibiotics with animals. In 2001, the American Medical Association approved a resolution to ban all low-level use of antibiotics. The USDA has developed guidelines to limit low-level use, and some major meat buyers (such as McDonald's) have stopped using meat that was given antibiotics that are also used for humans. The World Health Organization is also widely opposed to the use of antibiotics, calling for a cease of their low-level use in 2003. Some U.S. legislators are seeking to ban the routine use of antibiotics with livestock, and there has been legislation proposed to solidify a ban. The Preservation of Antibiotics for Medical Treatment Act (PAMTA), which was introduced in 2009, has the support of over 350 health,

consumer, and environmental groups (H.R. 1549/S. 619). The act, if passed, would ban seven classes of antibiotics important to human health from being used in animals, and would restrict other antibiotics to therapeutic and some preventive uses.

Other Effects – Property Values

Most landowners fear that when CAFOs move into their community their property values will drop significantly. There is evidence that CAFOs do affect property values. The reasons for this are many: the fear of loss of amenities, the risk of air or water pollution, and the increased possibility of nuisances related to odors or insects. CAFOs are typically viewed as a negative externality that can't be solved or cured. There may be stigma that is attached to living by a CAFO.

The most certain fact regarding CAFOs and property values are that the closer a property is to a CAFO, the more likely it will be that the value of the property will drop. The exact impact of CAFOs fluctuates depending on location and local specifics. Studies have found differing results of rates of property value decrease. One study shows that property value declines can range from a decrease of 6.6% within a 3-mile radius of a CAFO to an 88% decrease within 1/10 of a mile from a CAFO (Dakota Rural Action, 2006). Another study found that property value decreases are negligible beyond 2 miles away from a CAFO (Purdue Extension, 2008). A third study found that negative effects are largest for properties that are downwind and closest to livestock (Herriges, Secchi, & Babcock, 2005). The size and type of the feeding operation can affect property value as well. Decreases in property values can also cause property tax rates to drop, which can place stress on local government budgets.

Considerations for Boards of Health

Right-to-Farm Laws

With all of the potential environmental and public health effects from CAFOs, community members and health officials often resort to taking legal action against these industrial animal farms. However, there are some protections for farms in place that can make lawsuits hard to navigate. Right-to-farm laws were created to address conflicts between farmers and non-farming neighbors. They seek to override common laws of nuisance, which forbid people to use their property in ways that are harmful to others, and protect farmers from unreasonable controls on farming.

All 50 states have some form of right-to-farm laws, but most only offer legal protections to farms if they meet certain specifications. Generally, they must be in compliance with all environmental regulations, be properly run, and be present in a region first before suburban developments, often a year before the plaintiff moves to that area. These right-to-farm laws were originally created in the late 1970s and early 1980s to protect family farms from suburban sprawl, at a time when large industrial farms were not the norm. As industrial farms grew in size and number, the agribusiness industry lobbied for and achieved the passage of stricter laws in the 1990s, many of which are now being challenged in court by homeowners and small family farmers. Opponents to these laws argue that they deprive them of their use of property and therefore violate the Fifth Amendment to the Constitution.

Some state courts have overturned their strict right-to-farm laws, such as Iowa, Michigan, Minnesota, and Kansas. Others such as Vermont have rewritten their laws. Vermont's updated right-to-farm bill

protects established farm practices as long as there is not a substantial adverse effect on health, safety, or welfare.

Boards of health need to be aware of what legal protection their state offers farms. Right-to-farm laws can hinder nuisance complaints brought about by community members. State laws can prevent local government or health officials from regulating industrial farms.

Board of Health Involvement with CAFOs

Boards of health are responsible for fulfilling the three public health core functions: assessment, policy development, and assurance. Boards of health can fulfill these functions through addressing problems stemming from CAFOs in their communities. Specific public health services that can tackled regarding CAFOs include monitoring health status, investigating health problems, developing policies, enforcing regulations, informing and educating people about CAFOs, and mobilizing community partnerships to spread awareness about environmental health issues related to CAFOs.

Assessment: Board of health members should ensure that there is an effective method in place for collecting and tracking public complaints about CAFOs and large animal farms. Since environmental health specialists at local health departments are often responsible for investigating complaints, the board of health must take measures to ensure that they are properly trained and educated about CAFOs. It is possible that the board of health may be responsible or choose to do some investigations itself. Schmalzried and Fallon (2008) advocate that local health districts adopt a proactive approach for addressing public concerns about CAFOs, stating that health districts can offer some services that may help ease public frustration with CAFOs. A fly trapping program can establish a baseline for the average number of flies present prior to the start-up of CAFOs or large animal farms, which can then establish if a fly nuisance exists in the area. Testing for water quality and quantity can provide evidence if CAFOs are suspected of affecting private water supplies. Boards of health can also monitor exposure incidences that occur in emergency rooms to determine if migrant or farm workers are developing any adverse health conditions as a result of their work environments. Establishing these programs benefit both members of the community and provide information to future animal farm operators, and local boards of health should recommend them if they've been receiving complaints about CAFOs.

Policy Development: Boards of health in many states can adopt health-based regulations about CAFOs, however, they may be met with some resistance. Humbolt County, Iowa, adopted four health-based ordinances concerning CAFOs that became models for regulations in other states, but the Iowa Supreme Court ruled the ordinances were irreconcilable with state laws. Boards of health that choose to regulate CAFOs can also be subject to pressure from outside forces, including possible lawsuits or withdrawal of funding. Boards of health should also consider working with other local officials to institute regulations on CAFOs, such as zoning ordinances.

Assurance: Boards of health can execute the assurance function by advocating for or educating about better environmental practices with CAFOs. Board members may receive complaints from the public about CAFOs, and boards can hold public meetings to receive complaints and hear public testimony about farms. If boards of health are not capable of regulating industrial farms in their communities, they can still try to collaborate with other local agencies that have jurisdiction. Board of health members can educate other local agencies and public officials about CAFOs and spread awareness about the environmental and health hazards. They can request a public hearing with the permitting agency of the

CAFO to express their concerns about the potential health effects. They can also work with agricultural and farm representatives to teach better environmental practices and pollution reduction techniques.

In many states, boards of health are empowered to adopt more stringent rules than the state law if it is necessary to protect public health. Board of health members should examine their state laws before they take any action regarding CAFOs to determine the most appropriate course of action. Any process should include an investigative period to gather evidence, public hearings, and a time for public review of draft policies.

Board of Health Case Studies

Tewksbury Board of Health, Massachusetts

Locals have complained about Krochmal Farms, a pig farm, for many years, but complaints have increased recently. The addition of a hog finishing facility to the farm coincided with the time that community member complaints grew. Most complaints are centered on the odor coming from the farm. The complaints were originally just logged when phone calls were received; however, the health department added a data tracking system as the number of complaints increased. After a complaint is received, the sanitarian or health director does a site visit to investigate.

The health director in Tewksbury filed an order of prohibition against the farm, which is allowed under Massachusetts law 111, section 143, for anything that threatens public health. The order of prohibition was appealed and the matter was taken to the board of health for a grievance hearing. The board of health hearing included months of testimony about the pig farm. The board of health is also doing a site assignment, which determines if a location is appropriate for treating, storing, or disposing of waste, including agricultural waste. The site assignment process includes both the Department of Environmental Protection (DEP) and the local board of health. The board of health holds a public hearing process, while the DEP reviews the site assignment application. The board of health grants the site assignment only if it is concurrently approved by the DEP.

The health director in Tewksbury points out that the only laws the board of health is able to regulate the farm under are nuisance laws. There have been efforts by the community to do a home rule petition to address the air quality and pest management complaints. The home rule petition is currently working its way through the Massachusetts state house. The status of the petition is unknown.

The board of health has tried to work directly with the pig farm to manage complaints. The farm contains manure composting facilities and the health district has requested advance notice to warn the community before manure is treated or applied to the soil. The farm has adopted a new manure management system. This system uses Rapp technology to control odors and reduce ammonia and hydrogen sulfide levels. However, questions still remain as to whether this addition will fully solve the odor issue. Typically, systems using Rapp technology include an oil cap that floats on manure holding pools and helps seal odors inside. These techniques have been researched and proven to reduce odors. However, the Tewksbury farm did not install the oil cap, and it is unknown whether the exclusion of the cap will hinder the technology's ability to reduce odors.

The complaints about the farm primarily concern the odor that emanates from the farm. The complaints do include mention of health side effects, including nausea and burning eyes. The health director has also heard concerns about potential environmental effects from the pig manure. Community members are

worried the manure runoff is entering and contaminating Sutton Brook, since there has been flooding in that area. There has been no confirmation of this occurring. The board of health is aware that the farm has a nutrient management plan, but they are not allowed to request and find out what is incorporated in that plan.

The Tewksbury piggery is technically not classified as a CAFO, though it is believed to be the largest pig farm in the commonwealth of Massachusetts. The area around it has become densely populated and the community members state that they just want to live peacefully with the farm. The board of health has submitted multiple grant applications to study the health effects associated with the farm. After the site assignment process is complete, the board of health will decide how it will regulate the farm. At the beginning of 2010, the board of health was still working on drafting regulations for the pig farms.

Wood County Board of Health, Ohio

Wood County, Ohio, contains two existing large dairy farms, both of which were proposed in 2001 to be expanded to over 1500 cows each. It is also the site for three other proposed dairy farms. There is a large community effort that supports restricting the operation and expansion of these farms, mainly represented by the community group Wood County Citizens Opposed to Factory Farms. The Wood County Board of Health became involved in investigating these dairy farms through this community group and other local officials. The Trustees of Liberty Township requested assistance from the Wood County Board of Health in supporting a moratorium on factory farm operations until local regulations were in effect. The trustees believed that manure runoff from the farms could contaminate local waterways, lower the ground water table, increase the presence of insect vectors, and devalue local properties.

The Wood County Health Director, in cooperation with the board of health, contacted nearby counties to determine what actions they had taken against farms in their communities. While the health director and board of health investigated action in the form of a nuisance regulation against the farms, they were advised that nuisance lawsuits filed against farms in Ohio were held to a tough standard, and they would be forced to demonstrate with scientific proof that the farms have a substantial adverse effect on health. They found that no other board of health in Ohio had opted to regulate farming operations and relied on the enforcement of existing state laws.

The board of health held a public forum to hear public opinion regarding the industrial farms. Ultimately, the Wood County Board of Health took actions other than regulations to help protect the health and environment of its community. They helped community members protect the safety of their water wells by offering free and low cost water well testing and inspections. They tested area ditch and water ways for fecal coliform bacteria, phosphorous, and nitrates to monitor the impact of farm runoff. They also purchased fly traps to monitor and count fly types to determine if the farms have caused an increase in insect vectors. Board of health members also met with state officials from the Ohio EPA in an effort to facilitate cooperation regarding the factory farms. While the Wood County Board of Health and Health Department chose not to institute any local regulations, they continue to monitor the situation and respond to community complaints.

Cerro Gordo County Board of Health, Iowa

Officials in Cerro Gordo County, Iowa, began looking into regulating animal feeding operations after the number of hog farms in Iowa started to grow. Floods in North Carolina and new regulations in Colorado meant that many hog farms began relocating to Iowa. Many citizens had concerns over the effects of

CAFOs, and the Iowa State Association of Counties wanted to review air quality issues. Officials in Cerro Gordo County originally began working on a regulation that required inspections and was based on public health concerns, since farms were already exempt from any regulations related to zoning. However, Iowa state senators soon introduced legislation that passed and prevented any animal feeding operations from being regulated from a public health angle as well.

As Iowans were now prevented from regulating animal feeding operations in terms of zoning or public health, officials in Cerro Gordo County decided to place a moratorium on the construction of new animal feeding operations in that county. They wanted to temporarily stop the growth of animal feeding operations until they could get better science about their effects. Cerro Gordo County Ordinance #40, the "Animal Confinement Moratorium Ordinance," went into effect on May 14, 2002. Since the moratorium did not address public health or zoning, officials were able to get around the rules and still have a way to temporarily control animal feeding operation growth in their county. The ordinance placed "a 1-year moratorium on any new construction, expansion, or activity occurring on land used for the production, care, feeding, or housing of animals." The ordinance also afforded "local public health officials adequate time to appropriately assess health and environmental concerns that may be related to confined animal feeding operations and concentration of animals; establish objective measurable standards of enforcement; exercise the Board of Health's responsibility to protect and improve the health of the public; refrain from impacting farm operators unfairly; and provide penalties for violations of the provisions hereof pursuant to Chapter 137, Code of Iowa" (Cerro Gordo County, 2002).

The moratorium was first adopted by the Cerro Gordo County Board of Health. It was then presented to the county board of supervisors by the health director on behalf of the board of health. Before the board of health adopted the moratorium, they held an investigative meeting in which representatives from the Iowa Farm Bureau and other industry spokespeople exchanged opinions on the issue of animal feeding operations. The moratorium was created through a collaboration between local and county officials—health department staff, the board of health, and the board of supervisors. The moratorium did not receive any help or backing from state officials, who were concerned about the political nature of the ordinance. However it did receive backing from a *Globe Gazette* editorial.

The moratorium was immediately met with resistance from state officials. The Cerro Gordo County Board of Supervisors was contacted by a local legislator, and the Iowa Farm Bureau stated they would challenge the county budget. The Iowa Farm Bureau threatened to take the county to court. There were concerns over the cost of a court trial, which was estimated to be as high as $60,000. The county attorney doubted the legality of the moratorium and ultimately recommended removing it. The moratorium was in effect until June of 2005, when it was repealed by the county board of supervisors.

Since the moratorium was repealed there have been a few hog farms built in Cerro Gordo County, but the decline in pork prices has prevented any large growth of hog farms. Health officials believe that if the county had not implemented the animal confinement moratorium, there would have been many more farms built in their county, since many hog farms were built in counties south of Cerro Gordo County. There is now a process for siting new animal confinement operations in Iowa that uses a Master Matrix scoring system. The Cerro Gordo County Board of Supervisors tracks the Master Matrix system, but so far no animal feeding operations in Iowa who have applied using this system have been denied the right to build.

Conclusion

Concentrated animal feeding operations or large industrial animal farms can cause a myriad of environmental and public health problems. While they can be maintained and operated properly, it is important to ensure that they are routinely monitored to avoid harm to the surrounding community. While states have differing abilities to regulate CAFOs, there are still actions that boards of health can and should take. These actions can be as complex as passing ordinances or regulations directed at CAFOs or can be simply increasing water and air quality testing in the areas surrounding CAFOs. Since CAFOs have such an impact locally, boards of health are an appropriate means for action. Boards of health should take an active role with CAFOs, including collaboration with other state and local agencies, to mitigate the impact that CAFOs or large industrial farms have on the public health of their communities.

Appendix A: Regulatory Definitions of Large CAFOs, Medium CAFOs, and Small CAFOs

Animal Sector	Size Thresholds (number of animals)		
	Large CAFOs	Medium CAFOs[1]	Small CAFOs[2]
Cattle or cow/calf pairs	1,000 or more	300-999	Less than 300
Mature dairy cattle	700 or more	200-699	Less than 200
Veal calves	1,000 or more	300-999	Less than 300
Swine (over 55 pounds)	2,500 or more	750-2,500	Less than 750
Swine (under 55 pounds)	10,000 or more	3,000-9,999	Less than 3,000
Horses	500 or more	150-499	Less than 150
Sheep or lambs	10,000 or more	3,000-9,999	Less than 3,000
Turkeys	55,000 or more	16,500-54,999	Less than 16,500
Laying hens or broilers[3]	30,000 or more	9,000-29,999	Less than 9,000
Chickens other than laying hens[4]	125,000 or more	37.500-124,999	Less than 37,500
Laying hens[4]	82,000 or more	25,000-81,999	Less than 25,000
Ducks[4]	30,000 or more	10,000-29,999	Less than 10,000
Ducks[3]	5,000 or more	1,500-4,999	Less than 1,500

Data: Environmental Protection Agency

1 Must also meet one of two "method of discharge" criteria to be defined as a CAFO or must be designated.

2 Never a CAFO by regulatory definition, but may be designated as a CAFO on a case-by-case basis.

3 Liquid manure handling system

4 Other than a liquid manure handling system

Appendix B: Additional Resources

American Public Health Association. *Precautionary moratorium on new concentrated animal feed operations*. http://www.apha.org/advocacy/policy/policysearch/default.htm?id=1243

Center for a Livable Future. http://www.livablefutureblog.com/

Environmental Health Sciences Research Center. *Iowa concentrated animal feeding operation air quality study*. http://www.public-health.uiowa.edu/ehsrc/CAFOstudy.htm

Environmental Protection Agency. *Animal feeding operations*. http://cfpub.epa.gov/npdes/home.cfm?program_id=7

Food and Water Watch. http://www.foodandwaterwatch.org/

Impacts of CAFOs on Rural Communities. http://web.missouri.edu/ikerdj/papers/Indiana%20--%20CAFOs%20%20Communities.htm#_ftn1

Land Stewardship Project. http://www.landstewardshipproject.org/index.html

Midwest Environmental Advocates. http://www.midwestadvocates.org/

National Agriculture Law Center. *Animal feeding operations reading room.* http://www.nationalaglawcenter.org/readingrooms/afos

National Association of Local Boards of Health. *Vector control strategies for local boards of health.* http://www.nalboh.org/publications.htm

Pew Charitable Trusts. *Human health and industrial farming*. http://www.saveantibiotics.org/index.html

Pew Commission on Industrial Animal Farm Production. http://www.ncifap.org/

Purdue Extension. *Concentrated animal feeding operations*. http://www.ansc.purdue.edu/CAFO/

State Environmental Resource Center. http://serconline.org

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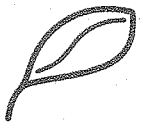
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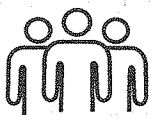
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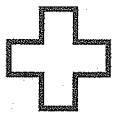
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NALBOH
National Association of Local Boards of Health

1840 East Gypsy Lane Rd., Bowling Green, OH 43402 Phone: (419) 353-7714 Fax: (419) 352-6278 www.nalboh.org

3-19-16

Dear ND Department of Health,

I am hoping that you will carefully consider the information shared by the Buffalo and surrounding area last Thursday.

Please pay close attention to the type of soil that the manure is to be applied and the amount of land available. I hope that soil expert's information and testimony will be beneficial in your decision. These areas are very close to water sources and our water needs to be protected.

Please pay close attention to land elevations, water table, wells and how the water flows in our area. If this site is approved, there is a realistic fear of our environment, air, water, land and personal health being compromised. Statements such as "If there is a problem we will fix it…" do not reassure me. How is the water and land quality in the Bakken area going to be fixed….when….how many years? Please protect us, and our future generations.

Please pay close attention to the numerous individuals in close proximity who have realistic concerns regarding their health and well being. If their physicians express concern should not you?

Our county is growing rapidly. Young families are building and moving out to our area. Logistically, many of them work in the Fargo area. They move here for several reasons including fresh air, quiet and space. This proposal, if approved will discourage growth, health and wellness for our area. Other CAFO in the state are located further away from towns and residents. I don't understand why this is even considered an appropriate area.

Please do not let the political pressures of our State Ag Department sway your decision. Protect our health, air, water and land.

Thank you for reading and considering this input.

Sincerely,

Gwen Fraase

3689 143rd Ave. SE Buffalo, ND 58011

TO N. Dak. Department of Health + Water
918 E. Divide ave
Bismark, N. Dak. 58501-1947

FROM Gerald A Larson
4201 33rd ave S apt 302
Fargo, N. Dak 58104

SUBJECT

DATE 3/8/2016

MESSAGE Dear Sir

I am writing to oppose the Hog Farm that is proposed near Buffalo, N. Dak. I am retired and live in Fargo. I was born and raised in Barnes County and I farmed for many years. my daughter and her family live just south of Interstate 94 by Buffalo N. Dak.. they told me that the proposed Hog Farm will be 1½ miles from there place. this is not a good area. there are a lot of open spaces in North Dakota this not a good area.

I am not in Favor of the Hog Farm proposed operation

thank you

Yours truly

Gerald Larson

RECEIVED
MAR 10 2016
DIV. OF WATER QUALITY

SIGNED

RECEIVED

MAR 14 2016

DIV. OF WATER QUALITY

3-12-16

I want to thank Sarah Vogel for stating facts in the Grand Forks Herald and Fargo Forum regarding the proposed hog farm by Buffalo ND.
I am not a resident of Cass County but live nearby in ND. We the people have historically turned down the corporate farming proposals and will be voting on it again this summer. Repetitively we have stated we do not want large corporate farms. What don't our representatives hear with our vote? Large factory farms destroy family farms; they pose a risk to our environment and to our health.
The environmental impact and the health and wellbeing of ND will be forever compromised if approved. It is the states judiciary responsibility to protect its citizens. If this proposal is approved by the state of ND it is reflective of reckless endangerment and neglect to its residents by compromising water and air quality, health and wellbeing.
I have many family and friends who have lived in Iowa and currently in Lamoure County who are affected by containment farms. They all say do not allow this to go through.
The owners of this proposal live out of state. So the money made is not an economic gain to ND. Homeowners nearby the site will lose property value. We all will live with the "stink" of their profits and suffer from their destruction of air, water and land quality. There are rumors circulating that they will target the I-94 corridor for many more of these containment farms, insidious intrusion at the least. Is this the eastern side of the state's ruination of our quality of life?
South Dakota turned the Rolling Green's Family Farms, LLP proposal down. Will our state be wise enough to do the same?

Gail Pederson

Gail Pederson
Valley City, ND
701-490-2132

Strommen, Rachel A.

From: Lang, Jeremiah M.
Sent: Monday, March 14, 2016 10:18 AM
To: Strommen, Rachel A.
Subject: FW: I support approval of the pig farm near Buffalo

-----Original Message-----
From: Weston Dvorak [mailto:user@votervoice.net]
Sent: Sunday, March 13, 2016 10:48 PM
To: Lang, Jeremiah M.
Subject: I support approval of the pig farm near Buffalo

Dear Environmental Engineer Lang,

The livestock industry is vitally important to the economy of North Dakota. Its good for local grain farmers and if done correctly, is good for the environment. I unconditionally support this hog farm in their application to the ND Dept. of Heath for their permit. I trust that this operation have and will follow all state laws outlined in our States Century Code in regards to CAFO's. I am a livestock feeding operation with our state and if this livestock operations meets all required rules and laws then i see it must not be held up by outside special interests that provide nothing but false information, unscientific information and feelings of fear and emotion. Allowing these "emotion" based people to dictate to law abiding livestock operations is a very slippery slope nobody in production agriculture can allow to happen.

It is the right thing for North Dakotas lack luster hog industry. It is good for grain operations with in the local area as they would be able to utilize a valuable resource in the liquid manure. This will reduce the amount of chemical fertilizer being applied and is extremely valuable source of bioavailable nutrients.

In closing I am in favor of the new hog farm being proposed by Buffalo. The impact to the local communities to have growth, and growing livestock farms in an area that has such low ag diversity is going to be extremely beneficial.

Thanks for your consideration.

Sincerely,

Weston Dvorak
1740 104th Ave SW
Manning, ND 58642
cowndboy@yahoo.com

STATE OF NORTH DAKOTA
DEPARTMENT OF AGRICULTURE
600 E BOULEVARD AVE, DEPT 602
BISMARCK, ND 58505-0020

DOUG GOEHRING
COMMISSIONER

The North Dakota Department of Agriculture works to enhance all forms of agriculture, and does not discriminate the small operators from the large. Our job is to assist current and new producers in their aspirations to enhance and expand their operations. We work diligently to educate producers of any applicable state and federal regulations during this process to ensure that they are compliant moving forward.

The advanced technologies available to modern agricultural producers, combined with the strictest of environmental regulations required at both the state and federal level makes concentrated animal feeding operations safe. Expanding any form of livestock production in the state will add value to our crops and our rural economies as well.

Year after year, agriculture remains on top as the number one industry in North Dakota. Our livestock industry alone provides several billion dollars in economic activity, tens of thousands of jobs and hundreds of millions of dollars in both property and income taxes. North Dakota is sixth in the nation in the value of its crops but only 34th in total value of livestock. A livestock operation adds value to crop farming operations by giving producers millions of dollars in direct marketing opportunities and hundreds of thousands of dollars in saved inputs.

It is no secret that biosecurity is a top priority for swine production facilities. North Dakota provides a tremendous advantage over other states because we have open spaces and limited existing swine operations. The success of these operations is dependent on a bio secure environment. I am honored that livestock producers looking to expand their operations consider North Dakota as a viable option for their businesses.

This state was built by our agriculture industry and is the industry that has maintained us through the hard times. Regardless of the size and shape of an agricultural operation, we need more diversification and support enterprises that complement farmers and ranchers.

Sincerely,

Doug Goehring
Agriculture Commissioner

701-328-2231
800-242-7535

Equal Opportunity in Employment and Services

GOEHRING@ND.GOV
WWW.ND.GOV/NDDA

North Dakota Department of Health
Environmental Health Section
918 East Divide Avenue
Bismarck, ND 58501-1947

Dear Sirs,

I am commenting on the application of Rolling Green Family Farms RE, LLP for an "Approval to Operate" for a concentrated livestock operation under the authority of section 61-28-04 of the North Dakota Century Code. The application was submitted by Barry Kerkhaert, Owner, on November 25, 2015. The proposed site is the SE ¼ Section 4 Township 139N Range 54W, Howes Township, Cass County, North Dakota. This is within Howes Township, which in 1992 availed itself of zoning authority as provided in NDCC 58-03. In the Howes Township zoning ordinances and regulations, new construction and buildings require a "Certificate of Zoning Compliance" or a "Conditional Use Permit." It is the perview of the local zoning authority, in this case Howes Township, to "Site" a facility such as the Rolling Green Family Farms RE, LLP proposal.

Howes Township is responsible for siting any facility such as the proposed Rolling Green facility, and it's zoning resolution, district map, ordinances and comprehensive plan are filed and were available with the Howes Township Clerk. Rolling Green Family Farms RE, LLP has never made an application for a conditional use permit or a certificate of zoning compliance with Howes Township. Howes township therefore has never sited any facility at SE ¼ Section 4 Township 139 N Range 54W.

On the third page of the "Application For Approval of Livestock Waste System" SFN 8296 (6/96), Block entitled "B", the applicant is required to "please check on the following information and, if it is available, include it with the application:" Block B continues to require : "1. Any applicable zoning requirements (city, county, township)". This application was signed on the bottom of that same page by Barry Kerkaert that "I testify that, to the best of my knowledge, this information is correct and accurate." Apparently , Mr. Kerkaert failed to include with the " Application For Approval Of Livestock Waste System" the applicable zoning requirements, because a necessary conditional use permit or certificate of zoning compliance has never been applied for or issued.

It is the responsibility of a person desiring to construct a facility in Howes Township to contact the township to comply with local zoning, as Howes Township is the local subdivision of the state and the local government. This is especially true in the light that Rolling Green family Farms RE,LLP has professional legal counsel that should be aware of the requirements of local governments, including North Dakota townships. Rolling Green Family Farms should also have been aware due to the fact that the person that they are acquiring the property from to build the proposed facility in Section 4 of Howes Township, Mr. Randy Melvin, was a Howes Township Supervisor and should know or should have known of the zoning requirements of the township that he sat as both a Zoning Commissioner, and as a Township Supervisor.

The North Dakota Department of Health has always maintained, and has stated in numerous public hearings and meetings that the Department does not site, and has insisted that the local zoning

authority is responsible for siting facilities over which the ND Department of Health has regulatory purview. The Department has also maintained that they work with the site that they are presented with to bring that site into regulatory compliance.

Because the local zoning authority, Howes Township, has not sited any facility in Howes Township at Sec. 4, I believe that the North Dakota Department of Health has received an erroneous and incomplete Application For Approval For Livestock Waste System from Rolling Green Family Farms RE, LLP, and that the ND Department of Health should reject the application as incomplete and suspend or terminate the application process until such time as Rolling Green Family Farms RE, LLP can make a new application, complete with the required applicable zoning requirements.

Todd Leake

2371 10th Ave. NE

Emerado, ND 58228

Strommen, Rachel A.

From: Rockeman, Karl H.
Sent: Monday, March 21, 2016 10:31 AM
To: Haroldson, Marty R.; Strommen, Rachel A.
Subject: FW: Rolling Green Family Farms, RE, LLP Water Permit

More comments for the record.

Karl Rockeman, P.E.
Director
Division of Water Quality
North Dakota Department of Health
(701)328-5210

From: Glen Philbrick [mailto:glen.philbrick@gmail.com]
Sent: Friday, March 18, 2016 10:19 PM
To: Rockeman, Karl H.
Subject: Re: Rolling Green Family Farms, RE, LLP Water Permit

Dear Mr. Rockeman,

Upon reading the permit application for the water permit for Rolling Green Family Farms, RE, LLP, I have some concerns. Wind is a frequent occurrence in the state and the proposed facility is close to a town not to mention other residents. There is nothing in the plan to deal with odor. Having traveled to area with CAFOs, the odor was apparent and overwhelming, even in distances in excess of two miles. This would be unfortunate for the community and irreversible once the facility is in operation.

The plan includes somewhat of a paper trail if the manure changes hands but who is really monitoring this? Too much manure in any one location will result in a negative impact. Are there any assurances too much manure will not be dumped in any one location including locations above aquifers? Is it assumed that all parties handling manure will be honest?

If the following issues cannot be resolved I urge a no vote.

I look forward to hearing from you.

Glen

Strommen, Rachel A.

From: Rockeman, Karl H.
Sent: Monday, March 21, 2016 10:29 AM
To: Strommen, Rachel A.; Haroldson, Marty R.
Subject: FW: Testimony - Hog Facility Proposal - Buffalo
Attachments: IndustrializedFarmingonCommunity.pdf

Importance: High

More comments for the record.

Karl Rockeman, P.E.
Director
Division of Water Quality
North Dakota Department of Health
(701)328-5210

-----Original Message-----
From: craig wendt [mailto:craigawendt@hotmail.com]
Sent: Friday, March 18, 2016 11:31 PM
To: Rockeman, Karl H.
Subject: Testimony - Hog Facility Proposal - Buffalo
Importance: High

I hereby submit this testimony in opposition to the proposed Rolling Greens Family Farms 9,000-hog facility outside of Buffalo, ND.

I oppose the construction of this site due to the detrimental affects that this facility would impose on my community.

The attached report was prepared for the State of North Dakota, Office of Attorney General, in September of 2006. In section IV. SUMMARY AND CONCLUSIONS, this report concludes "that public concern about the detrimental community impacts of industrialized farming is warranted".

Some highlights from section IV of this report include:

* In brief, this conclusion rests on five decades of government and academic concern with this topic, a concern that has not abetted but that has grown more intense in recent years, as the social and environmental problems associated with large animal confinement operations have become widely recognized. It rests on the consistency of five decades of social science research which has found detrimental effects of industrialized farming on many indicators of community quality of life, particularly those involving the social fabric of communities. And it rests on the new round of risks posed by industrialized farming to Heartland agriculture, communities, the environment, and regional development as a whole.

* More recent studies reported environment impacts. Because large animal confinement operations house densely concentrated livestock, they are prone to a host of negative environmental impacts on water, air, and human health.

* Given the relative consistency of past research, the studies such as Crowley's (1999), Crowley and Roscigno's (2004), and Welsh and Lyson's (2001) which specifically analyzed North Central states, including North Dakota, and research focused on neighboring states in the region, there is every reason to expect that the conclusions drawn here apply to North

Dakota. From the social science literature, we can anticipate four sets of impacts of industrialized farming for farming-dependent communities in Heartland states such as North Dakota: impacts on socioeconomic well-being, social fabric, the environment, and regional imbalances.

* Communities that gain new industrialized farming will encounter stresses in the social fabric; community decision-making is likely to be more subject to corporate farm interests; and in the case of large livestock confinement operations, communities will be at risk for environmental and health problems, entailing the need for state and local government intervention.

See the entire report at this link:
http://www.nffc.net/Learn/Reports/IndustrializedFarmingonCommunity.pdf

I insist that the North Dakota Department of Health deny the permit requested by Rolling Greens Family farms for this CAFO or any other.

Think about this: If the fans in this facility shut down, everything dies. But yet it's ok for these toxic gases to be released into our air? Tell me how you can guarantee that this pollution has no affect on people living in the area.

Thank you,
Craig Wendt
3805 139 Ave SE
Buffalo, ND 58011

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Karl Rockeman, P.E.
Director
Division of Water Quality
North Dakota Department of Health
(701)328-5210

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Some highlights from section IV of this report include:

* In brief, this conclusion rests on five decades of government and academic concern with this topic, a concern that has not abetted but that has grown more intense in recent years, as the social and environmental problems associated with large animal confinement operations have become widely recognized. It rests on the consistency of five decades of social science research which has found detrimental effects of industrialized farming on many indicators of community quality of life, particularly those involving the social fabric of communities. And it rests on the new round of risks posed by industrialized farming to Heartland agriculture, communities, the environment, and regional development as a whole.

* More recent studies reported environment impacts. Because large animal confinement operations house densely concentrated livestock, they are prone to a host of negative environmental impacts on water, air, and human health.

* Given the relative consistency of past research, the studies such as Crowley's (1999), Crowley and Roscigno's (2004), and Welsh and Lyson's (2001) which specifically analyzed North Central states, including North Dakota, and research focused on neighboring states in the region, there is every reason to expect that the conclusions drawn here apply to North

Dakota. From the social science literature, we can anticipate four sets of impacts of industrialized farming for farming-dependent communities in Heartland states such as North Dakota: impacts on socioeconomic well-being, social fabric, the environment, and regional imbalances.

* Communities that gain new industrialized farming will encounter stresses in the social fabric; community decision-making is likely to be more subject to corporate farm interests; and in the case of large livestock confinement operations, communities will be at risk for environmental and health problems, entailing the need for state and local government intervention.

See the entire report at this link:
http://www.nffc.net/Learn/Reports/IndustrializedFarmingonCommunity.pdf

I insist that the North Dakota Department of Health deny the permit requested by Rolling Greens Family farms for this CAFO or any other.

Think about this: If the fans in this facility shut down, everything dies. But yet it's ok for these toxic gases to be released into our air? Tell me how you can guarantee that this pollution has no affect on people living in the area.

Thank you,
Craig Wendt
3805 139 Ave SE
Buffalo, ND 58011

Industrialized Farming and Its Relationship to Community Well-Being: An Update of a 2000 Report by Linda Lobao

Prepared for the State of North Dakota, Office of the Attorney General

by

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For Case: State of North Dakota versus Crosslands
North Dakota District Court
September, 2006

Note: This report is a response to a request from the State of North Dakota to review past social science research on the effects of industrialized farming on community well-being. This review builds upon a similar review conducted by Dr. Linda Lobao in 2000. As author of the book *Locality and Inequality: Farm and Industry Structure and Socioeconomic Conditions* (SUNY Press, 1990), Dr. Lobao is the authoritative source on the relationship between industrialized farming and community well-being She is a professor of rural sociology in the Department of Human and Community Resource Development at The Ohio State University. This update to her 2000 review of the literature since the publication of her book focuses on the consequences of industrialized farming on community well-being irrespective of whether these effects were detrimental, positive or mixed. Thus, a comprehensive review of the literature included all studies in this area, regardless of their conclusions.

INTRODUCTION

Public concern about the consequences of non-family owned and operated, industrialized farms for communities dates back to the 1920s (Boles and Rupnow 1979).[1] The first published research on the topic appeared in the 1930s. Since then, government and academic researchers have produced numerous studies showing the potential for adverse impacts on community life. The bulk of evidence indicates that public concern about the detrimental community impacts of industrialized farming is warranted This report summarizes results from more than five decades of research that has investigated the relationship between non-family industrialized farming and community well-being. The purposes are: (1) to document the types of studies that have been conducted on the topic; (2) to delineate their results as to whether adverse consequences were found; and (3) to document the aspects of community life that may be jeopardized by industrialized farming.

This report is based on empirical results and observations drawn from Lobao's own research as well as from that of other social scientists. Observations are grounded in her longstanding research on farm change and its impacts on communities and families (Barlett, Lobao, and Meyer 1999; Belyea and Lobao 1990; Kenney, Lobao, Curry, and Goe 1989; Lasely, Leistritz, Lobao, and Meyer 1995; Lobao 1987, 1990; Lobao and Jones 1987; Lobao and Meyer1995a, 1995b, 1997; Lobao and Schulman 1991; Lobao, Swanson, and Schulman 1993; Lobao and Thomas 1988; Lobao and Thomas 1992) as well as her research on the broader topic of community development (Lobao 1993a,b,c, 1996, 1998; Lobao and Rulli 1996; Lobao, Rulli and Brown 1999). The previous research has been funded by major federal competitive grants programs, such as the National Science Foundation and USDA-National Research Initiative Competitive Grants Program, as well as state and regional sources, such as the North Central Regional Center for Rural Development. The previous studies are published in the top-ranked journals in several fields, sociology, rural sociology, geography, family studies, and community development. For specific empirical examples in this report, she draws primarily from her book *Locality and Inequality: Farm Structure and Industry Structure and Socioeconomic Conditions* (State University of New York Press, 1990), the most recent, comprehensive sociological volume published on farm structure and community well-being. Our comments and conclusions also are based on a systematic review of fifty six studies on the topic of industrialized farming and community well-being. For this report, we updated a review (Lobao 2000) which was an update of a previously published review (Lobao 1990) by including studies that were conducted since 2000 on the topic of industrialized farming and community well-being.

The industrialization of farming refers to the transformation whereby farms have become larger-scale, declined in number, and integrated more directly into production and marketing relationships with processors through vertical or contractual integration (Drabenstott and Smith 1996:4). In the past two decades, farms in the farming-dependent Heartland states,[2] which

[1] Boles and Rupnow (1979: 471) state that public concern about corporate influence in farming began in the 1920-30 period when concern about large, publicly held corporations centered on fears about the effect of mechanization, foreclosure of farm land mortgages held by corporations, and corporate monopoly of land.

[2] The states forming the nation's farm heartland extend from the Mississippi River to the Rocky Mountains and from Texas to Canada. These states are Colorado, Iowa, Kansas, Minnesota, Missouri Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, and Wyoming (Barkema and Drabenstott 1996:1). More than two-thirds of the nation's farm-dependent counties are located in these states.

include North Dakota, declined by roughly one-fourth while average acreage grew by one-fourth to about 750 acres (Barkema and Drabenstott 1996:62). As the number of farms declines, production becomes concentrated on larger farms. Nationally, small farms (defined here as those having annual gross sales less than $50,000) made up nearly three-quarters of the nation's farms in 1995 but they produced only about 8% of sales, while the top two percent of farms (those with sales of over a half million dollars annually) accounted for 44% of all sales (Sommer et al. 1998:10). Half of the nation's agricultural sales are produced by three percent of farms (Sommer et al. 1998:8).

Accompanying the growth of scale of operations are organizational changes in farming. These include an increase in the relative proportion of hired to family labor and greater use of incorporation[3] as a form of legal organization. Another organizational shift is the movement toward a more integrated industry from farm to grocery, whose "hallmark" is "contract production and vertical integration that is linking farmers, food processors, seed companies, and other agribusiness" (Barkema and Drabenstott 1996:64). Vertical integration refers to operation of farms by firms that also operate in at least one other stage of the food chain, such as input supply, processing, and marketing. Examples of vertically integrated firms are large livestock producer/processor enterprises, such as Seaboard Corporation and Tyson. In addition to their direct involvement in farm production, agribusiness firms contract with farmers for goods and services. Two types of contracting arrangements should be distinguished. Marketing contracts are used by independent operators to reduce their exposure to market price swings; these contracts stipulate a commodity price or pricing mechanism for delivered goods and are used mainly for crop and dairy commodities. Production contracts involve cost sharing arrangements and/or payment for operators' services usually for livestock production except for dairying. On farms using production contracts, the largest share of farm sales accrues to the contractor (an agribusiness processor and/or producer), with the operator generally receiving a fixed fee for services (Sommer et al. 1998:16-17). Production contracts extend agribusiness firms into direct farm production using the vehicle of the local farmer. To sociologists, production contract farms are an integral component of the agribusiness chain in which agribusiness firms, depending on corporate strategy, may enter farming through direct operation of their own units and/or through employing local farmers to participate in production home-work. Sociologists are concerned with contract farming because of the risks it poses to agrarian social structure, communities, and families.[4]

[3] In 1995, more than 98% of the nation's 2.07 million farms were classified as family operations. Ninety-one percent were sole proprietorships and five percent were partnerships. Only three percent of all farms were incorporated, and of these, 86% were considered family-held corporations by USDA as they had ten or less stockholders (Sommer et al.1998: iv).

[4] Sociologists are concerned with contract farming insofar that: it alters agrarian social structure by creating a segment of farmers who are the structural equivalent of factory production home-workers; it extends the influence of industrialized farming in a community; and it erodes formally independent operators' autonomy in direct production, farm decision-making and control over assets. Sociologists also are concerned with the general well-being of contractees (operators) and their families given their asymmetrical relationship in bargaining power with agribusiness firms. There is an inherent structural imbalance in contract farming and the degree to which this imbalance is manifest will vary, given specific contract arrangements. In principle, production contracts are used to share risks and costs of production between contractee and contractor. In practice, the bargaining power of external agribusiness is likely to result in a greater of share of risks and costs of production borne by contractees and their families.

In classifying farms as "industrialized" or "family" social scientists distinguish between the construct (an ideal-type concept) and its actual measurement (variables used to define the concept in practice).[5] "Family" farms and "industrialized" farms are constructs at opposite ends of the farm continuum. To sociologists, the construct "family farm," is that where the farm household owns and controls the majority of farm production factors, land, labor, capital, technology, and management. At the other end of the farm continuum, the construct, "industrial farm," refers to a non-household based production unit, with absentee ownership and control over production factors. As with nonfarm firms, industrialized farms have a division of labor among owners, managers, and labor with different groups of people assigned to different positions in the production process. Industrial farms "...are owned by one group of people, managed on a daily basis by another person or group, and worked by yet another group" (Browne et al. 1992:30). Between these "ideal-type" descriptions of family and industrialized farms are other arrangements in organizing farming, such as part-owner farming (a form of family farming where the operator both owns and rents-in land). Again, these are "ideal-type" constructs whose specific definition and measurement must depend upon the time period and public context.

When social scientists refer to "industrialized" farms, they invariably are referring to both scale and organizational characteristics of the farm unit. [6] In general, but not always, scale will

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[5] Different classifications of farms have been developed over the years because the structure of agriculture is continually changing. The term "farm structure" or "agricultural structure" "refers to a broad set of characteristics that describe U.S. farms, as well as the distribution of farm production resources and returns to those engaged in farm production activities"(Sommer et al. 1998:6). Sommer et al. (1998:6) provide a useful overview of the criteria used to classify farms:

> Producing units (farms and ranches) may be categorized by farm size (value of sales or number of acres), primary output, and geographic location. Farm businesses may be delineated by form of legal organization, degree of land ownership, marketing or production contractual arrangements, and financial position. Farm operators may be described by age, education, and primary occupation. Finally, farm households may be characterized by features of their associated farm businesses and interaction with the nonfarm sector, such as off-farm employment or income from non-farm sources. Any or all of these elements can be used to construct a structural portrait of farming in the Nation.

For sociologists, family farming is identified by whether the family unit owns a majority of capital resources, such as land, machinery, buildings, makes the majority of managerial decisions, and provides the bulk of labor (Goss et al. 1980). Social scientists often use farm scale as a proxy-measure to classify farms, because it is simple, clear, and often correlated with organizational characteristics of units. A recent USDA report classifies "commercial farms" as those with $50,000 or more in gross sales and "small farms" as those with gross sales less than $250,000 (Sommer et al. 1998:69). Family farms (organized as sole proprietorships, partnerships, or family corporations) with gross sales over $250,00 are classified as "large-family farms," while "non-family farms" are any farms organized as nonfamily corporations, cooperatives, and farms operated by hired managers (Sommer et al. 1998:72).

[6] Social scientists measure industrialized farming by both scale and organizational variables. Scale is usually measured by sales and sometimes by acreage and real estate and for livestock operations, animal inventory. The actual dollar value for scale indicators used by analysts to indicate a "large-scale" farm will obviously vary by the time period of study. In addition, what is considered a "large-scale farm" also varies by regional context and commodity. Organizational measures of industrialized farming include: vertical integration of corporations into farming; production contract farming arrangements; absentee ownership of production factors; dependency on hired labor; operation by farm managers, as opposed to material operation by family members; and legal status as a corporation (family or non-family) or syndicate.

coincide with organization. That is, large-scale farms (relative to smaller farms) are more dependent on hired labor and managers and more likely to have absentee owners, to be incorporated, and to be vertically integrated with agribusiness. For example, in 1995, mean gross sales of corporate farms were $576,925 as compared to $54,287 for sole proprietorship farms and $218,795 for farms organized as partnerships (Sommer et al. 1998:15). Farms with production or marketing contracts also tend to be larger. In 1995, farms with marketing contracts (about 11% of all farms) had mean gross sales of $242,888; while farms with production contracts (2.3% of all farms) had mean gross sales of $617,858 (Sommer et al. 1998: 12). For the purposes of this review, we use the umbrella term "industrialized farm" to refer to both scale and operating characteristics of industrialized farms. We also distinguish between scale and operating characteristics where it is useful and feasible to do so.

The discussion below is organized in four sections. (I) The first section discusses the history of government and academic concern about the risks of industrialized farming for community well-being, from the 1930s to the present. (II) The second section summarizes the findings from Lobao's research and that of colleagues. (III) The third section reviews findings from five decades of social science research. It is divided into several sub-sections discussing, respectively: (A) research issues involved in analyzing industrialized farming and community impacts, focusing on indicators of industrialized farming and types of consequences that a summary evaluation must consider; (B) the various research designs used to assess the consequences of industrialized farming; (C) a summary of the results of past studies as to whether detrimental impacts were found; (D) examples of recent sociological studies conducted on the topic; and (E) the potential for regional imbalances due to industrialized farming. (IV) The final section is a summary and conclusions.

It should be noted that public concern about industrialized farms extends beyond the well-being of states and their communities. Rather, public as well as academic concern extends to national food system issues, such as agribusiness concentration, consumer health, food safety, and sustainability of the national eco-system. The immediate effects of industrialized farms, however, are on the day-to-day lives of people residing in the places where these farms are located. It is also at this level, that social scientists have conducted a great deal of research over a long period of time. For these reasons, this report deals with the consequences of industrialized farming for well-being at the community level.

I. HISTORY OF PUBLIC, GOVERNMENT, AND ACADEMIC CONCERN WITH THE CONSEQUENCES OF INDUSTRIALIZED FARMING

More than a half century of research centers on the potential detrimental social consequences of industrialized farming. Since the 1930s, government and academic researchers have investigated the extent to which large scale, industrialized farms adversely affects the communities in which they are located. One of the first series of studies was conducted by a sociologist, E.D. Tetreau (1938, 1940), who found that large scale, hired-labor dependent farms were associated with poor social and economic well-being in rural Arizona communities.

In the early 1940s, the United States Department of Agriculture sponsored a research project on the effects of industrialized farming using a matched-pair of two California communities, Arvin where large, absentee-owned, non-family operated farms were more numerous, and Dinuba, where locally owned, family operated farms were more numerous. The report on this

project was prepared by Walter Goldschmidt, a USDA anthropologist. The purpose of the study was to assess the consequences of a California law with a provision placing acreage limitations on large farms located in California's Central Valley, so as to support family-size farms in the region. Goldschmidt (1978a: 458) notes that: "Large landholders throughout the state and corporate interests generally opposed this provision while diverse church and other agrarian-oriented interests wanted this law applied to California. The comparative study of Arvin and Dinuba...was designed to determine the social consequences that might be anticipated for rural communities if the established law was applied or rescinded." Goldschmidt later became President of the American Anthropological Association and remains one of our nation's leading anthropologists.

In his report, Goldschmidt (1978a) systematically documented the relationship between large-scale farming and its adverse consequences for a variety of community quality of life indicators. Goldschmidt (1978a) found that, relative to the family farming community, Arvin's population had a small middle class and high proportion of hired workers. Family incomes were lower and poverty was higher. There were poorer quality schools and public services, fewer churches, civic organizations, and retail establishments. Arvin's residents also had less local control over public decisions, or "lack of democratic decision-making," as local government was prone to influence by outside agribusiness interests. By contrast, family farming Dinuba had a larger middle class, better socioeconomic conditions, high community stability and civic participation. Goldschmidt's report was eventually published as Congressional testimony (1968) and as a book (1978a). Goldschmidt's conclusion that large scale industrialized farms create a variety of social problems for communities has been confirmed by a number of subsequent studies. One criticism of Goldschmidt's (1978a) research was published by agricultural economists Hayes and Olmstead (1984). They did not challenge Goldschmidt's (1978a) conclusion that large scale, industrialized farms have adverse community impacts. Rather they argued that Arvin and Dinuba were not as closely matched research sites in the 1930s as Goldschmidt had intended. Nearly four decades after Goldschmidt's study, the state of California, through its Small Farm Viability Project (1977:229-230), affirmed Goldschmidt's conclusions by re-visiting Arvin and Dinuba. They concluded that: "The disparity in local economic activity, civic participation, and quality of life between Arvin and Dinuba...remains today. In fact, the disparity is greater. The economic and social gaps have widened. There can be little doubt about the relative effects of farm size and farm ownership on the communities of Arvin and Dinuba."

As the structure of U.S. agriculture has evolved towards larger and fewer farms, and government and academic researchers have continued to investigate the extent to which large-scale, non-family owned and operated industrialized farms adversely affect communities. Congress has conducted inquiries, such as that by Senate Subcommittee on Monopoly dealing with Corporate Secrecy and Agribusiness, in which rural sociologists and agricultural economists provided testimony in 1973 about the dangers to communities posed by increasing corporate control of agriculture (Boles and Rupnow 1979:468-469). The Office of Technology Assessment (OTA), concerned that the relative growth of large scale industrialized farms might have adverse impacts on communities, commissioned a series of research papers on the topic. The OTA research came as a request from Congress and was published first as a report (U.S. Congress, Office of Technology Assessment 1986) and later as a book (Swanson 1988). Federal and state funding has been directed to at least two Agricultural Experiment Station projects that

assess the community consequences of large scale, non-family farms: Project S-148 "Changing Structure of Agriculture: Causes, Consequences, and Policy Implications" (1982-1986);" and Project S-198 "Socioeconomic Dimensions of Technological Change, Natural Resource Use, and Agricultural Structure" (1986-1990). The later project resulted in a book monograph on the consequences of industrialized farming for communities (Lobao 1990) among other publications.

In the 1990s, public concern with industrialized farming has centered particularly on large integrated livestock producer/processor enterprises. Recent studies supported by the North Central Regional Center for Rural Development (1999), the University of Missouri Agricultural Experiment Station (Seipel, Kleiner, and Rikoon 1998; Seipel, Hamed, Rikoon, and Kleiner 1998), and Duke University Medical School (Schiffman 1998) have documented a variety of adverse impacts of these enterprises on communities, households, and individuals.

In summary, there has been over fifty years of public, academic, and government concern that large-scale, industrialized farms jeopardizes community well-being. This concern has resulted in numerous studies, in government sponsored reports, and in Congressional Hearings. In the 1990s, public concern with industrialized farming has increased due to the problems posed by large-scale animal confinement operations. Social scientists have responded to this increased public concern by initiating a number of recent projects---leading to a new generation of literature on the community consequences of industrialized farming.

II. RESEARCH BY LOBAO AND COLLEAGUES

The most recent, comprehensive sociological study on the effects of industrialized and family farming on communities was conducted by Lobao (1990). This study examined relationships across more than 3,000 U.S. counties. The study used both farm scale and organization to measure farm structure; examined direct and indirect consequences of farming patterns; and examined long-term and immediate relationships for two time periods, 1970-1980. To measure community outcomes, the study focused mainly on socioeconomic well-being indicators (median family income, poverty, and income inequality between families measured by the gini coefficient[7]) but also included of community social disruption (births to teenagers) and health status (infant mortality). The study examined the effects of three different community farm structures: "smaller family farming" (small, part-time family farms); "larger family farming" (moderate-size, capital-intensive, family-operated units using little hired labor), and industrialized farming (large scale, hired-labor dependent farms). The community farming structures were constructed based on research by Wimberley (1987). Each of the measures of farm structure was a composite of scale and organizational indicators, created through a statistical technique called factor analysis. Multivariate statistical methods, regression and discriminant analysis, were used to analyze the effects of the three farm structures net of other community conditions, including non-farm industrial employment, establishment size of local businesses, human capital and demographics characteristics of the population (educational attainments, ethnicity), unemployment, social welfare payments, unionization, and spatial factors, such as region of the country.

[7] The gini coefficient is used by the federal government to document income inequality in the United States and is the measure used most frequently in recent studies of economic development across spatial units such as counties (Lobao et al. 1999).

The findings were the following. There was consistent support that moderate-size family owned and operated farms benefit communities. Counties where these types of farms (i.e., larger family farming) predominated had better socioeconomic well-being (lower family poverty, higher median family income, lower unemployment, and lower infant mortality). The beneficial effects of this family farming were found across the U.S., for two time points, 1970 and 1980. Moreover, this type of farming continued to result in beneficial effects over time. Counties where larger family farming was greater in 1970 continued to have better socioeconomic well-being over time. This study indicates that the "high road" to community development is a farming system based on moderate-size family operations. Such farming not only increases aggregate well-being, as indicated by income levels, but it also sustains a larger middle class, as indicated by lower income inequality and poverty, and thus allows more families to benefit from income produced.

However, where industrialized farming was greater, there were mixed effects on community well-being: either detrimental or no statistically significant impacts. For example, industrialized farming had no relationship with family poverty or median family income at either of two single time points (1970 and 1980). Industrialized farming, however, was related to higher income inequality at both time points, and also to lower family income, higher poverty, and higher income inequality across time, over the decade from 1970-1980 (i.e., counties with greater industrialized farming in 1970 experienced relative declines in socioeconomic well-being over the decade). The finding that industrialized farms are associated with high income inequality indicates that this farming segments social class structure by polarizing families into richer and poorer income groups. Income polarization is related to other social problems, such a crime and other breakdowns in community social fabric. The study also found that where very small farms predominated, well-being was poorer. This indicates that reseachers should distinguish between small and moderate family operated units in assessing consequences for well-being. Smaller family farming tends to predominate more in the South.

As would be expected in a post-industrial society, nonfarm manufacturing and service employment were stronger predictors of community well-being than farming. However, it is important to note the study found that farming, nonfarm industry, and other local characteristics were interrelated, mutually sustaining a population in a locale.[8] Good quality farms and high quality local employment were interrelated, with "larger family farming" associated with greater employment in high wage manufacturing and other beneficial sectors. The study offered consistent support that when farming is an economic development strategy of choice, moderate-size family farms are best for communities.

[8] That farming has a smaller impact on community well-being than does nonfarm industry is expected even for communities highly dependent on farming. Farming is interrelated with local nonfarm industry and other sectors, forming a community livelihood strategy which sustains a population in a locale. Communities where larger family farming predominated had greater high wage, durable manufacturing employment and greater employment in local schools and retail industries. Communities where industrialized farming predominated had greater employment in lower wage manufacturing such as food processing, less employment in education, health, and retail services, a higher minority population, and provided relatively higher per capita benefits to welfare recipients.

This research on farming systems and community and regional well-being has been elaborated in other articles (Kenney, Lobao, Curry, and Goe 1989; Lobao 1987, 1993c, 1996, 1998; Lobao and Jones 1987; Lobao and Schulman 1991; Lobao, Swanson, and Schulman 1993; Lobao and Thomas 1992).

One of the most recent sociological analysis on industrialized farming and inequality is that conducted by one of Lobao's students (Crowley, 1999; Crowley and Roscigno, 2004). This 1999 study is a Masters' thesis in Sociology supervised and reviewed by four faculty members in the Department of Sociology at The Ohio State University, including Lobao. The methodology used in the study is similar to that followed in Lobao (1990), but the indicators of farm structure differ. Crowley's research extends past work by examining the effects of farm sector concentration and by updating research to the 1990 period. It should also be noted that her work is more comprehensive than other recent research (reported below) in that she specifies direct and indirect paths by which farm concentration affect community well-being. By farm concentration, Crowely (1999) means that a few large farms hold a disproportionate share of farm property in a community. Crowley notes that concentration of business property is important to sociologists because they see concentration as conferring both economic and political power to those who control resources in a community. Concentration of farm property also constrains the options of local family farmers to pursue their interests and realize economic gains. Crowley (1999) analyzed the effects of farm concentration using several indicators, (concentration of land, value of land and buildings, and the value of equipment and machinery, indicators measured by the gini coefficient) and data for all (1053) counties in the North Central U.S. (Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, Ohio, North Dakota, South Dakota, and Wisconsin). She analyzed consequences of these dimensions of farm-sector concentration for local levels of family poverty and family income inequality net of other community characteristics. Using multivariate regression analysis, she controlled for the influences of labor market, demographic, spatial, and other farm structure characteristics. In counties where farm sector concentration was higher (i.e., a few large farms held a disproportionate share of local property in land and real estate), there was significantly higher poverty among families and significantly greater income polarization between families. Also, where farm concentration was higher, residents had lower education.

In the 2004 study, Crowley and Roscigno documented how concentration of agricultural resources shapes rural community stratification through the political economic process. In addition to measures of farm sector resource concentration (value of land, real estate, machinery and buildings), measured by the gini coefficient, and labor endowment (percentage of county work force employed in core, extractive, competitive, and state sectors), they included measures of political process (proportion of votes in presidential election for Democratic Party, average household payment rates, average per farm county level spending on agricultural assistance), and worker power attributes (percent of manufacturing employees that are unionized, proportion of population that are minority, percentage of 25+ population with a high school diploma, and proportion of labor force unemployed). Using data for all (1053) counties in the North Central U.S. they found that dimensions of farm sector concentration shape both poverty and inequality. Furthermore, they found that farm sector concentration is explained by political economic processes, and these processes mediate the negative effects of land concentration on economic well-being. In particular, they found that relative to large scale farms, capital concentration promotes government spending that benefits large farms while it blocks government or labor-

market programs that assists farmers whose farms it consumes and farm workers it exploits. These attempts are evident by the increased funding for agricultural research which benefits large farms, decreased redistribution efforts through transfer payments to benefit small farms and workers, decreased political consciousness through lower levels of Democratic party support, and reduced labor power through lower unionization rates and education and higher unemployment and minority representation.

To provide a balanced assessment of the consequences of industrialized farming, it is useful to review the past findings of other investigators, using different methodologies, for different time periods, and from different disciplines. In the following sections, we discuss the types of studies conducted on the relationship between industrialized farming and community well-being and their conclusions. On balance, the social science evidence accumulated from these and other studies supports public, academic, and government concern about the potential risks of industrialized farming. Recent research indicates the public's welfare is at risk in at least four major areas. Industrialized farming: (1) has a detrimental impact on certain aspects of socioeconomic well-being; (2) disrupts the social fabric of communities; (3) poses environmental threats where livestock production is concentrated; and (4) is likely to create a new pattern of "haves and have nots" in terms of agricultural production, whereby some communities gain large, industrialized farms (and attendant social problems) and others lose their farming base as production becomes concentrated elsewhere in the state and regional economy. (Drabenstott and Smith 1996:4)

III. REVIEW OF PAST RESEARCH ON INDUSTRIALIZED FARMING AND WELL-BEING

Over the past half century, numerous studies, spanning different time periods and regions of the county have tended to find that large-scale industrial farming has detrimental community impacts. This does not mean that every study has produced these results--but rather that:(a) empirical evidence accumulated over the years shows a repeated trend that large-scale industrialized farms have adverse impacts on a number of different indicators of community well-being; and (b) that this trend is sufficiently established in the social sciences, to the point that almost all sociological studies begin with the working hypothesis (research expectation) that large scale industrial farms will have adverse community effects. The extent to which past research supports this hypothesis is discussed below. It should be stressed that no single study can provide a definitive answer as to whether large-scale industrialized farming will or will not adversely affect public well-being in any particular region or state. This is due both to the complexity of the research question and to the lack of existing data required to fully analyze it. At best, a single study can assess the extent to which certain indicators of industrialized farming have adverse affects on certain indicators of community well-being in certain places and time periods. Therefore, the most comprehensive answer to the question of whether industrialized farming adversely affects public well-being comes not from a single study but from assessing the conclusions of decades of past research.

A. Research Issues Involved in Analyzing Industrialized Farming and Its Community Impacts

To adequately assess the consequences of large, scale-industrial farming, the following issues about indicators of industrialized farming and types of consequences must be considered.

1. *Industrialized farming should be analyzed using indicators of farm organization and not only scale.*

   Scale is usually measured by sales or sometimes acreage. As a measure of industrialized farming, scale is limited for several reasons:(a) family owned and operated farms may be large scale owing to technology; (b) scale alone does not capture organizational features of industrialized farming, such as absentee ownership and non-family control over production, that are thought to put communities at risk. Organizational measures of industrialized farming include: vertical integration of corporations into farming; contract farming arrangements; absentee ownership of production factors; dependency on hired labor; operation by farm managers, as opposed to material operation by family members; and legal status as a corporation. With regard to legal status, family and non-family-held corporations should be distinguished.[9]

2. *To adequately assess consequences for community well-being, the full array of outcomes should be considered. Research points to three major sets of consequences of industrialized farming in a community: impacts on socioeconomic well-being, community social fabric, and environment*.

   Socioeconomic well-being refers to standard measures of economic performance (essentially employment, income, and business activity) and to a broader range of socioeconomic indicators used by sociologists to tap material conditions of families and populations (family poverty rates, income inequality).

   Community social fabric refers to social organization, the features of a community that reflects its stability and quality of social life. Impacts on community social fabric are seen in social indicators such as: population change; social disruption indicators (crime rates, births-to-teenagers, social-psychological stress, community conflict, interference with enjoyment of property); educational attainments and schooling quality; changes in social class structure (decline of local middle class, in-migration of low wage workers); health status, such as mortality rates; civic participation (e.g., declines in church attendance, voluntary organizational membership, and voting); and changes in local governance, such as loss of local control over community decision-making, and resource/fiscal pressures on local government, such as those due to increased need for social services and diversion of public funds to subsidize agribusiness development.

   Environmental indicators include quality of water, soil, and air, energy usage, and environmentally-related health conditions.

[9] It also should be recognized that farms may be incorporated because of family farmers' interests in estate planning, greater assurance of business continuity, limited liability, and income tax advantages.

3. *Industrialized farming has both direct and indirect consequences for community well -being. Both sets of consequences should be considered.*

Industrialized farms directly influence community well-being: through the quantity of jobs produced and the earnings' quality of those jobs; by the extent to which these farms purchase inputs and sell outputs locally; by affecting the quality of local environmental conditions; and by affecting local decision-making about economic development and other public-interest areas relevant to community quality of life.

First-order, indirect effects on local economic performance and general socioeconomic conditions occur because the quantity and quality of jobs plus purchases affect total community employment, earnings, and income (e.g., economic multiplier effects), the local poverty rate, and income inequality. First order, indirect effects on local social fabric occur because: the quantity of jobs created by industrial farms affects total community population size; the quantity and quality of jobs affects social class composition, such as a when an increase in hired farm workers reduces the proportion of the local middle class; local control over community decision-making may erode or become conflictual, since the interests of industrialized farmers and absentee owners are detached from those of local residents.

Second-order, indirect effects on local social fabric work through first-order effects above. Population size and social class composition are related to: indicators of community social disruption, such as crime, family instability, the high school dropout rate, and conflict resulting in civil suits; local demand for schooling, public assistance, health, and other social services; and the property tax base (Boles and Rupnow 1979; Freudenburg and Jones 1991, Murdock et. al 1988; North Central Center for Regional Development 1999).[10] Decline of local control over community decisions-making creates problems associated with poor governance, such as: the potential for diversion of public resources toward financial incentives supporting the interests of agribusiness developers over the community at large; and the loss of public and private revenues to support local schools, community services, and infrastructure, which contributes to a downward spiral of community social and economic conditions.

The direct and indirect paths by which industrialized farming may affect community well-being are delineated in various studies, including Boles and Rupnow (1979), Lasley et al. (1995), Lobao (1990), MacCannell (1988), and the North Central Regional Center for Rural Development (1999).

4. *Differences in impacts for diverse social groups within the community must be considered*.

Changes in farming affect social groups differently, depending upon their age, class position, and residents' proximity to industrialized farms. The elderly and poor are

[10] Rapid increases in population size and poorer social class composition tend to be related to the indicators of social disruption noted above and also place increased demands on local schooling and other social services. Population decline reduces local demand for services and the property tax base..

affected by rising costs of housing and services whenever large corporations migrate to a rural community (Summers et al. 1976). Within communities with large confined animal feeding operations (CAFOs), residents who live closer to the operation report inability to enjoy their properties and physical and psychological problems associated with odor (Schiffman and others 1998; Wing and Wolf 1999; Reisner et al., 2004; Constance and Tunistra, 2005). Property closer to CAFOs has been found to fail to appreciate in value relative to places further away (Seipel and others 1998). Income generated by industrialized farming (relative to family farming and over time) also appears less likely to filter down to families of different social classes. As noted, Lobao (1990) and Crowley (1999) found that income inequality was higher in communities where industrialized farming was greater.

5. *There are long-term as well as short-term consequences of industrialized farming for communities and for regional development within a state.*

Industrialized farming puts a community on a path of development whose consequences are not fully manifest in the short term of one or two years. Lobao (1990) found that some impacts were manifest a decade later. As noted earlier, counties with greater industrialized farming in 1970 had significantly poorer well-being a decade later: these counties had lower median family income, higher family poverty rates, and higher income inequality relative to other counties and net of past county conditions.

For the heartland states, including North Dakota, economists at the Federal Reserve Board of Kansas City (Drabenstott and Smith 1996:4) indicate that differences in communities will widen over time. According to these economists:

> Industrialized agriculture produces two effects on rural communities. As production increases in some "cluster" communities, it will leave others, lessening agriculture's impacts. Communities that are home to industrialized production and processing may see jobs and income increase. But even there, the economic links will be different than under community production. More production inputs are purchased from nonlocal sources, and more of the profits go to nonlocal owners of the firm.

B. Types of Studies Conducted on the Effects of Industrialized Farming: Research Designs and Methodology

Analysts have used primarily four different types of research designs to assess whether industrialized farms have detrimental impacts on communities. Each design has inherent strengths and limitations in being able to comprehensively analyze industrialized farming and its many potential impacts noted above.[11]

1. *Case-study designs* provide in-depth analysis of the consequences of industrialized farming in a single or multi- community site. Usually, a comparative case-study design is implemented whereby a community or communities characterized by industrialized farming are contrasted with a community or communities with a different farming pattern

[11] We have outlined the strengths and limitations that are intrinsic to each research design. A individual study will vary as to how the analysts have exploited the strengths or overcome the limitations of the design.

(usually moderate-size, family-owned and operated farms). A comparative case-study design allows communities to be matched on similar background characteristics, such as location near cities and dependency on farming as an economic base, which helps to "control" (or exclude) extraneous factors that influence the relationship between farming type and community well-being. Examples of case studies are Goldschmidt (1978a) noted above and the North Central Regional Center for Rural Development (1999). The strengths of case-studies are the following. (a) They provide detailed information about how both scale and organizational aspects of industrialized farming impact community well-being. (b) They provide detailed information about outcomes for a great many community indicators of local socioeconomic well-being, social fabric, and environment. (c) They trace the direct and indirect effects of industrialized farming. (d) They can address short-term as well as long-term outcomes. The inherent limitation of case-studies is that detailed conclusions are produced about the impacts of industrialized farms in specific site communities at the expense of producing less detailed findings but over a greater number of research sites. Case-studies also vary as to how well the analyst is able to partition out extraneous factors that influence the causal relationships of importance.

2. *Macro-social accounting designs* involve statistical analysis of secondary or pre-collected data from government and other sources, such as the Census of Agriculture and Census of Population, to document relationships found in regional social structure (MacCannell 1988). Community units, such as counties and townships, and states are the research focus. To assess the consequences of industrialized farming, analysts usually compare its effects relative to other farming (usually smaller or moderate-size family farm units) and over time, while controlling for other, non-farm factors known to affect community well-being. Multivariate statistical techniques, such as regression procedures and discriminant analysis, are used so that the effects of farm structure are assessed net of other community conditions. Examples are Gilles and Dalecki (1988), Lobao (1990), Crowley (1999), Crowley and Roscigno (2004) and Irwin et al. (1999). The strengths of these studies are the following. (a) They provide conclusions about true (actual empirical) relationships, which are generalizable across many communities, various states, and the nation as a whole. (b) They provide conclusions about industrialized farming using measures of scale and organization. Customary measures of industrialized farming in these studies are: for scale, farm size in sales, such as the percent of farms above some gross annual sales threshold (e.g. above $500,000) or depending upon commodity, acreage above a certain size; for organizational indicators, percent of farms organized as corporations or non-family-held corporations; percent of farms with full-time hired labor; annual costs of hired labor per farm; and non-resident operators. (c) Macro-social accounting designs provide conclusions about a variety of socioeconomic well-being indicators (i.e., unemployment rate, poverty rate, income levels, income inequality), social fabric impacts (i.e., population change, educational attainments, health status, family disruption indicators), and about some environmental indicators (i.e., energy usage). (d) They address short-term and long-term relationships between industrialized farming and community well-being. The inherent limitation of these studies is that they depend on the availability of pre-collected data, which constrains the use of certain measures and time periods of study. Some organizational measures of industrialized farming, contract farm-

ing and vertical integration of farm units are not available over time from the Census of Agriculture or from other secondary sources across communities.

3. *Regional economic impact models* use linear programming methods to estimate impacts on employment and income for regions, states, and smaller units such as counties and cities. These studies focus on the integration of business enterprises in markets and use programs, such as variants of input-output analysis, to model the backward and forward linkages with enterprises in other industries and to estimate resulting local impacts. The costs and benefits of varying different firm-level practices can be estimated. Examples are studies by Heady and Sonka (1974), Marousek (1979), Otto et al. (1998), and Thompson and Haskins (1998). The strengths of regional economic impact models are the following. (a) They provide detail about economic performance, such as the number of jobs and total income produced by firms or industries in a region or community. (b) They can provide projected estimates, so that the potential impacts of not yet existing enterprises can be appraised. Limitations of regional economic impact, input-output models are well-known and documented.[12] In brief, most models involve assumptions about relationships not actually found in the community--that is, models depend on estimates from past years and different places. To the extent to which real (true, empirical) conditions in a particular community vary, these studies will not provide accurate assessment of impacts. Another inherent limitation is the types indicators of industrialized farming and impacts addressed. Farm scale, as indicated by sales and labor force size, is analyzed, not the organization of production. These studies do not examine certain socioeconomic well-being indicators such as family poverty and income inequality (the degree to which economic growth is shared by families throughout the community); nor do they examine social fabric or environmental indicators. Finally, input-output analyses of industrialized farming usually do not address long-term impacts, such as over the course of a decade.

4. *Survey-design studies* use samples of populations from any number of communities. These studies use interviews or questionnaires to document how industrialized farming affects residents or a particular social group exposed to industrialized farming as compared to those who are not (such as those residing in family farming communities). In contrast to macro-social accounting and economic impact models which are based usually on secondary or pre-collected data, the researchers using a survey design collect primary data directly from individuals or families. Multivariate statistical procedures such as regression are used to assess the consequences of farm variables net of other community and individual characteristics. Examples of studies based on survey designs are Heffernan and Lasley (1978), Poole (1981), Wing and Wolf (1999). The strengths of these studies are the following. (a) They provide detailed information about how both scale and organizational aspects of industrialized farming impact individuals or families. (b) They

[12] A good review of input-output analysis is provided by the recent report published by the University of Minnesota (1999) on the impacts of the livestock industry. The authors (pp. F35-F56) note that input-output models, such as IMPLAN, are limited by the quality of data used in the models, the assumptions made about regional purchase coefficients, and how economic shocks are specified. The authors note that for the present period it has become increasingly difficult to obtain data from large farms and therefore more difficult to adequately analyze costs by size of operation.

provide detailed information about outcomes for a great many indicators of personal and family social and economic well-being, including social fabric indicators, such as community participation and stress, health status, all of which allows for a more in-depth analysis of quality of life. Inherent limitations of surveys for addressing the impacts of industrialized farming are that cost considerations often restrict surveys to specific states and communities and to one time point.

C. Conclusions of Studies Examining Industrialized Farming and Community Well-being

As noted, to assess the consequences of industrialized farming, it is useful to examine the body of past work conducted by researchers from various social science disciplines, over time, and using different methodologies. Table 1 reports the conclusions from 56 studies conducted since the 1930s on the effects of industrialized farming on communities to provide the most recent findings for each of the four study designs above. This table has been updated from Lobao (2000) by adding all empirical studies published on the topic in *Rural Sociology* (the major scholarly journal in this field) since 2000. A review of articles in the *American Journal of Agricultural Economics* (the major scholarly journal in this field) over the past five years was undertaken but no empirical studies were found on the topic. In addition, the following journals were surveyed for articles relevant to the topic: *Agriculture, Food and Human Values, Culture and Agriculture, Sociologia Ruralis, Southern Rural Sociology, American Journal of Alternative Agriculture* (now the *Renewable Agriculture and Food Systems* journal*), Journal of Rural Studies* and the *International Journal of the Sociology of Agriculture and Food.* Two scholarly search engines -- *Google Scholar* and *Agricola* – were also used to find relevant articles. Some articles were located serendipitously. The programs and abstracts for the 2000-2005 annual meetings of the Rural Sociological Society also were reviewed.

In Table 1, studies are classified by: (a) methodology, referring to the research designs described above; (b) regions of the country analyzed; (c) the indicators used to measure industrialized farming; (d) types of impacts analyzed; and (e) results of the study as to whether detrimental impacts were found (discussed further below). With regard to the indicators of industrialized farming, most of the studies examine farm scale; organizational characteristics are examined less frequently. The studies examine a wide variety of impacts on community well-being. Community well-being impacts were classified as to whether they were socioeconomic well-being indicators (income levels, poverty, and unemployment); indicators of social fabric (population change, social class, civic involvement, quality and types of community services, population size and composition, and social disruption indicators such as stress and crime); and environmental impacts. In most studies (all of the sociological studies), the authors hypothesize that where farms are larger scale or industrialized in terms of organizational characteristics, they have a detrimental impact on the indicator(s) of community well-being, relative to family-owned and operated farms. These relationships are expected to be found across communities and over time.

Types of Detrimental Impacts Reported by Social Scientists

Social scientists report that industrialized farms are related to relatively worse conditions for the following community impacts:

Socioeconomic Well-being

1. Lower relative incomes for certain segments of the community: greater income inequality (income polarization between affluent and poor), or greater poverty.
   (Tetreau 1940; Goldschmidt 1978a; Heady and Sonka 1974; Rodefeld 1974; Flora et al. 1977; Wheelock 1979; Lobao 1990; Crowley 1999, Deller, 2003; Crowly & Roscigno, 2004: Peters, 2002; Welsch & Lyson, 2001; Durrenberger and Thu, 1996)
2. Higher unemployment rates.
   (Skees and Swanson 1988; Welsch & Lyson, 2001)
3. Lower total community employment generated.
   (Marousek 1979; Thompson and Haskins 1999)

Social Fabric

1. Population: decline in local population size where family farms are replaced by industrialized farms; smaller population sustained by industrialized farms relative to family farms. (Goldschmidt 1978a; Heady and Sonka 1974; Rodefeld 1974; Wheelock 1979; Swanson 1980)
2. Class composition: social class structure becomes poorer (increases in hired labor). (Gilles and Dalecki 1988; Goldschmidt 1978a; Harris and Gilbert 1982)
   Social disruption:
   - increases in crime rates and civil suits (North Central Regional Center for Rural Development 1999);
   - general increase in social conflict (Seipel et al. 1999);
   - greater childbearing among teenagers (Lobao 1990);
   - increased stress, social-psychological problems (Martinson et al. 1976; Schiffman et al. 1998)
   - swine CAFOs located in census blocks with high poverty and minority populations (Wilson, et al., 2002)
   - deterioration of relationships between hog farmers and neighbors (Jackson-Smith & Gillespie, 2005; McMillan and Schulman, 2003)
   - more stressful, less neighborly relations (Constance & Tuinstra, 2004; Smithers, et al., 2004)
4. Civic participation: deterioration in community organizations, less involvement in social life. (Goldschmidt 1978a; Heffernan and Lasley 1978; Poole 1981; Rodefeld 1974; Lyson, et al, 2004; Smithers, 2004)
5. Quality of local governance: less democratic political decision-making, public becomes less involved as outside agribusiness interests increase control over local decision-making.
   (Tetreau 1940; Rodefeld 1974; Goldschmidt 1978a; McMillan and Schulman, 2003)

6. Community services: fewer or poorer quality public services, fewer churches. (Tetreau 1940; Fujimoto 1977; Goldschmidt 1978a; Swanson 1980)
7. Retail trade: decreased retail trade and fewer, less diverse retail firms. (Goldschmidt 1978a; Heady and Sonka 1974; Rodefeld 1974; Fujimoto 1977; Marousek 1979; Swanson 1980; Skees and Swanson 1988; Foltz et al, 2002; Foltz & Zueli, 2005, Smithers, 2004; Gomez & Zhang, 2000)
8. Reduced enjoyment of property: deterioration of landscape, odor in communities with hog CAFOs (Schiffman et al. 1998; Wing and Wolf 1999; Constance & Tuinstra, 2005; Reisner et al., 2004; Wright et al., 2005; Wing and Wolf, 2000; Kleiner, 2003; McMillan and Schulman, 2003)
9. Health: neighbors of hog CAFOs report upper respiratory, digestive tract disorder, eye problems. (Wing and Wolf 1999; Constance & Tuinstra, 2005; Reisner et al., 2004; Wright et al., 2005; Wing and Wolf, 2000; Kleiner, 2003)
10. Real estate values: residences closest to hog CAFOs experience declining values relative to those more distant. (North Central Regional Center for Rural Development (1999:46); Seipel et al. 1998; Constance & Tuinstra, 2005; Reisner et al., 2004; Wright et al., 2005)

Environment

1. Eco-system strains: depletion of water, other energy resources. (Tetreau 1940; Buttel and Larson 1979; North Central Regional Center for Rural Development 1999)
2. Environmental consequences of CAFOs: increase in Safe Drinking Water Act violations, air quality problems, increased risks of nutrient overload in soils. (North Central Regional Center for Rural Development 1999)

Summary of Conclusions Reported by Social Scientists by Study

In addition to showing the types of impacts reported in the social science literature, the studies also provide an overview of the consistency of evidence on the risks of industrialized farming. For each study, a number of different relationships may be tested. Authors invariably provide a summary estimation of each study's conclusion. Whether hypotheses about detrimental effects were largely supported (e.g. the authors report detrimental impacts overall); whether there were mixed findings (authors report only some detrimental impacts were found); and whether authors' report no detrimental effects. The results of the studies were then classified according to findings along those three lines: detrimental, some detrimental, or No Detrimental. Out of the total 56 studies, the researchers report largely detrimental impacts in 32, some detrimental impacts in 14, and no evidence of detrimental impacts in 10. Thus, over 82% (46 out of 56) of the studies report finding some negative impacts of industrialized farming. It is this consistency of past research which leads researchers to hypothesize that industrialized farming will jeopardize communities.

Of the thirty two studies where social scientists found predominantly detrimental impacts, the following points should be noted. First, studies reporting these impacts exist through all time periods, from the 1930s to the present. The studies show detrimental impacts for socioeconomic well-being, social fabric, and environment across communities, for both scale and organizational indicators, and throughout all regions of the country, including the North Central heartland states. These studies use five types of research designs, comparative case study, macro-social

accounting, regional economic impact models and survey. In other words, a great deal of evidence produced over time, for various regions of the country, by different researchers, and by five different research designs shows that industrialized farming has detrimental impacts.

Of the fourteen studies where social scientists report some, but not consistenly negative impacts of industrialized farming, the following points should be noted. These studies provide mixed findings, in that while adverse effects on some community indicators were found, at least one of the following also occurred: (a) industrialized farming had no statistical relationship with other indicators (i.e. there was an absence of any relationship); (b) industrialized farming had a trade-off effect, with beneficial effects on certain indicators; (c) industrialized farming did not consistently produce negative impacts for all time periods or regions; or (d) industrialized farming produced beneficial effects for some groups but Detrimental to other groups. These studies were found principally in the use of four research designs: regional impact studies of economic performance, macro-social accounting, case study, and survey. Regional impact studies (e.g., Heady and Sonka 1974; Marousek 1979) have tended to show costs-benefits for economic performance indicators, with larger farms injecting greater total income into the community, but also producing less employment relative to smaller farms. In the case of macro-social accounting studies reporting mixed effects, Lobao's (1990) study is an example. For counties in the forty-eight contiguous states, industrialized farming had no relationship with family poverty or median family income at either of two single time points (1970 and 1980); however, industrialized farming was related to higher income inequality at both time points and also to lower family income, higher poverty, and higher income inequality over the decade from 1970-1980 (i.e. counties with greater industrialized farming in 1970 experienced relative declines in socioeconomic well-being over the decade).

An example of a case study showing mixed effects is Wright, et al., (2001) conducted in six CAFO counties in Minnesota. This study demonstrated the mixed impacts of CAFOs for residents in these counties. This study found that CAFOs had positive effects for farmers who expanded their operations, detrimental effects for neighbors to CAFOs who saw their ability to enjoy their property deteriorate, detrimental effects for younger and mid-sized producers unable to expand because expansion by others had restricted their access to markets, detrimental effects for older producers who mourned a loss of a way of life, and no effects for those who were not neighbors or who were not expanding. The greatest detrimental effects were the decline in social capital as trust in government agencies declined due to their inability to make decisions in a timely manner, and a decline in cultural capital because of the differing visions of agriculture and of local communities.

A survey study (Jackson-Smith and Gillespie, 2005) also found mixed effects regarding the impact of scale on social relations. When demographic variables were controlled, there was little evidence that size of farm or use of hired workers was related to relationships with neighbors, however, farm size was the strongest predictor of neighbors' complaints about a dairy operation.

The ten studies that found no detrimental impacts of industrialized farming used regional impact models, macro-social accounting, and survey designs. Most of these studies analyzed only indicators of socioeconomic well-being. The regional impact study by Otto et al. (1998) indicated that larger farms are beneficial, both in terms of injecting greater income into a community and in creating more jobs. The results of this study were later challenged by Thompson and Haskins (1998) who argued that Otto et al. (1998) failed to correctly compare

large farms with smaller farms by holding constant total output. Here the point is not to dispute either study but to note that regional impact models because of their assumptions, use of shocks (i.e. disruptions to the regional economy), and focus on scale as opposed to organizational indicators usually find net benefits for specific economic performance indicators. An example of a macro-social accounting study that found no detrimental impacts is Lobao and Schulman (1991). They examined whether industrialized farming was related to higher poverty for the four major agricultural regions in the contiguous states for 1970-1980. They found while moderate-size family farming was related to lower poverty for the North Central states, there was no significant relationship between poverty and industrialized farming in any of the four U.S. regions analyzed. Most of the macro-social accounting studies finding no detrimental impacts of industrialized were conducted using data for 1970-1980. Skees and Swanson (1988) note that the time period may be a factor why detrimental impacts are less likely to be found, because industrialized farming was more regionally confined and of less magnitude in the past than in more recent time periods. A recent survey design study (Foltz and Zueli, 2005) did not find evidence that large farms are unlikely to purchase locally when the presence or absence of local suppliers was taken into consideration, and instead demonstrated that purchasing patterns are commodity specific and are determined by community attachment, and local supply considerations.

D. Examples of Recent Sociological Research on the Consequences of Industrialized Farming

1. Macro-social Accounting: Several macro-social accounting studies provide examples of recent sociological research on industrialized farming. The most recent macro-social accounting studies on the effects of industrialized farming are by Crowley (1999), Crowley and Roscigno (2004), Welsh and Lyson (2001), Lyson et al. (2001), and Peters (2002).

The 1999 study by Crowley analyzed the effects of farm concentration using several indicators: concentration of land, value of land and buildings, and the value of equipment and machinery) and data for counties in the North Central region comprising Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, Ohio, North Dakota, South Dakota, and Wisconsin. She analyzed consequences of these dimensions of farm-sector concentration for local levels of poverty and inequality, controlling for the influences of labor market, demographic, spatial, and other farm structure characteristics. As noted earlier, she found where farm sector concentration is higher (i.e., a few large farms held a large share of local property in land and real estate) both poverty and inequality are higher and education is lower.

In the 2004 study, Crowley and Roscigno documented how concentration of agricultural resources shapes rural community stratification through the political economic process. In addition to measures of farm sector concentration, measured by the gini coefficient and labor endowment, they extended the analysis to include measures of political process, and worker power attributes. Again using data for all (1053) counties in the North Central U.S. they found that dimensions of farm sector concentration shape both poverty and inequality. Furthermore, they found that farm sector concentration is explained by political economic processes, and these processes mediate the negative effects of land concentration on economic well-being. In particular, they found that relative to large scale farms, capital concentration promotes govern

ment spending that benefits large farms while it blocks government or labor-market programs that assist farmers whose farms it consumes and farm workers it exploits.

Whether people in agricultural areas in states with anti-corporate farming laws fare better on measures of economic health than do people in agricultural areas in states without such laws was studied by Welsh and Lyson (2001). In examining states with anti-corporate farming laws (Iowa, Kansas, Minnesota, Missouri, North Dakota, South Dakota, Oklahoma, and Wisconsin), they found that agriculture dependent counties in states with such laws fare better on economic measures, i.e. less families in poverty, lower unemployment, and higher percentages of farms realizing cash gains.

In the first analysis of all agriculture dependent counties, they found that agriculture dependent counties in states with anti-corporate farming laws have lower poverty rates, lower levels of unemployment, and a higher percentage of farms reporting cash gains than agriculture dependent counties in states without anti-corporate farming laws. These results were consistent for both the cross-sectional analysis (across states in same time period) and longitudinal analysis (within states across time periods). In the second analysis of states with more restrictive anti-corporate farming laws compared to states with less restrictive laws, the restrictiveness index had no effect on poverty in the cross sectional analysis (across states at the same time period) but a slight, positive association in the longitudinal analysis (within state, across time periods). That is, states with more restrictive laws have slightly higher poverty rates over time than do states with less restrictive laws. The restrictiveness index had a strong, negative association with unemployment in the cross-sectional analysis, but no association in the longitudinal analysis. That is, states with more restrictive laws have lower poverty rates at the same point in time than do states with less restrictive laws. Finally, the restrictiveness index had a strong positive association with the percentage of farms reporting cash grains in the cross-sectional analysis, but no association in the longitudinal analysis. That is, states with more restrictive laws have higher percentages of farms reporting cash gains at the same point in time than do states with less restrictive laws.

Lyson et al. (2001) found support for Goldschmidt's findings of a negative relationship between farm scale and community well-being, but these negative relationships were mediated by the presence or absence of a civically-engaged middle class. This study examined the agriculture dependent counties in the U.S. for the period 1982 to 1992. In this study, community welfare is measured by percentage of families in poverty, unemployment rates, and percentage of low birth weight babies. Civically-engaged middle class is measured by percentage of workforce that is self-employed, percentage of labor force working at home, and percentage of small commercial establishments. Farm scale is measured by percentage of sales by farms of $500,000 in sales, percentage of farm operators residing on their farms, percentage of tenant farmers in county, and percentage of hired labor on largest farms. They concluded that the presence of a civically-engaged middle class is a more consistent predictor of rural community welfare than was farm scale. More specifically, they found that counties dominated by large scale, absentee owned, agricultural enterprises have less favorable welfare outcomes. However, the presence of a civically-engaged middle class mitigates the negative relationships and enhances positive relationships between farm scale and community welfare. Their findings did not dispute the Goldschmidt hypothesis of a negative relationship between large scale, industrial type farms and community welfare, but they argue that the relationship is not as economistic and deterministic as had been typically hypothesized.

A study of the non-metropolitan counties in Iowa, Kansas, and Missouri by Peters (2002) found support for the argument that the economic structure of the agricultural, industrial and service sectors impacts socioeconomic conditions in non-metropolitan areas. More specifically, he found that areas with greater concentrations of owner-operated farms result in decreased children at risk scores. He argues that this finding supports the Goldschmidt hypothesis that family farming areas are better developed both economically and socially. Because the concentration of non-farm proprietorships did not predict children at risk scores, he suggests that it was not proprietorships in general that mattered as much as the economic nature of farming. He notes two problems with this measure: It does not differentiate between types of farm proprietorships, either by farm size, primary occupation, or management structure, and it does not identify what is unique about farm proprietorships as contrasted to other types of proprietorships that causes improved socioeconomic conditions for children. He also found that areas with greater concentrations of industrial agriculture, characterized by wage labor relations, produce worse socioeconomic conditions for children. This was one of the weakest predictors of children at risk scores, but one of the strongest predictors was percent employed in animal slaughter and meat processing which causes scores to increase. Peters argues that although not considered agricultural production, meat manufacturing is considered part of the agro-food industrial complex. When the measures of both production and of manufacturing of agricultural products are taken together as a measure of industrial agriculture, he argues they support the Goldschmidt hypothesis.

2. Case Studies: Five recent case studies (NCRCRD, 1999, Seipel et al., 1999; Wright et al., 2001; Constance and Tunistra, 2005; McMillan and Schulman, 2003) document the detrimental effects of confined animal feeding operations (CAFOs), a particular kind of industrial agriculture, on community quality of life.

A comprehensive case-study on industrialized farming is that by the North Central Regional Center for Rural Development (NCRCRD, 1999). This study is useful for providing documentation about relationships over time and for assessing impacts on a wide range of socioeconomic, social fabric, and environmental indicators. The study examines the impacts of a large, confined animal feeding operation (CAFO) owned by the Seaboard Corporation, which moved to Texas County, Oklahoma in 1992. Company officials indicated that Seaboard was attracted to Oklahoma because of the state's "relatively lax anti-corporate farm laws, permissive groundwater access laws, and generous public sector incentives" (NCRCRD 1999:1). Public sector incentives given to Seaboard to locate in the county totaled $60.6 million dollars, with the capital coming from publicly repaid bonds, taxes foregone, interest subsidies and grants, an investment of $27,500 per job created. At the time Seaboard moved to Texas County in 1992, the county had an unemployment rate of 3.7% and was among the highest per capita income counties in the state. Seaboard made extensive land purchases in the county to establish corporate-owned swine production facilities as few local cattle ranchers were interested in raising pigs due to the terms of the contracts offered (NCRCRD 1999:16). To analyze the effects of the CAFO, a comparative case-study design was used where changes in Texas County were compared to thirteen other farming dependent counties in Oklahoma. As a strategy of local

economic development, the CAFO performed poorly.[13] The number of jobs, per capita income, poverty rate, number of new businesses, and total bank assets did not change at a rate significantly different from the other, comparison farming dependent counties. Consumer loans increased at a greater rate in Texas County, but increases in commercial and industrial loans were greater in the comparison counties. The economic benefits gained were increases in retail sales and property values. The community costs of the CAFO were experienced largely in social fabric and environment. With regard to social fabric, beneficial impacts were seen in increased population and school enrollment relative to comparison counties. But most other indicators showed rifts in the social fabric. Crime rates increased by 74% in Texas county, compared to a decline of 12.5% in the comparison counties over 1990-1997 (NCRCRD 1999:38). Theft increased 64%, while it decreased 11% in the comparison counties. Violent crimes increased 378%, but decreased by 29% in the comparison counties. Availability of housing declined and rental rates increased to a greater degree than the comparison counties, indicating that crowding is occurring and that the elderly and poor may be priced out of the county. With regard to the environment, water quality violations were much greater in Texas County relative to the comparison counties. Livestock water use increased 66% from 1990 to 1995 in the county. Environmental impacts noted by NCRCRD (1999) were in water depletion and quality, odor, and increased risks of nutrient overload in local soils.

Research by Seipel et al. (1999) elaborate on the NCRCRD (1999) findings by outlining reasons why industrialized farming contributes to breakdowns in social fabric and to environmental degradation. Based on research in four Missouri communities, they note that *CAFOs tend to increase social conflict and personal and community stress for the following reasons:*

1. Some individuals and communities are exposed to the social and environmental harm of CAFOs when other people and communities are not, creating conflict between those residents that pay the costs of industrialized farming and those that do not.
2. The public has often not been involved in decision-making and has not chosen this development as a group.
3. Community residents experience loss of personal control as outsiders, politicians, and corporations are perceived as exercising control over local lives.
4. There is an infusion of new systems and people that communities must now accommodate.
5. While hog farms are a normal part of many rural areas, concentrated operations of thousands of animals confined to one location are not.
6. There is insecurity about health. Residents look to CAFOs and odor to explain personal and family health-related problems. There is increased concern about the health of children and later generations.

[13] The NCRCRD (1999:28-29) study describes how incorrect assumptions in input-output analysis led to misleading results about projected impacts of recruiting the new integrated corporate hog and pork producer to Texas county. Analysts used a figure of $35,137 for average annual income of swine production jobs in input-output models. However, this figure was derived from research in Iowa and was nearly twice the amount earned by swine production workers in Oklahoma. Thus, the input-output analysis severely over-estimated the total income and number of jobs that would be produced in the county by recruiting the corporation.

7. There is "loss of perceived control" (an indicator related to social psychological stress and depression). There is guilt and anxiety over the inability to protect oneself and family, and a feeling of powerlessness concerning resolution of the problems brought on by the industrialized operation.
8. Residents' perceptions about their community changes from a place of security and sense of attachment to a "a degraded space and context of conflict."
9. There is anger and disgust with those who bring CAFOs to the community, which leads to general distrust of government.
10. There is a social stigma attached to living in a CAFO community due to the deterioration of local landscape and to odor problems.

Seipel et al. (1999) note the following general environmental problems related to hog CAFOs:

1. Algae growth and oxygen depletion of surface waters
2. Contamination of wells and groundwaters
3. Contamination of surface water drinking supplies
4. Risk of drinking water contamination due to pathogens such as fecal coliform
5. For workers on CAFOs, the risks of health problems include: asthma, organic dust toxic syndrome, upper airway inflammation, and bronchitis
6. For neighbors of CAFOS, environmental health problem risks include: upper respiratory and digestive track disorders, headaches, nausea, and burning eyes.

Case studies conducted by Wright, et al., (2001) in six CAFO counties in Minnesota demonstrated the mixed impacts of CAFOs for residents in these counties. In these studies they found that CAFOs had positive effects for farmers who expanded their operations, detrimental for neighbors to CAFOs who saw their ability to enjoy their property deteriorate, detrimental for younger and mid-sized producers who were unable to expand because expansion by others has restricted their access to markets, detrimental for older producers who mourned a loss of a way of life, and no effects for those who were not neighbors and who were not expanding. The greatest detrimental effect was the decline in social capital as trust in government agencies declined due to their inability to make decisions in a timely manner, and a decline in cultural capital because of the differing visions of agriculture and of local communities.

A case study by Constance and Tuinstra (2005) found that the quality of life was more stressful and less neighborly in communities with chicken CAFOs. The strain between neighbors and CAFO owners was evident in their perception of the issues. While neighbors focused on substantive concerns of odor nuisances, water pollution, health problems, property values and community disruption, CAFO owners minimized these concerns by saying that it was either neighbors' jealousy or their impractical views of rural land use was the basis for their complaints. Some neighbors had been interested in becoming contract producers, but they had been turned off by Sanderson Farms' hard sell and did not think the contract Sanderson held out was a good business decision. Others realized that once the contract had been signed and chicken houses had been built, growers were locked into long term commitments. Thus, the community was at an impasse over the chicken CAFOs which polarized community relations.

As in the previous example, McMillan and Schulman (2003) also found that CAFOs reduced the quality of life and increased community conflict. Neighbors complained about odor nuisances, voiced concerns about the environmental consequences, worried about health related

concerns, thought they had been betrayed by hog producers, and felt the government had been unresponsive. Producers contended that swine CAFOs provided economic benefits to a depressed community, blamed the media for sensationalizing the concerns about CAFOs, and dismissed neighbors' concerns about quality of life, environmental and health issues as being irrational or overstated. Activists were concerned about the impact of the hog industry on health, the environment, local economic opportunities, community neighborliness and cohesion. They were especially concerned about its effects on the environment and human health through contamination of drinking water.

3. Regional Economic Impact Models: Results of analysis from several recent economic impact models (Gomez and Zhang, 2000; Deller, 2003; Foltz, et al., 2002) indicate that industrial agriculture poses detrimental effects to community well being.

The results of one study in Illinois (Gomez and Zhang, 2000) found that large hog farms actually hinder economic growth in rural communities. In a study of 2240 non-metropolitan US counties, Deller (2003) found that large scale agriculture, measured in sales and value added, and counties' dependence on agriculture, tends to result in lower levels of economic growth. He suggests that as agriculture expands either in terms of farm size or overall share of the economy, it would place downward pressure on regional growth rates. A study of dairy farms in Wisconsin by Foltz, et al. (2002), showed that scale (measured in herd size) had a negative effect on share of input purchases made locally. While one model suggests that community attachment increases local expenditures, another model indicates that that effect is described by distance. Demographic variables did not explain where dairy farmers make their purchases either. Both of the economic models show a significant negative effect for larger farm sizes (herd size) on the share of purchases made locally.

4. Survey Research: Several recent Survey Design Studies demonstrate the effects of industrialized farming on community quality of life. The most recent survey research on the effects of industrialized farming are by Reisner et al., (2004), Smithers et al. (2004), Foltz and Zueli, (2005), and Jackson-Smith and Gillespie (2005). Reisner et al. (2004) focuses on the strain on relations between neighbors and CAFO owners. The remaining three studies focus on how industrial agriculture affects relationships with neighbors or farm purchasing decisions.

The research by Reisner et al., (2004) documented the extent to which CAFOs increase the social tensions between neighbors and owners of swine farms in the community as well as the completely different definitions of the problem by neighbors and swine CAFO owners. While both residents and CAFO owners agreed on the presence, level and length of the controversy, residents were much less satisfied and perceived much less support for CAFOs than did the owners. Additionally, while the owners blamed many groups for the controversy over building or expansion of swine CAFOs, the neighbors identified themselves as the source of the controversy. Neighbors felt that large scale farming was a fait accompli, but they were much less satisfied with the presence of CAFOs than the owners thought they were. The greatest differences between neighbors and owners was about the degree of effect of the large-scale swine farms. Neighbors reported more days with detectable odors than did owners and were more likely to believe that there were problems with water pollution and more likely to report that CAFOs were causing their homes to decline in value.

Three survey design studies also discussed the extent to which industrial agriculture has affected social relationships between large scale farmers and their neighbors, or between large scale farmers and their communities. Smithers et al., (2204) in their survey of Ontario farmers, found that those classified as being in the expansionist mode were constrained in their ability to participate in social activities and organizations, were more likely to not purchase their inputs locally but instead sought the cheapest source, and viewed the community instrumentally in regards as to the goods and services it could provide the farm.

Foltz and Zeuli (2005) did not find that large scale farms (in terms of herd size) purchased less locally than did small farms. They did find that the presence or absence of local marketing or supply outlets and attachment to community influence the decision to purchase locally. Generally, they found that purchasing patterns are commodity specific and not determined by farm size or other farm-level characteristics. Attachment to a community affects purchasing decisions only where there is a choice available to farmers.

Jackson-Smith and Gillespie (2005) were also interested in the relationships between large scale dairy farmers (in terms of herd size) and their neighbors. In the multivariate analysis, demographic variables were associated with knowing neighbors well. When demographic variables (age, children at home, length of time operating the farm) were controlled, there was little evidence that size of farm or use of hired workers was related to relationships with neighbors. Farm size, however, was the strongest predictor that neighbors had complained about a dairy operation. These results, they suggest, indicate that regardless of a dairy farm's household social ties, building a large operation will generate conflicts with neighbors. In regard to community participation, they found that both demographic and farm structural variables determine participation. More specifically, age, education, children at home, use of hired workers, and plans to remain in dairy farming are positively related to involvement in community organizations.

Finally, one study used neighborhood level analysis to test the relationship between exposure to concentrated animal feeding operations and perception of CAFO impacts on rural communities, the economy, and the environment. Kleiner (2003) argues that the neighborhood and not the county is the unit of analysis that is more appropriate for understanding the impacts of industrialization of agriculture. Using GPS technology, she identified households for their actual distance from a swine CAFO in two counties characterized by large-scale, corporate-owned and operated swine CAFOs. She compared responses to rural residents in a control group county without such CAFOs. Her analysis found that proximity to large-scale livestock facilities is associated with people's perceptions of CAFOs impacts, especially environmental impacts. The lower mean scores on overall community impacts and environmental impacts for residents in the neighborhood closest to a CAFO of a county characterized by high concentration of CAFOs were expected when compared to mean scores derived from the combined data from the three counties. Furthernore, attitudes about current regulations for CAFOs were found to be more negative for the residents in the neighborhood in the county characterized by a high concentration of CAFOs compared to the combined scores for the three counties. When the types of impacts were analyzed separately, she found that economic impacts are more obvious to residents than perceived social and environmental impacts. This explains, she contends, why residents of corporate CAFO counties are more likely to perceive CAFO impacts more positively than residents of the non-corporate CAFO county which have less direct experience with them. The findings suggest that negative CAFO impacts perceived by residents in close proximity tend

to impact behavioral patterns in and around the home, especially in the county where CAFOs are most concentrated.

E. Industrialized Farming and Regional Imbalances in Opportunities to Engage in Farming and Well-Being

Thus far this report has focused on impacts occurring in communities. Another way that industrialized farming may adversely affect public well-being is through creating differences within a region. Until recently, the historical predominance of moderate-size family farms in the Heartland helped create a stable region economy with middle class farming communities (Flora and Flora 1988; van Es et al. 1988). This is now changing. For the Heartland states, economists at the Federal Reserve Board of Kansas City indicate that differences in communities within any given state will widen over time with regard to communities' ability to participate in commodity agriculture. It is useful to quote at length from their analysis (Drabenstott and Smith 1996:4).

> Agriculture is a common ingredient to the rural economy throughout the Heartland. The 12 Heartland-states are home to more than two-thirds of the nation's farm-dependent counties. Historically, agriculture has been a primary engine of growth for rural communities. A large number of mid-sized farms have created significant economic multiplier effect for agriculture, enhanced by any local agricultural processing in rural areas.
>
> Today, that picture is changing. Heartland agriculture has moved quite rapidly to fewer, bigger farms. The largest farms in the United States, those with annual sales greater than $500,000 a year are just 2.5% of all farms; yet they account for 40 percent of farm output. A similar pattern is found in Heartland states.
>
> As agricultural production has moved to bigger farms, agriculture's links with local rural communities have weakened. Large farms tend to procure their inputs, including financial capital, from more distant places that can offer more products and lower prices. In addition, large farms often have direct marketing relationships with processors, by-passing local buyers.
>
> More recently, a pickup in the industrialization of agriculture has further weakened linkages to local rural communities. Industrialization refers to the movement toward more direct production and marketing relationships between producers and processors, a trend now symbolized by the broiler industry. Under industrialization, processors attempt to secure a stable supply of consistent product while exploiting the economies of scale in new production and processing methods. The result is a further concentration of production, as production shifts to bigger firms and clusters around processing plants much more than in the past.
>
> Industrialized agriculture produces two effects on rural communities. As production increases in some "cluster" communities, it will leave others, lessening agriculture's impacts. Communities that are home to industrialized production and processing may see jobs and income increase. But even there, the economic links will be different than under community production. More production inputs are purchased from nonlocal sources, and more of the profits go to nonlocal owners of the firm.
>
> Agriculture remains important to the Heartland. But its economic impact is much different than in the past. Commodity agriculture remains, but it is in bigger hands. And the advent of industrialized agriculture creates a new pattern of agricultural haves and have-nots. And even in those communities that have industrialized agriculture, the economic links are different than in the past.

Barkema and Drabenstott (1996:72) note that while some communities in the region will lose farms and farmers due to production concentration in other communities, those gaining new agribusiness, at least in the meat industry, are not likely to realize great economic gains.

> While the region's meat prospects are good, the corresponding economic impact may be low. Wages in the meat industry are relatively low. Moreover, the value added in meat processing is low. The average value added for all food products is 39 percent, for meat products it is just 21 percent. Thus, the region's solid prospects for expanding meat processing are unlikely to provide a wide-spread economic tide for Heartland

Barkema and Drabenstott's (1996:72) conclusion is supported by the NCRCRD (1999) study above that found no appreciable gains in per capita income and employment growth where CAFO recruitment occurred relative to comparison counties in Oklahoma where it did not occur. In the industrial sociology and economic geography literatures, food processing is considered part of the peripheral manufacturing sector (Lobao et al. 1999). Production here is routinized, wages are relatively low-wage compared to durable manufacturing and certain services, and firms tend to be more footloose in seeking out low-costs labor. In sum, reliance on meat processing is not likely to enhance community development over the long-term.

Relatedly, communities that look to industrialized farming to solve economic development problems will not only confront the problems noted above in terms of social fabric and environment but also are pursuing a strategy that may be costly in terms of long-term development. While it is often noted that smaller farms (as all smaller businesses) fail more often than larger farms,[14] analysts rarely consider the opposite side of the coin: when large vertically-integrated farm corporations fail they are likely to do a great deal of community damage, particularly if scarce public resources have been used to attract them. NCRCRD (1999) details the extensive public sector incentives such as tax increment financing, tax exemptions, interest-free loans, and grants given to recruit CAFOs. Public resources and community well-being are at risk should such farms underperform in their agreements with local governments or fail overall.

As vertically integrated production in agriculture is new to many communities, its failure rate is yet to be adequately assessed, particularly over the long-term. Public concern with large confinement operations is demanding that these farms adhere to ever higher standards of social and environmental responsibility. Whether the operators of these farms have the skills and expertise to succeed in a climate demanding increased consumer and public accountability and at the same time remain competitive is unclear. In Ohio, for instance, the German owner of Buckeye Egg Farm (one of the country's largest egg producers with nearly 15 million hens in three Ohio counties) was banned from professional contact with animals in his native Germany. His operations in Ohio have faced a continual series of "serious environmental, regulatory, financial and public- relations problems" in the 1990s (Columbus Dispatch, November 7, 1999: 2g). The Ohio EPA recently filed a lawsuit accusing the company of violations of Ohio's solid-waste, water-pollution-control, safe-drinking-water, air-pollution and nuisance laws (Columbus Dispatch, December 22, 1999:1h-2h).

The diversion of state and local resources toward regulating the operation of large farms confining many animals to a single location must be considered in assessing the impacts of industrialized farming. The problem is compounded in rural areas, because rural local governments are already disadvantaged in staff and fiscal resources needed to adequately serve their

[14] Sociologists again would point out that moderate-size farms are not inherently less efficient producers but that they are disadvantaged in competing with large farms that have transaction costs advantages in terms of buying and selling.

populations. They do not have the resources to engage in endless rounds of litigation to protect the well-being of their residents.

IV. SUMMARY AND CONCLUSIONS

Based on the evidence generated by social science research, we conclude that public concern about the detrimental community impacts of industrialized farming is warranted. In brief, this conclusion rests on five decades of government and academic concern with this topic, a concern that has not abetted but that has grown more intense in recent years, as the social and environmental problems associated with large animal confinement operations have become widely recognized. It rests on the consistency of five decades of social science research which has found detrimental effects of industrialized farming on many indicators of community quality of life, particularly those involving the social fabric of communities. And it rests on the new round of risks posed by industrialized farming to Heartland agriculture, communities, the environment, and regional development as a whole.

In this report, a review by Lobao (2000) was updated to 2006 so that the findings of past and recent research on industrialized farming could be systematically documented. The conclusions from fifty six studies (32 detrimental effects and 14 some detrimental effects) examining the consequences of industrialized farming for communities were evaluated. Approximately 82 percent of these studies found adverse impacts on indicators of community well-being. The types of indicators and the number of studies reporting these are discussed in Table 1 and in the text. Analysts have tended to find the following impacts.

For socioeconomic well-being, researchers noted that industrialized farming was related to higher income inequality and to lower community employment, relative to moderate-size family farming. Higher income inequality indicates that industrialized farming is less likely to sustain middle-class communities. Places with higher income inequality also are prone to other social problems because the gap between affluent and poor is greater. With regard to other socioeconomic impacts, such as total income injected into the community, regional economic impact models were likely to report beneficial impacts. However, the findings for income inequality suggests that income growth is impeded in trickling down to families.

Studies assessing consequences for the social fabric of communities were likely to find detrimental impacts. Industrialized farming affects the social fabric of communities through altering population size and social composition which affect crime, social conflict, family stability, the local class structure, community participation, and local shopping patterns. Case-studies reported the loss of local autonomy, in which communities become increasingly subject to the influence of external business owners who interests may not be compatible with their own. More recent studies reported environment impacts. Because large animal confinement operations house densely concentrated livestock, they are prone to a host of negative environmental impacts on water, air, and human health.

Given the relative consistency of past research, the studies such as Crowley's (1999), Crowley and Roscigno's (2004), and Welsh and Lyson's (2001) which specifically analyzed North Central states, including North Dakota, and research focused on neighboring states in the region, there is every reason to expect that the conclusions drawn here apply to North Dakota. From the social science literature, we can anticipate four sets of impacts of industrialized farming for farming-dependent communities in Heartland states such as North Dakota: impacts

on socioeconomic well-being, social fabric, the environment, and regional imbalances.

Communities that receive industrialized farming are likely to increase population relative to other communities (that is, if local family farmers are not displaced). These communities may increase employment and per capita income but as shown by the NCRCRD (1999) study, this may not be at a rate significantly different from comparison locales.

Communities with industrialized farms are likely to experience greater income inequality; government services for the poor and other disadvantaged groups are likely to be needed in these locales.

Communities that gain new industrialized farming will encounter stresses in the social fabric; community decision-making is likely to be more subject to corporate farm interests; and in the case of large livestock confinement operations, communities will be at risk for environmental and health problems, entailing the need for state and local government intervention.

Communities that lose moderate-size family farms, in part because of transaction cost advantages (e.g., volume buying-selling) and public incentives given to industrialized farms, will lose a base of middle class producers and experience rifts in social fabric, including population decline. These communities are likely to have declines in other businesses and in the local property tax base and may require government aid for social and public services.

Regional clustering of agricultural production is likely to occur (Drabenstott and Smith 1996:4). While some communities will gain industrialized farming (and it attendant costs and benefits) others will continue to lose their family farm base as production clusters closer to large processors. Within states, there is thus likely to be greater inequality between communities over time.

Not discussed in this report are alternative economic development strategies that farming dependent communities can pursue. Notwithstanding arguments that vertical integration into farming and production contracts are the only options left to keep American farmers farming, there are alternatives and some working examples are discussed in NCRCRD (1999).

From a sociological standpoint, government plays a role in the types of consequences that industrialized farming will have for community well-being. It establishes the legal-institutional framework for regulating these farms. It establishes the incentive structure offered to agribusiness firms in their location decisions. It provides the public services needed to mop up the destabilizing impacts of industrialized farming, such as a rising crime rate, increased social conflict, and the need for social services to cope with a changing population. And government will need to provide the social services related to population decline and poverty alleviation in communities which lose family farming.[15]

Prior to Welsh and Lyson's (2001) research, the role that laws regulating corporate farms have in countering detrimental community impacts of industrialized farming had only been alluded to by some researchers. Lobao and Schulman (1991:596) postulated that one of the reasons why a few studies have found that industrialized farming has had less adverse effects in the North Central Heartland region (relative to the South and West) is due to its agrarian history

[15] In non-farm dependent communities, government intervenes in a number of ways when paid employment, such as in manufacturing and mining declines: through programs such as unemployment insurance, various income transfers, such as welfare payments, for which independent farm operators are generally not eligible due to property ownership; through re-training programs, such as for workers who lose jobs because of NAFTA; and through enforcement of community rights in plant closure laws. Because of their farming base, farm-dependent communities usually cannot make as full use of these social safety nets as can other communities.

of protection of family farming and regulation of corporate farming. NCRCRD (1999:1) also indicated that "relatively lax anti-corporate farming laws, weak environmental regulations and permissive groundwater access laws" not surprisingly encouraged large, animal confinement operation to locate in Kansas. When Welsh and Lyson (2001) examined states with anti-corporate farming laws (Iowa, Kansas, Minnesota, Missouri, North Dakota, South Dakota, Oklahoma, and Wisconsin), they found that agriculture dependent counties in states with such laws fare better on economic measures, i.e. less families in poverty, lower unemployment, and higher percentages of farms realizing cash gains. In the comparison of states with less restrictive vs. states with more restrictive laws, they generally found the same results as with the comparison of states with anti-corporate farming laws and states without such laws.

Remote rural counties appear to be targeted as recent operating sites by large animal confinement operations. Research by Wilson et al. (2002) demonstrated that census blocks in Mississippi with high percentages of African Americans or people in poverty were much more likely to be the locations of swine CAFOs. Of all local governments, remote rural counties have the least resources (staff, economic development, and social service budget) to cope with industrialized farming. These governments are in weak positions to bargain successfully with external corporations, to regulate their operations once they are in place, and to protect community social life and environment overall. Remote rural counties are the places where state protection from industrialized farming is most critical due, in part, to the fragility of local government.

From a social science standpoint, the farming system in place today has been created from both market forces and government policy and programs. It is thus logical that government can also be an instrument in transforming this system toward greater public accountability.

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Table 1. Summary of Studies Examining Industrialized Farming and Community Well-Being*

Study	Methodology	Region	Measures of Industrialized Farming	Community Well-Being Indicators	Results
Goldschmidt (1968, 1978a) (1944, original)	Comparative Case Study, two communities	California	scale/ organization	Socioeconomic/Social Fabric (class structure, services, population, politics, retail trade)	Detrimental
Tetreau (1938, 1940) (one study, two articles)	Survey Design Study, 2700 households	Arizona	scale/ organization	General Socioeconomic Indicators/Social Fabric (class structure)	Detrimental
Heffernan (1972)	Survey Design Study, 138 broiler producers	Louisiana	organization	Social Fabric (social psychological indicators, community involvement)	Detrimental
Heady and Sonka (1974)	Regional Economic Impact Model of 150 producing areas	continental U.S.	scale	Socioeconomic: Economic performance (income, employment generation)	Some Detrimental: large farms lower food costs but generate less total community income
Rodefeld (1974)	Survey Design Study, 180 producers from 100 farms	Wisconsin	scale/ organization	Socioeconomic/Social Fabric (class structures, services, population size)	Detrimental
Martinson et al. (1976)	Survey Design Study, 180 producers	Wisconsin	organization	Social Fabric (social psychological indicators)	Detrimental
Fujimoto (1977)	Macro-social Accounting, 130 towns	California	scale	Social Fabric (community services)	Detrimental

Study	Methodology	Region	Measures of Industrialized Farming	Community Well-Being Indicators	Results
Flora et al. (1977)	Macro-social Accounting, 105 counties	Kansas	scale/ organization	Socioeconomic/Social Fabric (class structure, services)	Some Detrimental: industrialized farming is related to greater income inequality but other relation-ships not clearly supported
Small Farm Viability Project (1977)	Comparative Case Study, reanalysis of Arvin and Dinuba	California	scale/ organization	Socioeconomic/Social Fabric (class structure, services)	Detrimental
Goldschmidt (1978b)	Macro-social Accounting, states	entire U.S. except Alaska	scale	Social Fabric (agrarian class structure)	Detrimental
Heffernan and Lasley (1978)	Survey Design Study, 36 grape producers	Missouri	organization	Social Fabric (community social and economic involvement)	Some Detrimental: operators of nonfamily farms less involved in community activities but little support for other relationships
Wheelock (1979)	Macro-social Accounting, 61 counties	Alabama	scale	Socioeconomic/Social Fabric (class structure, population size)	Some Detrimental: rapid increases in farm scale related to decline of population, income, and white collar labor force; other relation-ships mixed.
Marousek (1979)	Regional Economic Impact, one community	Idaho	scale	Socioeconomic: Economic performance (income, employment generation)	Some Detrimental: large farms result in greater regional income but produce less employment than small farms

Study	Methodology	Region	Measures of Industrialized Farming	Community Well-Being Indicators	Results
Buttel and Larson (1979)	Macro-social Accounting, state-level data	entire U.S.	scale/ organization	Environment (energy usage)	Detrimental
Heaton and Brown (1982)	Macro-social Accounting, county-level data	continental U.S.	scale/ organization	Environment (energy usage)	No Detrimental
Swanson (1980)	Macro-social Accounting, 27 counties	Nebraska	scale	Socioeconomic/Social Fabric (population size)	Detrimental
Poole (1981)	Survey Design Study, 78 farmers	Maryland	scale	Social Fabric (involvement in community organizations)	Detrimental
Harris and Gilbert (1982)	Macro-social Accounting, state-level data	continental U.S.	scale/ organization	Socioeconomic/Social Fabric (class structure)	Some Detrimental: large farms result in more lower class farm personnel but have positive total effects on rural income
Swanson (1982)	Macro-social Accounting, 520 communities	Pennsylvania	scale/number of farms	Social Fabric (population)	No Detrimental
Green (1985)	Macro-social Accounting, 109 counties	Missouri	scale/ organization	Socioeconomic/Social Fabric (services, population size)	No Detrimental

Study	Methodology	Region	Measures of Industrialized Farming	Community Well-Being Indicators	Results
Skees and Swanson (1988)	Macro-social Accounting, 706 counties	Southern U.S., excluding Florida, Texas	scale/ organization	Socioeconomic/Social Fabric (services)	Some Detrimental: moderate-size farms produce greater employment; large and very small farms related to higher unemployment; some detrimental impacts of large farms over time
MacCannell (1988)	Macro-social Accounting, 98 counties	Arizona, California, Florida, Texas	scale/ organization/ capital intensity	Socioeconomic/Social Fabric (population size, retail trade, local government taxation and expenditures)	Detrimental
Flora and Flora (1988)	Macro-social Accounting, 234 counties	Great Plains and West	scale	Socioeconomic/Social Fabric (retail trade, population size)	Some Detrimental: medium-sized farms relative to large farms enhance community well-being
Buttel et al. (1988)	Macro-social Accounting, 105 counties	Northeast	organization	Socioeconomic/Social Fabric (population, retail trade)	No Detrimental
van Es et al (1988)	Macro-social Accounting, 331 counties	Corn Belt	scale/ organization	Socioeconomic/Social Fabric (population size)	No Detrimental
Gilles and Dalecki (1988)	Macro-social Accounting, 346 counties	Corn Belt and Central Plains	scale/ organization	Socioeconomic	Some Detrimental: counties with greater numbers of hired laborers tend to have lower socio-economic well-being; other relationships for scale not supported

Study	Methodology	Region	Measures of Industrialized Farming	Community Well-Being Indicators	Results
Lobao (1990)	Macro-social Accounting, 3037 counties	Continental U.S.	scale/ organization	Socioeconomic/Social Fabric (income, poverty, income inequality, teenage fertility, infant mortality)	Some Detrimental: moderate-size family related to better socioeconomic conditions. Industrialized farming related to greater income inequality and births to teenagers, and over time to greater poverty and lower family income, but not to other indicators
Lobao and Schulman (1991)	Macro-social Accounting, 2,349 rural counties	U.S. and four regions	scale/ organization	Socioeconomic (poverty)	No Detrimental: moderate-size family farms related to lower poverty, most regions, industrialized farms have little relationship to poverty in any region
Barnes and Blevins (1993)	Macro-social Accounting, 2,000 rural counties	U.S.	scale/ organization	Socioeconomic (poverty, median income)	No Detrimental

Study	Methodology	Region	Measures of Industrialized Farming	Community Well-Being Indicators	Results
Durrenberger and Thu, (1996)	Macro-social Accounting	Iowa	Scale: farm size in acres, total county hog inventory, farms with hogs, farms with more than 1000 hogs, net agriculture sales	Socioeconomic (people living in poverty, people receiving food stamps)	Detrimental: The more large scale operations, the fewer small and moderate farms and the more people who use food stamps. Most hogs in Iowa are produced in small and moderate sized integrated operations. Since total hog operations are related to a decline in small and moderate sized operations. The more farms that produce hogs, the fewer people who use food stamps.
Otto, et al. (1998)	Regional Economic Impact Study: pork operations	Iowa	scale	Socioeconomic: economic performance	No Detrimental: larger units create more local jobs and income
Thompson and Haskins (1998)	Regional Economic Impact, pork operations	Iowa	scale	Socioeconomic: economic performance	Some Detrimental: larger units create fewer local jobs than smaller units
Seipel, et al. (1998)	Hedonic Price Analysis, one county	Missouri	concentrated animal feeding operation	Sales prices of farmland parcels with and without houses	Detrimental: reduction in property prices of $144 per hectare within 3.2 km of a CAFO
Schiffman, et al. (1998)	Quasi-experimental Design: 88 matched individuals	North Carolina	concentrated animal feeding operation	Social Fabric (social-psychological distress)	Detrimental: residents living near swine operations are more depressed due to psychological and physical effects of odors, reduced enjoyment of property

Study	Methodology	Region	Measures of Industrialized Farming	Community Well-Being Indicators	Results
Wing and Wolf, One study, (1999, paper) (2000, article)	Survey Design Study: 155 residents, three communities	North Carolina	concentrated animal feeding operation	Social Fabric (quality of life, health status)	Detrimental: residents of CAFO community report greater respiratory and gastrointestinal problems and eye irritations, lower quality of life, reduced enjoyment of property
Seipel et al. (1999)	Survey Design Study: 780 residents in four counties with pork production	Missouri	concentrated animal feeding operation	Social Fabric (attitudes toward increasing government regulation of corporate swine production)	Detrimental: majority of residents support increased regulation, strongest determinants of this position due to perceived detrimental economic, social, environ-mental impacts on community
North Central Regional Center for Rural Development (1999)	Comparative Case Study, 14 farm dependent counties, one of which recruited CAFO	Oklahoma	CAFO county compared to others	Socioeconomic: well-being, social fabric, Environment	Some Detrimental: Detrimental on social fabric and environment (e.g., greater crime), no appreciable gains in per capita income and jobs relative to non-CAFO counties; beneficial effects for a few indicators (increase in population, school enrollment, retail sales and property values)
Irwin et al. (1999)	Macro-social Accounting: 3024 counties	Continental U.S.	organization	Social Fabric (residential stability)	No Detrimental

Study	Methodology	Region	Measures of Industrialized Farming	Community Well-Being Indicators	Results
Crowley (1999)	Macro-social Accounting: 1053 counties in NC states	12 north central states	organization	Socioeconomic (poverty rate, income inequality)	Detrimental
Gomez & Zhang (2000)	Regional Economic Impact Models: (rural hog producing towns located in 76 rural cos. and 26 non-metro urban cos. with < than 50K hogs sold annually)	Illinois	CAFO/Scale	Social Fabric: Annual change in inflation-adjusted "real" retail spending	Detrimental on lower economic growth
Welsh and Lyson (2001)	Macro-social Accounting: 433 agric. dep. cos. in states with anti-corp. farming laws and in states without such laws.	Iowa, Kansas, Minnesota, Missouri, North Dakota, Oklahoma, South Dakota vs. states without anti-corp. farm laws	Scale/ Organization	Socioeconomic: percentage of families in poverty, unemploy-ment rate, farms realizing cash gains	Detrimental on agric. dep. cos. in states without anti-corp. farming laws or in states with weaker anti-corp. farming laws.
Lyson et al., (2001)	Macro-social Accounting: 433 Ag. Dep. Cos. in the U.S	Ag. Dep. Cos. in the U.S.	Scale/Organization	Social Fabric: Civically engaged middle class, participation & involvement in civic affairs, community welfare	Detrimental are mediated by presence of civically engaged middle class. Communities in agric. dep. areas in which a high percentage of persons work for them- selves or operate independent businesses have higher levels of social welfare.

Study	Methodology	Region	Measures of Industrialized Farming	Community Well-Being Indicators	Results
Wright et al., (2001)	Case Study: Six CAFO counties – Pennington, Clearwater, Rock, Goodhue, Sterns, Morrison	Minnesota	CAFO/Scale	Social Fabric: social & community well-being – quality of life, community interaction, social capital	Some: Detrimental effects for neighbors, younger and mid-sized producers. Positive effects for those who expanded operations; No effects for those not neighbors or not expanding. Detrimental due to lack of trust in gov't. agencies and differences in shared vision of agric. & of local communities.
Foltz, et al., (2002)	Regional Economic Impact Models: 100 dairy farms in three dairy dependent communities – Athens, Chilton, and Richland	Wisconsin	Scale	Social Fabric: Share of local input purchases made locally	Detrimental: Significant negative effect for larger farm sizes (herd size) on share of input purchases made locally.
Peters, (2002)	Macro-social Accounting: All agric. dep. cos.	Iowa, Kansas & Missouri	Organization	Socio-economic: Children at risk -- % of children enrolled in free-reduced price meals, low birth rate infants,	Detrimental: Areas with lower concentrations of farm proprietorships results in increased children at risk scores. Areas with greater concentrations of industrial agriculture production results in increased children at risk scores.
Wilson et al., (2002)	Macro-social Accounting: Census blocks in rural counties with CAFOs	Mississippi	CAFOS (Swine)	Social Fabric: Whether swine CAFOs were located in high poverty/high Black census blocks	Detrimental: Swine CAFOs 2.4-3.6 times more likely to be located census block with poor African Americans.

Study	Methodology	Region	Measures of Industrialized Farming	Community Well-Being Indicators	Results
Deller, (2003)	Regional Economic Impact Models: 2249 non-metro U.S. cos.	Non-metro U.S. cos.	Scale	Socioeconomic: Growth rates in per capita income	Detrimental: Counties dominated by larger-scale agriculture experience slower growth rates in per capita income. As agric expands in terms of farm size or share of local economy, downward pressure is placed on regional growth rates.
Reisner, et al, (2004)	Survey Design Study: 22 newspapers covering 52 cos.	Illinois	CAFOs Swine	Social Fabric: Perceptions of source of controversy over swine CAFOs, of frequency of swine CAFO odors, & problems caused by CAFOs	Detrimental: Residents were far less satisfied with presence of facilities than farmers thought, reported more days with odors, were more likely to believe that CAFOs contributed to water quality problems, and report loss of value of homes near CAFOs
Crowley & Roscigno, (2004)	Macro-social Accounting: All counties in North Central States -- IA, IL, IN, KS, MI, MN,MO, NE, OH, ND, SD	North Central States	Scale/Organization	Socioeconomic: Percent of population living below poverty & inequality of income distribution among families	Detrimental: Dimensions of farm sector concentration shapes both poverty and inequality of income.

Study	Methodology	Region	Measures of Industrialized Farming	Community Well-Being Indicators	Results
Smithers, et al., (2004)	Macro-social Accounting	North Huron County, Ontario	Scale	Social Fabric: Community involvement, purchasing behavior, perception of community support by expanding, stable, and contracting farms	Detrimental: Farmers in the expansionist trajectory were constrained in their ability to participate in social activities & organizations, sought inputs at lowest cost, were less committed to sourcing locally, and saw the community in terms of what it could do for them rather what they could do for it.
Kleiner (2003)	Survey Design Studies: Three counties in MO, two characterized by swine CAFOs & one by independent hog production	Missouri	CAFOs	Social fabric: Effects of CAFOs on rural communities including economic, social and Environmental	Detrimental: Proximity to large-scale livestock facilities is associated with perceptions of CAFO impacts, especially environmental impacts.

Study	Methodology	Region	Measures of Industrialized Farming	Community Well-Being Indicators	Results
Constance and Tuinstra (2005)	Case Study Design; Three rural clusters of communities -- Normangee and Flynn Leon Co. and Midway in Madison Co.	East Texas	CAFOs (chicken broilers)	Social Fabric: Odor, water quality, health, property values, source of conflict, social effects	Detrimental: Quality of life deteriorated as it became more stressful and less neighborly. Neighbors focused on issues of odor nuisances, water pollution, health problems, property values, & community disruption. Growers minimized complaints by saying that neighbors' jealousy was the root cause of discomfort or suggested they were city folks with impractical views of rural areas.
Whittington & Warner (2006)	Case Study Design: Two communities with large-scale dairies (under 700 cows) Jackson Twp. in Wyandot Co. and Liberty Twp. in Wood Co.	Ohio	Scale	Social Fabric: Knowledge of and attitudes towards managers of risk of large scale dairies	Detrimental: Community members unable to identify managers of risk, felt hopeless to act, personal experience in agric. leads to understanding of issues, large-scale animal agric. is a cultural shift, two-way communication is essential, safety precautions by CAFO leads to greater community acceptance.

Study	Methodology	Region	Measures of Industrialized Farming	Community Well-Being Indicators	Results
Jackson-Smith & Gillespie (2005)	Survey Design Studies: Nine dairy farm dependent rural communities in seven states	Dairy dependent areas in NY, WS, MN, TX, UT, ID, & NM	Scale	Social Fabric: Relationships between farmers & neighbors; how well they know their neighbors; if they had ever had complaints about odor, flies, or noise; level of involvement in local community organizations & activities;	Some: Demographic variables are related to knowing neighbors well. When these are variables are controlled, there is little evidence that size of farm or use of hired workers was related to relationships with neighbors. Farm size is strongest predictor of likelihood that neighbors have complained about a dairy operation.
Foltz and Zueli, (2005)	Survey Design Studies: 141 dairy farmers in three dairy dependent WS towns – Athens, Chilton, and Richland	Wisconsin dairy dependent towns	Scale: Farm size measured by size of dairy herd	Social Fabric: Annual quantity of expenditures per unit for various farm inputs and supplies	No Detrimental: Very little evidence that small farms are more likely to buy locally than large farms. Purchasing patterns are commodity specific and not determined by farm size or farm-level characteristics. Presence of local marketing outlets affects decisions to purchase locally. Community attachment affects purchasing decisions when there is a choice available locally.
McMillan and Schulman (2003)	Case Study: Two CAFO counties, four focus groups (Citizens, Leaders, Producers, Activists) and anti-hog informants interviews	No. Carolina	CAFOs	Social Fabric: neighbor relations, environmental concerns, health concerns, enjoyment of property, quality of democratic participation, community cohesiveness	Detrimental: Increased community conflict and tensions between neighbors, reduced quality of life due to CAFO odors, increased worries about health concerns related to CAFO odors, and worries about environmental consequences

North Dakota Department of Health

Environmental Section

Division of Water Quality

Attention: Karl Rockeman, P.E.

Additional Public Hearing Testimony Regarding the Rolling Green Family Farms Re LLP submitted from The Concerned Citizens of Buffalo

Dear Mr. Rockeman,

The Concerned Citizens of Buffalo hereby request that the Permit Applicant be rejected due to being incomplete. The Permit Application lacks calculations and disclosure of expected mortality rates of all groups of the hog population planned to be present at the facility. These expected rates, along with the expectation of stillbirth hog quantities, and afterbirth volume have not been disclosed nor have the proposed procedures for composting, calculations of total volume of carcass/carrion/animal material to be composed, and the actual verification of necessary compost bin area and volume necessary to safely and effectively compost the carrion. Without these calculations and "right sizing" of the compost bins, and without stated proposed procedures and processes, the composting process itself will become one of the most dangerous exposures of pathogen spread from flies/insects, scavengers and predators. The biological waste fluids will spill from the bin area and contaminate the site, the runoff areas, and subsequently the adjacent farm lands, with potentially lethal pathogens. As stated during the verbal presentation by yourself at the actual hearing, "…an incomplete permit application is one of the grounds for rejection…" Your follow-up and rejection of the permit is expected.

Thank you for clarifying those points in the hearing.

Alan D. Dostert, on behalf of

The Concerns Citizens of Buffalo

CC: (via email)

Derrick Braaten

Liane Stout

March 18, 2016

North Dakota Department of Health
Division of Water Quality
918 Divide Avenue, 4th Floor
Bismarck, ND 58501-1047

Attention: Karl Rockeman, Director

This addendum is submitted on behalf of the Concerned Citizens of Buffalo regarding the Rolling Green Family Farms illegal permit application.

"We demand that the nutrient application setbacks match those that have been submitted and filed at the North Dakota Department of Health by Howes Township on February 26, 2016."

Please include this statement as part of testimony.

Liane Stout, on behalf of
The Concerned Citizens of Buffalo

cc: via email
Derrick Braaten

Strommen, Rachel A.

From: Rockeman, Karl H.
Sent: Monday, March 21, 2016 10:24 AM
To: Strommen, Rachel A.; Haroldson, Marty R.
Subject: FW: CAFO

More comments for the record.

Karl Rockeman, P.E.
Director
Division of Water Quality
North Dakota Department of Health
(701)328-5210

From: kent beilke [mailto:kentbeilke@hotmail.com]
Sent: Saturday, March 19, 2016 12:57 PM
To: Rockeman, Karl H.
Subject: FW: CAFO

From: kentbeilke@hotmail.com
To: health@state.nd.us
Subject: CAFO
Date: Sat, 19 Mar 2016 12:25:16 -0500

ND Department of Health,

My name is Kent Beilke and I live two and a half miles from the proposed hog facility near Buffalo. I had turned in my concerns at the Buffalo meeting but after attending and hearing some of the statements I am writing another.

I heard the statement that someone prepared on behalf of our Ag. Commissioner and the ND Farm Bureau's presidents speech touting economics and calling us liars. I find it very concerning that our ND elected officials made a point to praise the economic benefits of this CAFO, (which is very very easily proven to be wrong), during a meeting that I was under the impression was only to give health and and environmental concerns. If I would have known that anyone would come and talk economics I would have had a speech prepared for the meeting. It personally offended me when ND's Farm Bureau president had the nerve to stand up in front of the people who's lives will forever be affected and talk in favor of an industry that has negatively effected his own life since the middle 90's.

The Health Dept. has all the records of what was presented at the meeting and I would ask you what health concerns from the ND citizens were dispelled by the proponents of this facility? They know they cannot prove that there are no health and environmental problems that arise from every single large scale CAFO.

Sean, who happens to be their legal representative, made the biggest impression on me when he spoke. He used the word "intent" many times. Intent always seems to be a lawyers favorite word when they are trying to minimize the responsibility of ones actions. Sean, using the word "intent" throughout his whole speech even before any health or environmental issues have arisen should have sent up a red flag to the health Dept. that they are already trying to minimize responsibility for problems that surely will arise from this project.

Knowing very well the community would be showing documented health and environmental issues from these type corporate farms, why did not the proponents provide testimony to contradict what they knew was coming? Fact is they cannot!

My last concern is who will be held responsible for the adverse health and economic issues the will arise from this facility? Can a ND resident file suit against the state of ND, the Health Dept. or even the Corporation bringing this to our state?

I strongly urge the Health Dept. to do what their job demands and provide a clean and healthy environment for the residents of ND which must inclide the denial pf this permit!

Thanks, Kent

Strommen, Rachel A.

From: Rockeman, Karl H.
Sent: Monday, March 21, 2016 10:24 AM
To: Haroldson, Marty R.; Strommen, Rachel A.
Subject: FW: Buffalo

More comments for the record.

Karl Rockeman, P.E.
Director
Division of Water Quality
North Dakota Department of Health
(701)328-5210

From: Michelle Weigelt [mailto:mmweig3122@hotmail.com]
Sent: Saturday, March 19, 2016 1:01 PM
To: Rockeman, Karl H.
Subject: Buffalo

I am writing in petition against the proposed pig farm at Buffalo ND. I am a nurse and we are all aware of the documented health risks to surrounding land and human beings of pig farms. My question to you is, in recent years a commercial pig farm permit was declined by Carrington, ND. This area is much more remote than the proposed area in Buffalo, so why will one be granted in a much more populated area? Please take a serious look at this situation and my hope is you will listen to your concerned citizens. Thank you for your attention.
Michelle Weigelt
P.O.Box 273
Fessenden, ND 58438-0273

RECEIVED

MAR 07 2016

DIV. OF WATER QUALITY

March 3, 2016,

To The North Dakota Department of Health,

I am writing to you to express my concerns regarding the Rolling Green Family Farms, LLP. (RGFF, LLP) and their proposal to build a large confinement hog operation by Buffalo, ND. At first I was overwhelmed by 6,000 sows and now I hear that it will house over 9,000 hogs. If they become established then how many hogs will there be?

I have numerous concerns including; water quality, air quality, devaluing of local homes, destruction of our small town and rural culture, road safety, lack of economic growth and closure and clean up.

Water quality and air quality. RGFF,LLP stated that when they are unable to inject the manure into the ground, they will place it on top of the ground and that the state would permit that. I am concerned but will not elaborate on the methane and other toxic gas emissions since at the meeting RGFF, LLP told us "it will smell". But I do have numerous concerns regarding spring runoff and their overflow and composting management. Will these barns be kept up to code or grandfathered in? Also, we have residents living in close proximity to the proposed site with various health issues who have expressed concern about their health being compromised.

Traditionally homes around large confinement barns will be devalued. On a personal note, my son along with his wife and soon to be child just built a home 1.5 miles from the proposed site not knowing about the proposal. We have found out that this proposal has been in the "works" for over 1 year. There are 9 rural homes less than 2 miles away from the proposed site. Our home town, Buffalo is near by the proposed site. Many people have poured their life savings into their homes and now are fearful of declining property values.

Concerns with destruction of our small town and rural culture. I am concerned regarding destruction of culture and find myself presently looking at numerous levels of destruction and safety issues in the Bakken Oil field area. What haven't we as a state learned about protecting our own residents? Why does big business from out of state trump the rights of local tax payers and residents? Why does our quality of health and life even have to be challenged? I thought it was the states responsibility to protect its citizens.

Road safety. The proposed site will be using 1 mile of county road and ½ mile of township. How do you expect a township to maintain a road that is highly trafficked without affecting service to our present residents? The roads involved are used by numerous residents, numerous times a day. RGFF,LLP financial input to the township from taxes is minimal and will take needed resources for road maintenance from families already living here and travel can quickly become a safety risk.

Economic growth. This is an out of state LLP. Plain and simple, the majority of the money will be leaving our state. My perception is that mainly one local individual will benefit from this proposal. I fail to see the consideration of the greater good in this.

What occurs when the barns close down for whatever reason? If the LLP is dissolved is the township responsible for cleanup of a business they did not welcome? Since this proposed project was invited by ND will the state take care of it? Is there a bond in excess to the LLP that will help the state or township pay for clean up? Limited liability is just that, limited.

RGFF, LLP stated that ND "invited" them. I just drove to Bismarck the other day and noticed several areas of wide open spaces. Why would ND pick the fastest growing county affecting 9 rural homes and a local town? ND residents keep overwhelmingly voting large corporate farms down, why? Because they destroy family farming and environment. What is ND doing to promote Ag/Ranching to its local people?

People are upset about this and fearful of the consequences of this proposal going through. How can a small area fight a giant business? Interestingly enough, the few individual s who are for the proposal when asked if they want it in close proximity to their home or town emphatically say "No!" Individuals who live by an animal factory do not seem to be happy about it being there and I have received phone calls from them urging us to fight and to stop this proposal. I hope that North Dakota doesn't' reduce us to the "test or trial" project and endanger our health, safety and wellbeing.

As you can see, I have listed a few concerns regarding the health, safety and well being of the present residents with this proposal. I believe this proposal was initiated secretively and underhandedly. RGFF, LLP at their informational meeting stated that they have done everything by the book. If that is the case and the state approves this proposal, I will feel sold out and neglected by the state of ND.

Thank you for listening to my concerns and taking the rights, health and welfare of local citizens into consideration.

Sincerely,
Gwen Fraase

Gwen Fraase

3689 143rd Ave SE Buffalo, ND 58011 h) 701-633-5533 cell) 701-361-0207 rgjamfraase@hotmail.com

Strommen, Rachel A.

From: Kyle Schultz [embdenhaymaker@gmail.com]
Sent: Saturday, March 19, 2016 3:50 PM
To: Strommen, Rachel A.
Subject: Support for hog operation near Buffalo

I am just writing to show my support for the proposed hog operation by Rolling Green Family Farms LLP. My farm is located near Embden which is approximately 7 miles from the proposed site. As a cattle producer and farmer with my major commodity being row crops, I see a need of more livestock operations in the area to use our corn and soybeans as feed. I realize there may be issues but this will be a state of the art operation with a major emphasis on biosecurity, using the latest technology so the whole"stink" factor is not a valid point against it. Please see through all the negative comments and help North Dakota move forward in recruiting more livestock production.

Thank You,

Ryan Schultz
Kyle Schultz

Strommen, Rachel A.

From: Rockeman, Karl H.
Sent: Friday, March 18, 2016 4:24 PM
To: Strommen, Rachel A.
Subject: FW: Testimony regarding Rolling Greens proposed hog-facility near Buffalo

Another comment for the record

Karl Rockeman, P.E.
Director
Division of Water Quality
North Dakota Department of Health
(701)328-5210

From: Vicki J Wendt [mailto:Vicki.Wendt@corelinksolutions.com]
Sent: Friday, March 18, 2016 4:04 PM
To: Rockeman, Karl H.
Subject: Testimony regarding Rolling Greens proposed hog-facility near Buffalo

Good afternoon, Mr. Rockeman.

I testified at the hearing in Buffalo yesterday. I am adding additional testimony which you said you are accepting through March 19th.

We heard many comments at the hearing regarding how the proposed facility "meets code". My concern is that the "code" is not strong enough to protect our community from the risks of living alongside a CAFO. It appears that the State of ND has limited experience with such operations. Hence, researching what's happened in other states is necessary to make an informed decision. There are substantial amounts of studies done by various universities and research organizations that factually suggest health risks to CAFO neighbors and CAFO employees. Pipestone representatives suggested yesterday that these are just fears and not reality. I disagree. These are real research studies which present factual evidence. Promises that it "will all be fine" are where the assumptions lie. Also, as Alecia Wisnewski testified, our society does have reason to be concerned about increasing antibiotic resistance and that effect on human health. The CAFO role in contributing to such increased antibiotic resistance is very reasonably questionable. Proponents want to call our fears unfounded when there is plenty of evidence that the risks to human health are very real. It would be irresponsible for the Department of Health to approve this permit, regardless of current code, when there is so much evidence of risk. Why would the Department of Health take that chance? It would be premature to grant a permit at this time. We are not currently subjected to these risks. Studies show that the risks are real. It is not acceptable to bring such a controversial operation into our neighborhood. Your responsibility is to protect public health, not promote economic development.

Regarding odor nuisance: You said a level of odor is considered unacceptable when it "affects our behavior" and that code has deemed a "7" on your smell-o-meter scale as such a level. You referred to the need to close windows as an affected behavior. I would consider avoiding outdoor eating due to odor as a behavior change. I expect the department of health to determine that odor nuisance level before subjecting our community to it. By the way, if this odor affects our way of life, it is more than a nuisance. It's life-changing.

One might also claim that this is just one facility. Well, the Ag Commissioner's plan to balance crop production with livestock production in the state is not going be done with one facility. The plan is certainly for multiple facilities built over time. You permit one and it's just a matter of time before you're approving more. I'm begging you to stop it before it starts. Make sure you know exactly what you're approving before you set the ball rolling. One of the local farmer proponents of this facility told one of our Concerned Citizens of Buffalo that Pipestone's long-term vision is to put a

facility every three miles along I94 from Casselton to Valley City, a “corridor of hog facilities”, with another corridor along highway 2. What effect will that have on our state? It will drastically change our way of life in our treasured state.

Find this out and communicate it to the public: What is the State’s Plan in regard to developing livestock production in North Dakota? And at who’s expense?

We value our rural North Dakota quality of life over mere economic development. Prove to us that you’re not willing to risk public health for somebody else’s money, especially out-of-state money. And keep in mind that government exists for the people. Represent us with integrity.

Thank you.

Vicki Wendt
3805 139 Ave SE
Buffalo, ND 58011

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Strommen, Rachel A.

From: Rockeman, Karl H.
Sent: Friday, March 18, 2016 2:36 PM
To: Strommen, Rachel A.
Subject: FW: "family farm" - CAFO

Another comment for the record.

Karl Rockeman, P.E.
Director
Division of Water Quality
North Dakota Department of Health
(701)328-5210

From: Brenda Jorgenson [mailto:brendajorgenson@hotmail.com]
Sent: Friday, March 18, 2016 12:10 PM
To: Rockeman, Karl H.
Subject: "family farm" - CAFO

CAFO is Confined Animal Feeding Operation. 9000 hogs confined to one feeding operation is not a Family Farm operation. Those two ideas are not acceptable in my book. Misconstruing the confinement of 9000 hogs as a family farm operation is a lot more - it's an outright false statement. The name Rolling Green Family Farms give the illusion of something wholesome. Confining 9000 hogs is not wholesome. It is far from wholesome. There will be no "green" and there is no "family farm"! The area of eastern North Dakota is not even "rolling". So these folks are already lying before they get past their farm name. My trust in anything more about them is lost. My trust in our ND State Department of Health (NDDoH) is very low after seeing all the spills in NW ND and how the companies are being coddled by the NDDoH rather than fined and punished for their wrong-doings! The NDDoH sides with the ND Industrial Commission and the ND Petroleum Association rather than the landowners and neighbors. This is a big problem.

There is no need to contaminate any more land that could otherwise be useful for food production. There are other means to produce food than in a CAFO. Our Ag Dept need to realize that the farmers/ranchers that have been here for years and are struggling to produce wholesome food for the masses need help to keep real "Family Farms" in operation - not backing this fiasco.

Please share this with others!

Brenda Jorgenson
701-464-5710

Strommen, Rachel A.

From: Rockeman, Karl H.
Sent: Friday, March 18, 2016 2:27 PM
To: Strommen, Rachel A.
Subject: FW: Rolling Greens Family Farm LLP water permit

Another comment for the record

Karl Rockeman, P.E.
Director
Division of Water Quality
North Dakota Department of Health
(701)328-5210

From: Craig Scott [mailto:craig.scott@bis.midco.net]
Sent: Friday, March 18, 2016 12:06 PM
To: Rockeman, Karl H.
Subject: Rolling Greens Family Farm LLP water permit

Dear Mr. Karl Rockeman,

As someone who cares about the health of all people in North Dakota, I ask that you reject the application from Rolling Green Family Farms, RE, LLP to build a 9,000 hog factory near Buffalo. The permit application falls short in many areas. The full application for the NDPES permit is not available on the North Dakota Department of Health's website. The full application should be there so the public can easily access the application and evaluate it.

The proposed hog factory is very close to the town of Buffalo. Why should the people living there sacrifice their quality of life when all of the potential benefits of the operation go to investors who live outside of the community?

There are countless stories from communities in Iowa, South Dakota and other states of people becoming sick because of living nearby these types of hog factories. There are better ways to develop animal agriculture in North Dakota that do no put the health of people and communities like Buffalo at risk. Please reject this permit application.

According to a Johns Hopkins (Center for a Livable Future) analysis of peer reviewed studies (see attached), some of the potential negative health impacts include:

- groundwater and surface water pollution and associated health impacts
- air pollution, odors, and associated health and social impacts
- antibiotic resistance and the spread of infectious diseases to communities

Click here to download the letter from Johns Hopkins concerning the health impacts of the proposed CAFO in Buffalo.

I returned from my father's home and spent 3 days in the Marshalltown, Iowa area last week with family. I am not sure if you have ever visited Iowa but I assure you that the odor that looms over the

area is not the smell of money it is VERY distinct and in some cases out right offensive. I invite you to take a trip to central Iowa now that winter is at bay and see for yourself what confined animals can do to the environment. I am sure you have heard of the pollution in the rivers in Iowa this past year. The city of Des Moines has a law suit pending against several counties in Iowa for the pollution of the river, the major water supply for the city. Believe me confined animals had a part to play in this issue as the manure that is produced is injected into the soil and thus increased the nitrate runoff into the water ways of the state.

Please reject the application.

Craig Scott
716 N. Washington St
Bismarck, ND 58501
701.391.2128

Strommen, Rachel A.

From: Todd Sears [tddsrs@gmail.com]
Sent: Friday, March 18, 2016 1:15 PM
To: Strommen, Rachel A.
Subject: Rolling Green - Buffalo ND

I support the right of the facility for Rolling Green Family Farm LLC to proceed as long as they meet legal requirements. We must use science and common sense to make any regulations not fear and mass hysteria. The legal use of property and ability to have large scale animal agriculture is critical to the future of North Dakota.

Todd Sears
Wheatland ND

Strommen, Rachel A.

From: Rockeman, Karl H.
Sent: Friday, March 18, 2016 10:34 AM
To: Strommen, Rachel A.
Subject: FW: Rollin Greens Family Farms

Another comment for the record

Karl Rockeman, P.E.
Director
Division of Water Quality
North Dakota Department of Health
(701)328-5210

-----Original Message-----
From: -Info-Dept. of Health
Sent: Friday, March 18, 2016 7:59 AM
To: Glatt, Dave D.; Rockeman, Karl H.
Cc: Cain, Cindy C.; Piper, Dianna L.
Subject: FW: Rollin Greens Family Farms

FYI
Londa

-----Original Message-----
From: Brian Steckler [mailto:killorantrucking@icloud.com]
Sent: Thursday, March 17, 2016 6:14 PM
To: -Info-Dept. of Health
Subject: Rollin Greens Family Farms

I do not know if I am to late or not but I thought I would go head and email any how.

After today's testimonies I do not know how you let Rolling Greens continue with the hog operation that the have proposed. I am not against it but do believe there needs to be more consideration into the build plans and manure spreading operations of this facility.

I work for 15 years in commercial construction and Mr Doserts testimony is complete accurate. You DO NOT and CANNOT pour concrete in the Red River Valley without control joints no matter the length let alone 700 feet. Talk to any one that has ever done concrete work in North Dakota and they will tell you the same. After listening to today's testimony the Heath Department has totally dropped the ball on this and is in great danger of letting a mass disaster happen.

Sent from my iPhone

Strommen, Rachel A.

From: Rockeman, Karl H.
Sent: Friday, March 18, 2016 10:33 AM
To: Strommen, Rachel A.
Subject: FW: Reject the application from Rolling Green Family Farms, RE, LLP to build a 9,000 hog factory near Buffalo, ND (Public Notice: ND-2016-007, ND Pollutant Discharge Elimination System Discharge Permit)

Another comment for the record

Karl Rockeman, P.E.
Director
Division of Water Quality
North Dakota Department of Health
(701)328-5210

From: Terry Schaunaman [mailto:eqlrght@gmail.com]
Sent: Thursday, March 17, 2016 10:31 PM
To: Rockeman, Karl H.
Subject: Reject the application from Rolling Green Family Farms, RE, LLP to build a 9,000 hog factory near Buffalo, ND (Public Notice: ND-2016-007, ND Pollutant Discharge Elimination System Discharge Permit)

March 17, 2016

Karl Rockeman

North Dakota Department of Health

Division of Water Quality

918 E Divide Avenue, 4th Floor

Bismarck, ND 58501-1947

Dear Mr. Karl Rockeman,

I urge you to reject the application from Rolling Green Family Farms, RE, LLP to build a 9,000 hog factory near Buffalo, ND (Public Notice: ND-2016-007, ND Pollutant Discharge Elimination System Discharge Permit), for the following reasons:

1) Studies assessing consequences of CAFOs on the social fabric of communities find detrimental impacts - overall decrease in quality of life in their communities

2) Residents near CAFOs report decreased property values

3) Negative impacts of large, industrial agricultural operations on traditional diversified farming communities

4) Residents of hog CAFO communities reported greater respiratory problems and eye irritations

5) Growing concerns about the higher risks of E-coli O157:H7 and antibiotic resistant bacteria, including MRSA

6) Residents living near CAFOs report being more depressed due to psychological and physical effects of odors

7) Inevitable odors caused by huge quantities of livestock manure generated and number of animals

8) Pollution of streams, aquifers, and watersheds with huge quantities of animal and antibiotic wastes

9) Studies on large animal confinement operations report environment problems affecting air and water quality and human health

10) Create greater inequity in income distribution - new jobs are lower-paying than existing jobs

Because of overwhelming negative/detrimental impacts of CAFOs on the quality of community life, I urge you to reject the application.

Terry Schaunaman

1314 6th Ave S

Fargo, ND

Strommen, Rachel A.

From: Rockeman, Karl H.
Sent: Friday, March 18, 2016 10:32 AM
To: Strommen, Rachel A.
Subject: FW: Reject Permit for 9,000 Hog Factory near Buffalo

Another comment for the record

Karl Rockeman, P.E.
Director
Division of Water Quality
North Dakota Department of Health
(701)328-5210

-----Original Message-----
From: Rev. Gretchen Deeg [mailto:gdeeg@midconetwork.com]
Sent: Thursday, March 17, 2016 10:57 AM
To: Rockeman, Karl H.
Subject: Reject Permit for 9,000 Hog Factory near Buffalo

Dear Mr. Karl Rockeman,

The health of everyone in North Dakota is important to me. Please reject the application from Rolling Green Family Farms, RE, LLP to build a
9,000 hog factory near Buffalo. This permit is not good for North Dakotans.

The proposed hog factory is too close to the town of Buffalo. No one should be asked to sacrifice their health and quality of life for an operation that will primarily benefit people outside of the community.

There are countless stories from communities in Iowa, South Dakota and other states of people becoming sick because of living nearby these types of hog factories. There are better ways to develop animal agriculture in North Dakota that do no put the health of people and communities like Buffalo at risk. Please reject this permit application.

Thank you,

Gretchen Deeg
Bismark, ND 58501

Strommen, Rachel A.

From: Rockeman, Karl H.
Sent: Friday, March 18, 2016 10:32 AM
To: Strommen, Rachel A.
Subject: FW: Buffalo Hog Operation

Another comment for the record

Karl Rockeman, P.E.
Director
Division of Water Quality
North Dakota Department of Health
(701)328-5210

From: Jean [mailto:jhmcmanigle@yahoo.com]
Sent: Thursday, March 17, 2016 10:19 AM
To: Rockeman, Karl H.
Subject: Buffalo Hog Operation

Dear Mr. Karl Rockeman,

As someone who cares about the health of all people in North Dakota, I ask that you reject the application from Rolling Green Family Farms, RE, LLP to build a 9,000 hog factory near Buffalo. The permit application falls short in many areas. The full application for the NDPES permit is not available on the North Dakota Department of Health's website. The full application should be there so the public can easily access the application and evaluate it.

The proposed hog factory is very close to the town of Buffalo. Why should the people living there sacrifice their quality of life when all of the potential benefits of the operation go to investors who live outside of the community?

There are countless stories from communities in Iowa, South Dakota and other states of people becoming sick because of living nearby these types of hog factories. There are better ways to develop animal agriculture in North Dakota that do no put the health of people and communities like Buffalo at risk. Please reject this permit application.

According to a Johns Hopkins (Center for a Livable Future) analysis of peer reviewed studies (see attached), some of the potential negative health impacts include:

- groundwater and surface water pollution and associated health impacts
- air pollution, odors, and associated health and social impacts
- antibiotic resistance and the spread of infectious diseases to communities

Gene and Jean McManigle

Fort Ransom ND

Sent from Mail for Windows 10

JOHNS HOPKINS
CENTER *for* A LIVABLE FUTURE

The Johns Hopkins Center for a Livable Future
Bloomberg School of Public Health
615 North Wolfe Street, W7010
Baltimore, MD 21205

March 14, 2016

Dr. Terry Dwelle
State Health Officer
North Dakota Department of Health
600 East Boulevard Ave
Bismarck, ND 58505-0200

Disclaimer: The opinions expressed herein are our own and do not necessarily reflect the views of The Johns Hopkins University.

Re: Rolling Green Family Farms RE LLP proposed 9,000-head capacity sow facility

Dear Dr. Dwelle,

We are researchers at The Johns Hopkins Center for a Livable Future, based at the Bloomberg School of Public Health. The Center engages in research, policy analysis, education, and other activities guided by an ecologic perspective that diet, food production, the environment, and public health are interwoven elements of a complex system. We recognize the prominent role that food animal production plays regarding a wide range of public health issues within and associated with that system.

We have been contacted by Buffalo, North Dakota residents concerning the proposed 9,000-head capacity sow operation, Rolling Green Family Farms. We understand that the North Dakota Department of Health is preparing to review a Confined Animal Feeding Operation permit application for this operation, and we are writing to express our concerns regarding the potential public health impacts of this operation. Based on evidence from numerous scientific studies of similar facilities, the proposed operation, if constructed and put into operation, may present a range of health risks to members of the surrounding community.

Our concerns regarding the proposed swine operation include the following:

1. Antibiotic resistance and the spread of infectious diseases to communities
2. Groundwater and surface water pollution, and associated health impacts
3. Air pollution, odors, and associated health and social impacts

These are detailed below, with supporting evidence from the peer-reviewed scientific literature. Thank you for the opportunity to comment on this important issue—we appreciate you taking these concerns into consideration.

1. Industrial swine production has been linked to the spread of antibiotic-resistant pathogens to surrounding communities.

Crowded conditions in intensive livestock operations present frequent opportunities for the transmission of viral and bacterial pathogens among animals, and between animals and humans. Many of these pathogens live in the digestive tracts of animals and are passed in their waste (1–3).

The severity of disease risks stemming from intensive livestock production is heightened by the potential for infection with antibiotic-resistant bacteria. The non-medicinal use of antibiotic drugs as a means for growth promotion[1] in animals has become commonplace—an estimated 80 percent of antibiotics sold for human and animal uses in the U.S. are sold for use in food-producing animals (4). Administering antibiotics to animals at doses too low to treat disease fosters the proliferation of antibiotic-resistant pathogens. Resistant infections in humans are more difficult and expensive to treat (5) and more often fatal (6) than infections with non-resistant strains. The continued misuse of antibiotics in food animal production thereby threatens the effectiveness of these lifesaving resources for combating disease.

A growing body of evidence points to the potential pathways by which pathogens (antibiotic-resistant or otherwise) might spread from intensive livestock operations into communities. Studies suggest, for example, that antibiotic-resistant pathogens may be transmitted by workers into their homes and communities (7–10), conveyed by runoff into ground and surface waters (3), blown out of barns by ventilation systems (11–13), and spread to consumers via contaminated meat (14,15). Pathogens may also be transported by flies (16), wild birds (17,18), and animal transport vehicles (19).

[1]U.S. Food and Drug Administration (FDA) voluntary industry guidelines continue to endorse the use of antibiotics in livestock production for "disease prevention", which allows for dosing that is largely indistinguishable from growth promotion, thus tolerating business as usual (45).

Further evidence for disease transmission risks was documented in a 2013 study of nearly 450,000 Pennsylvania residents, in which living near larger swine operations or cropland where swine manure is spread was significantly associated with elevated rates of infection with methicillin-resistant *Staphylococcus aureus* (MRSA) and skin and soft tissue infections (20). MRSA is an antibiotic-resistant pathogen that can be challenging and expensive to treat. In a similar study in Iowa, persons living closer to swine operations had a greater risk of colonization with MRSA (21).

Industrial swine operations also present opportunities for the replication, mutation, and recombination of viruses—including novel influenza viruses—that may facilitate human-to-human transmission (22). Workers in swine operations face a greater risk of infection and may also increase the risk of influenza virus transmission to their surrounding communities (23,24).

2. Industrial swine operations can contaminate ground and surface waters, potentially leading to health impacts

Confining large numbers of animals indoors presents the challenge of how to collect, store, and dispose of the massive quantities of manure they generate. When such quantities are applied to nearby fields (the usual method of disposal), the amounts often exceed what surrounding land can absorb. When manure is over-applied, the excess—along with chemical and bacterial contaminants—is transported by runoff into surface waters and may leach into groundwater. A 2015 study traced fecal microbes specific to swine in surface water upstream and downstream of swine operations and found that swine specific microbes were nearly 2.5 times as prevalent in surface water downstream than upstream of swine operations, indicating poor sanitary quality of surface waters near industrial swine operations (25).

A 440 lb gestating sow generates an average of 11 lbs of wet manure daily[2], or roughly three times the mass of excreta generated by a person (26). With a projected inventory of over 9,000 sows, a conservative estimate indicates that Rolling Green Family Farms would be comparable, in terms of waste generated, to the addition of over 30,000 humans—more than 150 times the population of Buffalo, ND—without the benefit of a wastewater treatment plant to treat microbial and chemical pathogens.

Communities living near or downstream from confinement operations may be exposed to a range of waterborne contaminants, including nitrates, bacterial and viral pathogens, heavy metals, and veterinary pharmaceuticals (27). People may be exposed to these contaminants from drinking contaminated groundwater, placing them at greater risk for adverse health

[2] Lactating sows generate an average of 25 lbs of wet manure per day (26).

outcomes. Chronic exposure to nitrates (naturally occurring in animal waste), for example, has been associated with increased risks for thyroid conditions (28,29), birth defects and other reproductive problems (28,30), diabetes (28), various cancers (28,31), and methemoglobinemia (blue baby syndrome), a potentially fatal condition among infants (32).

3. **Industrial swine operations release air pollutants and odors, which are associated health and social impacts**

Animal confinement operations have been linked to a range of airborne pollutants, including ammonia, hydrogen sulfide, and other gases emitted from animal waste; and airborne particulates, which may be comprised of dried feces, animal dander, fungal spores, and bacterial toxins (33).

Much of the research on the health effects associated with exposure to airborne pollutants from confinement operations has focused on workers. At least one in four workers in these operations are estimated to suffer from respiratory illness (34).

A growing body of evidence suggests residents living near animal confinement operations may also be at greater risk of respiratory illness. One study detected high concentrations of particulate matter downwind from swine confinement operations, which was linked to wheezing, breathing difficulties, and eye, skin, and nasal irritation among residents of downwind communities (35). Indicators of air pollution (e.g., odors) from swine confinement operations have also been linked to asthma symptoms among students at nearby schools (36).

Odors associated with air pollutants from confinement operations have been found to interfere with daily activities, quality of life, social gatherings, and community cohesion (34,37). In addition to the stigma and social disruption they often generate, odors from swine confinement operations have been associated with physiological and psychological effects, including high blood pressure, depression, anxiety, and sleep disturbances (38–40).

Residents in Buffalo, ND and surrounding areas have relayed concerns to us regarding community members' various chronic health conditions, including asthma, chronic obstructive pulmonary disease (COPD), high blood pressure, cancer, and other ailments. There is evidence that some of these conditions—primarily asthma—may be exacerbated by living near industrial food animal production facilities (41,42), which raises concerns about whether these residents could be particularly vulnerable to the health risks described above.

We hope our letter is helpful in describing some of the potential public health harms associated with large-scale swine confinement operations. We strongly advise the North Dakota Department

of Health to take these concerns into consideration when deciding whether or not to approve the construction of Rolling Green Family Farms. Through our research, we know that health departments face many barriers addressing issues surrounding industrial food animal production (43,44), and we are prepared to serve as a resource to your office. Please do not hesitate to contact us if you have any questions.

Sincerely,

Anthony So, MD, MPA
Robert S. Lawrence Professor, Department of Environmental Health Sciences
Johns Hopkins Bloomberg School of Public Health
Director, Johns Hopkins Center for a Livable Future
Johns Hopkins University

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RECEIVED
MAR 21 2016
DIV. OF WATER QUALITY

March 18, 2016

North Dakota Department of Health
Division of Water Quality
918 Divide Avenue, 4th Floor
Bismarck, ND 58501-1047

Attention: Karl Rockeman, Director

Please find enclosed "North Dakota Water", March, 2016 magazine for additional Public Hearing information regarding the Rolling Green Family Farms proposed permit application, submitted on behalf of the Concerned Citizens of Buffalo, ND.

Please read and review two articles of importance:

1. Drought Management Planning Important for Communities, Rural Water Systems.

2. Our Water, Keeping it Clean, from the ND Department of Health, Environmental Health Section on Basin Water

Obviously these two issues are important to the State of North Dakota regarding the permitting of a 9000 swine operation in Howes Township, impacting our rural water system and keeping our water clean and safe.

Thank you for including this document in our concerns.

Liane Stout

Liane Stout, on behalf of
The Concerned Citizens of Buffalo

cc: via email
Derrick Braaten

RECEIVED
MAR 21 2016
DIV. OF WATER QUALITY

March 18, 2016

Department of Health
Bismarck ND

To Whom It Concerns:

Thank you for the opportunity to testify at yesterday's public hearing. It was a very interesting day to say the least. I did not testify but was in attendance the entire day. The reason for today's letter is that I have been asked by numerous residents/employees/employers in the area to draft this letter. As you can see by the signatures/names listed there are many people that welcome the opportunity this new business can bring to our area. This is not by any means an "official" petition but instead a letter of support. Several people are currently out of the area so have asked to have their names signed by proxy or by members of their family in their absence.

We feel with the proper guidance, regulations and oversight put into place, this operation could be a success and welcome addition to our small town. We understand this will be a state of the art facility and all considerations will and have been made to ensure the safety and integrity of our local environment.

- They have picked a location that has a setback of at least one mile which is generous considering our state laws have ½ mile setback
- They stated they will sign road haul agreements to help maintain the roads
- They will plant trees around the facility which will help disperse with the odors based on studies showing this is beneficial in helping with odor
- A diversion berm will be around the building
- Bait systems will be established to help with coyotes, rats, mice
- Plan in place for distribution of the nutrients with farmers on a waiting list to provide acres

Unfortunately, family farms are becoming a thing of the past. With the continual rise in prices for everything needed to farm, small farmers can no longer sustain a livelihood. The national average age of farmers is currently at 57.5 and is continually on the rise. We need to do something to help support the growing need for food production and this is one avenue. Hopefully Rolling Green Farms will bring much needed income and opportunities to our small town. We welcome that opportunity.

Thanks!

I have read the attached letter an agree with the statements

Deanna Kasowski	701-388-1357
[signature]	701-371-0813
[signature] Bryce Kasowski	701-371-8137
Roxy Kasowski	701-421-1058

I have read the attached letter and agree with the Statements

Marsha Snyder Kasowski	701-630-4472
Robert Snyder by proxy Marsha Kasowski	701-840-0071
Jordan Friestad by proxy Marsha Kasowski	218-850-2217
Amanda Steckler	701-840-4563
Jerry Killoran by proxy Amanda Steckler	701-238-7336
Sheree Killoran by proxy Amanda Steckler	701-261-4987
Aunt Lady	218-205-7097
Jessica Hill	701-200-2538
Greg Friestad by proxy Marsha Kasowski	701-552-1401

TO: Dept. of Health Div. of water

We object to the Hog (Pig) Farm that will be approx 9000, Pigs in 1 place Concerns are air quality, Water Contamination and Heath. It will be to close to town of Buffalo. N.P. and 9 homes with family's We own a home in Buffalo and are quite concerned about the town, being TO close and the smell, What would they do with the waste?

We would vote NO to the hog farm.

Sincerly

The TWeeds

Evelyn M. Tweed

Amber L. Deminck.

RECEIVED
MAR 21 2016
DIV. OF WATER QUALITY

RECEIVED
MAR 21 2016
DIV. OF WATER QUALITY

March 17, 2016

North Dakota Department of Health
Division of Water Quality
918 East Divide Ave – 4th Floor
Bismarck, ND 58501

To Whom It May Concern,

I am writing to express my concerns regarding the proposed Hog Operation near Buffalo, North Dakota. Having grown up on a farm in North Dakota, I have concerns about the environmental impact of the operation. There appear to be many questions regarding the effect on the air, land and water quality in the Buffalo area. I live in Fargo, but work in rural Cass County, and have heard concerns raised by many Buffalo area residents.

Agriculture is obviously central to the Buffalo area. Many of the local farms have been in families for generations. I believe the concerns of local farmers and area residents need to be heard before granting permits. In my opinion, the health of local residents, environmental impacts, quality of life and the impact on property values of surrounding farms, homes and communities should be central to any decisions.

Sincerely,

Myrna Hanson

2845 142nd Ave SE Ayr ND

My name is Alicia Wisnewski. I am a resident of the Buffalo/Ayr community. I am also a veterinarian.

I am here today because I have several concerns regarding a CAFO starting up in our neighborhood.

My concerns mirror that of many community members and that of many people across the country.

First and foremost, I am concerned about the means that this facility will be able to minimize environmental impact on our community, namely air, water, and soil contamination.

Hog CAFO's are much more prevalent in states such as Iowa, North Carolina, and Illinois. These communities already have more regulations and monitoring in place; yet these states continue to have problems with environmental contamination, particularly from manure run off. I have supplied numerous articles, as I am sure other members of the community have as well, that describe risk after risk and case after case of contamination, despite facilities being regulated and monitored.

The Natural Resources Defense Council lists several examples of situations of large scale contamination. E.g. in 2011, an Illionois hog farm spilled 200,000 gallons of manure into a creek, killing over 110,000 fish.

My concern for our region is the dramatic amount of overland flooding that can occur every spring. How are we going to be guaranteed that our community will not fall victim to contamination?

Once the damage is done, even though it is an accident of nature, the effects are long standing.

We should learn from the challenges that other states and communities have faced and implement the stricter requirements and more frequent testing now, before these type of facilities are in place. It is much easier to prevent a disaster than deal with the damage after it occurs. I would hope the state of ND would table this CAFO until more research and preventive requirements could be put in place.

As a parent and local community member, I am very concerned about the impact of the air quality. I have a son with asthma who cannot tolerate the risk of contamination of the air he breaths. There are forms of waste management, such as the type of odorless lagoons that are being used at CAFO's in Saskatchewan Canada. I have provided a short article that describes a media day at one such facility. The means to manage odor and air quality are there, but they are not required yet. I challenge the state of North Dakota again to at least table approving this venture to allow our regulatory agencies to explore the concerns of the people of North Dakota and look at the tools that are out there to better minimize these risks for our community should this venture continue.

who says animal diversification needs to occur, who gets to determ

Lastly, as a medical professional, I do not feel the use of CAFO's is beneficial to our community, state, country, or world due to the risk of antibiotic resistance. Because of unsafe antibiotic use practices, we are facing the end of the era of effectiveness of antibioitics. While there are many contributing factors, CAFO's play a significant role. The use of certain antibiotics as growth promotants needs to be addressed for the safety of our entire world, before we ever consider allowing more CAFO's to continue to set up or expand. When you treat an animal or person with antibiotics, you treat the entire body. All the bacteria get exposed. The ones that survive harbor that potential to survive in the face of that

what is needed

challenge → public health dept. missing an important public health risk in not testing for AB residues and for AB resistant bacteria → addition of any CAFO's suspended

From Vet

Alecia Wisnewski

antibiotic. Bacteria also communicate and share information – allowing them to share the ability to resist antibiotics. Additionally, when animals or people come into contact with each other, there is transfer of bacteria. When we shake hands, when we touch animals, those bacteria transfer. When animals are given antibiotics, there is still antibiotic shed in their urine and their feces. This allows the antibiotic residue to gain access to our soils and water – which we then get exposed to. The university of Illinois in 2009 complete an evaluation of antibiotic resistance and residues in water and soil in close proximity to swine production facilities. They stated that is a risk to our environment and that these risks need to be addressed.

As a medical practitioner, I am seeing increased cases of resistance on a regular basis. This is a major issue in both human and veterinary medical professions. It affects us all. It is vital that we take every measure possible to reduce or slow the spread of resistance.

University of Missouri Agricultural Economist John Ikerd did an excellent job summarizing the risks to communities with large CAFO's. In it he evaluated the commercial benefits of CAFO's, citing a financial benefit of only $2/cwt of live hog – passing on a consumer savings of less than two cents per dollar for what we spend at the store.

Is this savings worth the risk of infections that we cannot treat?

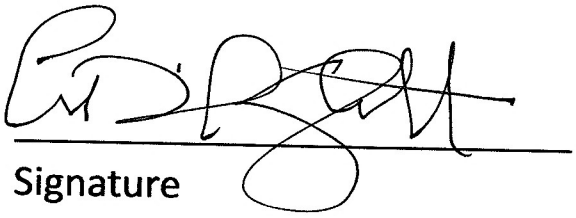
I strongly urge that at this time, this CAFO not be allowed to open in our community until these concerns can be addressed. Additionally, I have provided a assessment tool from our local NDSU extension service that allows evaluation of risks to the community of an animal feeding operations. I would ask that minimally, this tool at least be used and the risks discussed and addressed prior to granting approval.

- CDC's 2013 report on AB resistance - 2,049,442 illnesses and 23,000 deaths due to resistance
- in NC, during 2005, estimated they use 3M lb. of AB's annually alone which is estimated to be the same as the estimated amt. of AB's used Nationally to Treat People
- Nationwide → AB's used nationally are estimated for growth promotants to be 24.6M lb/year
- All microbes in or on these animals are exposed to the antibiotics used. They also appear on the facilities, transport systems, environment, watershed
- University of Illinois in 2009 completed evaluation of antibiotic resistance and residues in water and soil in close proximity to swine production facilities. Found tetracycline resistant genes in 2 CAFO's, & found in soils where manure is added
- AMA + Am. Academy of Pediatrics among other medical & health bodies have issued a stance against CAFO's d/t the impact on antibiotic resistance and risk to population
- * Say that they make good neighbors, if that is true, why are there continuing complaints, why are there continuing studies

Acknowledgement of Receipt

I hereby acknowledge receipt of the following documents, delivered by Liane R. Stout, for the concerned citizens and property owners in Buffalo, North Dakota and the surrounding area, in the County of Cass, State of North Dakota, in the matter of the permit for Application No. DNAF00853 filed by Rolling Green Family Farms RE, LLC of Pipestone, Minnesota.

Attached document: "Request for Public Hearing" containing 17 pages with 128 signatures.



Signature

1-25-16

Date

North Dakota Department of Health
Division of Water Quality
Environmental Health Section
918 East Divide Avenue
Bismarck, ND 58501

REQUEST FOR PUBLIC HEARING

To: The North Dakota Department of Health
Division of Water Quality and Division of Air Quality
918 East Divide Avenue, Fourth Floor
Bismarck, ND 58501

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SIGNATURE	HOUSE NUMBER OR STREET ADDRESS	DATE
Lillian VonBank	3848 140th Ave SE	1-23-16
Todd Combs	203 Broadway S	1-23-16
Caid Combs	203 Broadway S	1-23-16
Reynold Helenne	205 1ST. Ave East	1-23-16
Cassandra Bleenn	205 1st Ave East	1-23-16
David Vergel	401 Pearl St N	1-23-16
Jan VonBank	402 Pearl St	1-23-16
Gerald Mauch	3506-140 Ave SE	1-23-16
Ronald Hoyt	601 Bond St. S.	1-23-16
Harold Kasenske	101 Pearl St.	1-23-16

REQUEST FOR PUBLIC HEARING

To: The North Dakota Department of Health
Division of Water Quality and Division of Air Quality
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SIGNATURE	HOUSE NUMBER OR STREET ADDRESS	DATE
Judith Von Bank	3610 140th Ave SE	1-23-16
Robert Von Bank	3610 140th Ave SE	1-23-16
Marian Kasowski	Box 48 - 101 Pearl street	1-23-16
Craig D Wandt	3605 139½ Ave S.E Buffalo N.D.	1-23-16
Sheila Thompson	3517 142nd Ave SE. Buffalo ND	1-23-16
~~Roy Thompson~~ Duplicate +1		11
[illegible]	3266 140th Ave SE Buffalo, ND	1-23-16
Jacqueline Marcks	3506 140th Ave SE Buffalo, ND	1-23-16
[illegible]	304 4th Ave S Buffalo ND	1-23-16
[illegible]	14255 34th St. SE Buffalo ND	1-23-16

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SIGNATURE	HOUSE NUMBER OR STREET ADDRESS	DATE
[signature]	304 Wilcox Ave N. Buffalo ND	1/23/16
[signature]	304 Wilcox Ave Buffalo ND	1-23-16
[signature]	3666 139th Ave SE Buffalo, ND	1-23-16
[signature]	3666 139th Ave SE Buffalo, ND	1-23-16
[signature]	13889 39th Ave SE Buffalo ND	1-24-16
[signature]	3936 138th Ave SE Buffalo, ND	1-23-16
[signature]	3936 138 Ave SE Buffalo, ND	1-23-16
[signature]	13791 91st St SE Buffalo	1-23-16
[signature]	3805 139 Ave SE Buffalo ND	1-23-16
[signature]	3661 137th Ave SE Buffalo ND	1-23-16

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SIGNATURE	HOUSE NUMBER OR STREET ADDRESS	DATE
Jill M. Zaun	3661 137th Ave. SE, Buffalo, ND	01-23-16
Sue Buhr	503 Bond St., Buffalo, ND	1-23/16
Kalvin Boyd	201 2nd ave S, Buffalo, ND	1-23-16
Connie Boyd	201 2nd Ave S. Buffalo, ND	1-23-16
Wf Kuznia	203 4th Ave S, Buffalo, ND	1-23-16
[illegible]	203 4th Ave S. Buffalo ND	1-23-16
John & Kitty Cushman	202 Front St S Buffalo ND	1-23-16
[illegible] & Carol Meeks	13954-34th St SE. Buffalo ND	1-23-16
Cathy Mauf	" "	1-23-16
Lori J. Smith	501 3rd St. N, Buffalo	1/23/16

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SIGNATURE	HOUSE NUMBER OR STREET ADDRESS	DATE
Virgil Olson	Virgil Olson; 104 Bush Ave.; Buffalo, ND	01/23/16
Kaitlyn Kaeser	102 Bush Ave PO. 74, Buffalo, ND	1-23-16
Mari Ketterer	105 Wilcox Ave N. Buffalo, ND	1-23-16.
Al Lee	605 main street EAST Buffalo ND	1-23-16
Lyn Lee	605 Main St. E. Buffalo, ND	1-23-16
Lonnie Larson	3119 142nd ave SE Buffalo	1-23-16
Clint Dietz	201 - 1st Ave. E Buffalo	1-23-16
Lee Froese	3564 143rd Ave. SE Buffalo ND	1-23-16
Kent Beck	14195 - 39th St. SE. Buffalo ND	1-23-16
Pete Baasch	3538 136th Ave SE Buffalo, ND	1-23-16

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SIGNATURE	HOUSE NUMBER OR STREET ADDRESS	DATE
Dan Sheldon	14409 35th st SE BUFFALO ND	1-23-16
Kristin Sheldon	14409 35th St SE Buffalo, ND	1-23-16
Kal Green	204 4th Ave S Buffalo	1-23-16
Sherry Peterson	603 Bond St S Buffalo ND	1-23-16
Von Pere	603 bond st Buffalo N.D	1-23-16
Antoinette Babcock	200 pearl St. Buffalo ND	1/03/16
Roy Thompson	3517 142 Ave S.E. Buffalo	11
Ethel Grieger	13695 31 St SE Buffalo, ND	1-23-16
Claudia Van Bank	602 Pearl St	1-23-16
Bradley Clark	3266 140th Ave SE Buffalo ND	1-23-16

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SIGNATURE	HOUSE NUMBER OR STREET ADDRESS	DATE
Amanda Lien	204 Strand Ave N	1-23
Justin Marcks	13954 34TH St SE Buffalo ND	1-23
Joni Baggers	3790 141st Ave SE Buffalo, ND	1-23
Brenda VonBank	402 Pearl St Buffalo N.D	1-23
Janice Bjornest	204 1st Ave E	1-23
[illegible]	102 1ST AVE E	1-23
Candy Blow	102 1st Ave E	1-23
Lee Fischer	300 BOND ST BUFFALO, ND	1-24
Carolyn Dostert	305 4th St. N. Buffalo	1-24
Alan D. Dostert	305 4th St. N Buffalo	1-24

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SIGNATURE	HOUSE NUMBER OR STREET ADDRESS	DATE
Beverly Jaeger	601 Main St Buffalo	1-23-16
[illegible]	103 2nd Ave So. Buffalo	1-23-16
Karen Smith	14212 40 St SE Alice	1-23-16
[illegible]	14212 40th St SE Alice	1/23/16
Eric Lione	204 Strand Ave N	1/23/16
Corey Tobin	205 Strand Ave N	1/23/16
[illegible]	14006 37th St. SE. Buffalo	1/23/16
Sandra Cromwell	14006 37th St SE Buffalo ND	1/23/16
Arietta Sauer	14006 37th St SE Buffalo ND	1-23-16
Melissa Baasch	3538 138th Ave SE Buffalo ND	1-23-16

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SIGNATURE	HOUSE NUMBER OR STREET ADDRESS	DATE
Marlene Sheldon	3477 144 Ave Buffalo ND 58011	1-23-16
Bill Sheldon	3477 144 Ave Buffalo ND 58011	1-23-16
Linda Wendel	3395 143rd Ave SE Buffalo ND 58011	1-23-16
Janice Kaszuntki	14757 33rd St SE Buffalo, ND 58011	1-23-16
[illegible]	14252 330 ST SE Buffalo 58011	1-23-16
Kenneth Ronning	202 5TH AVE N Buffalo ND 58011	1-24-16
Kerry Ronning	202 5th Ave N Buffalo, ND 58011	1-24-16
Clyde Anderson	204-5th Ave. N. Buffalo, ND	1-24-16
Jane Anderson	204-5th Ave N. Buffalo, ND	1-24-16
[illegible]	105 5th Ave N Buffalo ND	1-24-16

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SIGNATURE	HOUSE NUMBER OR STREET ADDRESS	DATE
	13819 41st SE Buffalo ND	1/23/16
	302 3rd St North Buffalo, ND	1-23-16
	300 1st Ave E Buffalo, ND	1-23-16
	13717 30 St SE	1-23-16
	203 Broadway S Buffalo	1-23-16
	200 2nd Ave S Buffalo	1-23-16
	403 Bond St S Buffalo	1-23-16
	200 2nd Ave S Buffalo	1-23-16
	206 5th Ave N Buffalo	1-23-16
	3262-142nd Ave SE Buffalo	1-25-16

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SIGNATURE	HOUSE NUMBER OR STREET ADDRESS	DATE
	405 Wilcox AVE N	1-23-16
Betty Von Bank	100 2nd Line S.	1-24-16
Cecil P. Von Bank	100 2nd ave S.	1-24-16
John L. Hansen	4127. 138th ave S.E.	1-24-16
Betty Jan Stalmon	13602 36th St SE	1-24-16
Frank Biggen	3927. 143 rd ave SE	1 24 16
Lana Biggen	3927-143rd Ave SE	1-24-16
Gary Wilbrandt	401 4th Street	1-24-16
Sandra Wilbrandt	401 4th Street N. Buffalo, ND	1-24-16

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SIGNATURE	HOUSE NUMBER OR STREET ADDRESS	DATE
Rhonda Nudell	610 3rd St. N	1-24-16
Rylee Nudell	610 3rd St. N	1-24-16
Corinne Erwin	202 5th Ave, S.	1-24-16
[redacted]	105 2nd Ave, S.	1-24-16
Vera Creager	2958 136th Ave SE	1-24-16
Laine Stoltz	300 S Bond St, Buffalo, ND	1-24-16

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SIGNATURE	HOUSE NUMBER OR STREET ADDRESS	DATE
Heidi Baasch	3545 139th AVE SE Buffalo	1-23-16
William P. Baasch	200 pearl St. Buffalo, ND	1/23/16
Daniel Biggus	3790 141 Ave. S.E. Buffalo ND	1-24-16
Keith Biggus	3790 141 Av SE; Buffalo ND	1-24-16

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SIGNATURE	HOUSE NUMBER OR STREET ADDRESS	DATE
William Bork	105 5th Ave N Buffalo ND	1-24-16
Angela McGuire	202 Wilcox Ave N. Buffalo, ND	1-24-16

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SIGNATURE	HOUSE NUMBER OR STREET ADDRESS	DATE
Stephanie Baasch	13905 36th St SE	Jan 22, 2016
David M Baasch	13905 36th St SE	Jan 22 2016

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Each says for himself or herself that he or she has personally signed this Request for a Public Hearing; that his or her resident address is correctly written after his or her name; and that he or she owns property or resides within close proximity of the proposed site of the swine production facility. The undersigned respectfully submit this Request for a Public Hearing in order to obtain accurate information.

SIGNATURE	HOUSE NUMBER OR STREET ADDRESS	DATE
Kelli Sproul	251 STRADA NOVA, PALM DESERT, CA 92260	1/22/2016
Greg Sproul	12 EDEN, IRVINE, CA 92620	1-22-16
Sue Sproul	12 EDEN, IRVINE, CA 92620	1-22-16

REQUEST FOR PUBLIC HEARING

To: The North Dakota Department of Health
Division of Water Quality and Division of Air Quality
918 East Divide Avenue, Fourth Floor
Bismarck, ND 58501

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SIGNATURE	HOUSE NUMBER OR STREET ADDRESS	DATE
[signature]	1620 36th ave S Fargo ND	1-24-16
Chuck Hagen	1629 13th Ave So Fargo	1-24-16
Robert Hagen	" " " "	1-24-16

March 14, 2016

Karl Rockeman, P.E., Director
Division of Water Quality
North Dakota Department of Health
918 East Divide Avenue, 4th Floor
Bismarck, ND 58501-1947

Dear Mr. Rockeman:

News articles in the Fargo Forum recently highlighted concerns regarding a proposed large hog facility to be located near Buffalo in Section 3 of Howes Township, Cass County. Given the anticipated plans for manure application on local soils from this facility, it is incumbent upon me to comment on the inadequate evaluation of local soil and geological information contained in Public Notice Number: ND-2016-007 posted on the Department of Health website. I have personally inspected many scores of soil profiles, to depths of about 4 feet, in Sections 2, 3, 4, 5, and 8 of Howes Township for both agricultural research and teaching duties since the late 1980s. Some of these observations are germane to the suitability of local soils for manure application.

A soil interpretation map is attached that was created in the NRCS Web Soil Survey application for an area from the Alice I-94 interchange to the western boundary of the Lake Agassiz Campbell beach on the eastern boundary to within one half mile of Buffalo, this area occupies just over 7200 acres. Results of running a manure application rating on this area show that 36% of the land is very limited, largely due to shallow groundwater, ponding potential, or slow water movement in subsoils. Another 22 percent of the area is rated by Web Soil Survey as somewhat limited, but that is likely an underestimate given the nature of soils and sediments in this region of the township, as will be discussed below.

Soil map unit G101A, the Hamerly-Wyard loams, 0 to 3 percent slopes, does not specifically list the Wyard component in the calculations for the rating, but is mapped on nearly 1500 acres of the 7200 acre (20.8%). The limited value (0.86 for depth to saturated zone) for the Wyard soil is listed in the Lankin loam soil map unit (1413A) of the Web Soil Survey report. The Cass County Soil Survey soil scientists mapped the Wyard soil on the till plain of western Cass County and recognized this somewhat poorly drained soil in landscape positions lower than both Hamerly and Svea soils on the landscape. Common redox features, i.e., mottles, which reflect alternating periods of aerobic and anaerobic conditions were identified by soil scientists at depth of 10 inches in the typical pedon used for the soil survey (Prochnow et al., 1985). In the soils of northern Howes Township there is a high likelihood that a significant portion of the Wyard component has a clay enriched B horizon that would be rated as 1.0 for slow water movement (the most limiting condition for manure applications). These observations suggest that the "very limited" rating area of the 7200 acres is probably considerably higher than 36 percent.

In addition to the very limited and somewhat limited ratings identified on the Web Soil Survey report, other sedimentologic evidence suggests that local conditions are not optimum for manure application on a continuing and broad-scale basis. Most of the upland glacial till I have observed in this area consists of stratified lenses around the 2 to 3 foot depth that students often misname "platy structure"; it is not. Instead these laminae result from what field soil scientists recognize as "water worked till", which has much greater lateral rather than vertical hydraulic conductivity. This anisotropic material will allow effluents released from manure application to move laterally

at depth. Even though manure is applied to a Barnes-Buse soil mapping unit, at some point, leachates will move downslope and influence adjacent map units or shallow groundwater.

In Section 5 of Howes Township we have discovered nearly pure lenses of a pebble free heavy silt loam that was obviously deposited in relatively calm water. Dr. John Bluemle (1991) stated in his Face of North Dakota publication that lake sediments have been discovered at elevations higher than the Campbell beachline. Bluemle named these the Norma, Cuba, Fingal, and Alice strandlines (Bluemle, 1991, Table 1, p. 80) and he stated that these are "complex features that are difficult to trace laterally." Such features would certainly affect both vertical and lateral groundwater movement in areas that might be chosen for manure application; these features would not be routinely identified in a county soil survey maps.

Lastly, detailed surficial geology mapping in western Cass county reveal many Quaternary fluvial deposits known as eskers. These coarse textured deposits were formed in flowing streams below glacial ice. In upland areas there would be very poor filtering of applied manure, and given the low surface area of these soil textures, pollutants could move rapidly with excess rainwater or snowmelt. The distribution of eskers near the proposed hog facility is more correctly referred to as an "esker swarm" in geological terms (Fig. 1). The presence and distribution of these eskers, and other coarse textured fluvial channels so close to the proposed livestock facility will certainly cause difficulty in some fields where manure is applied.

From my professional experience, the hog facility is ill-advised in this location.

Respectfully yours,

Dr. David Hopkins
North Dakota Registered Professional Soil Classifier, No. 59
Fargo , ND

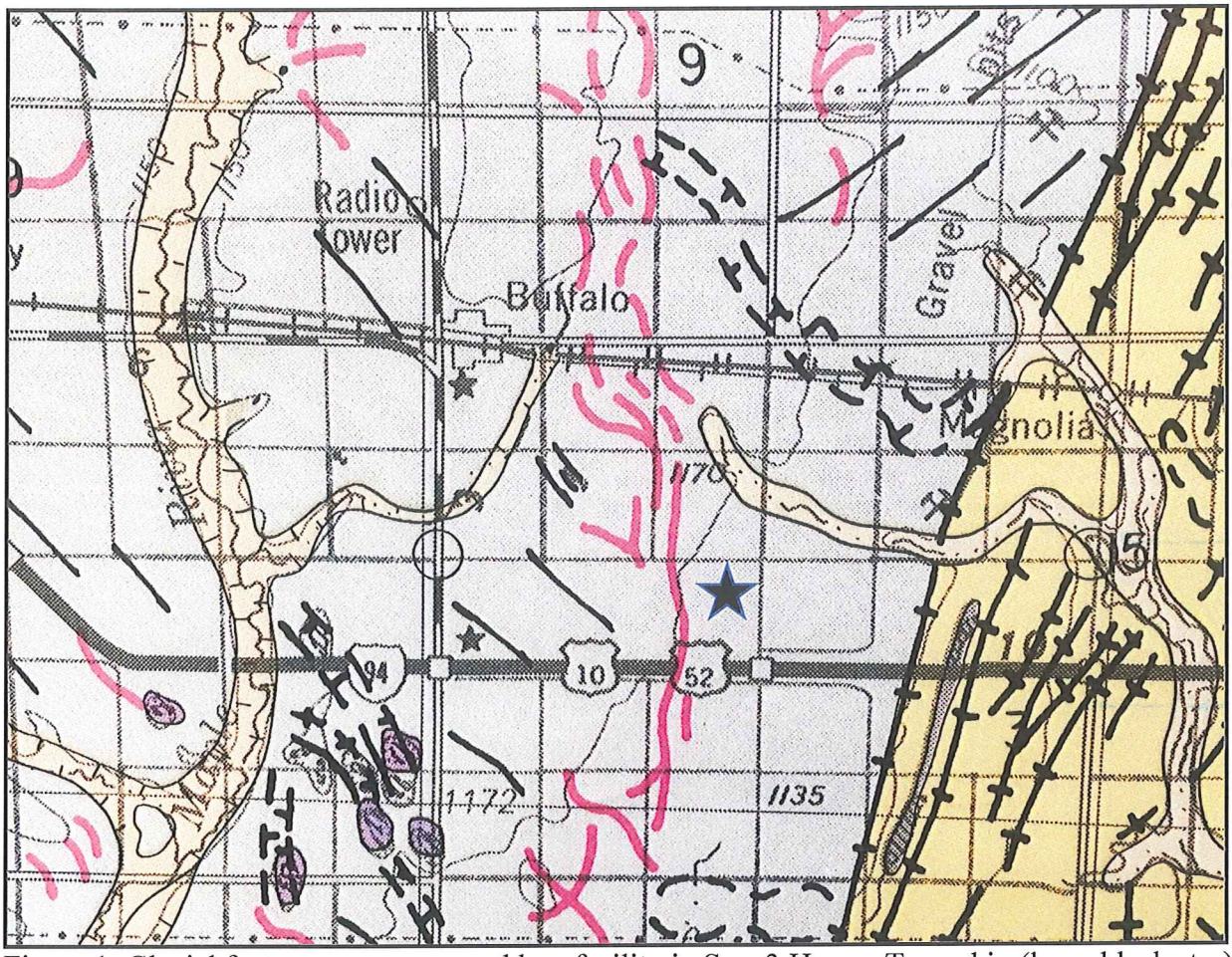


Figure 1. Glacial features near proposed hog facility in Sec. 3 Howes Township (large black star) as shown on a geological map of western Cass County. The map legend states that red thick lines are eskers; and paired black lines are buried meltwater channels, collapsed tunnel valleys, or esker complexes (taken from Harris, 1987).

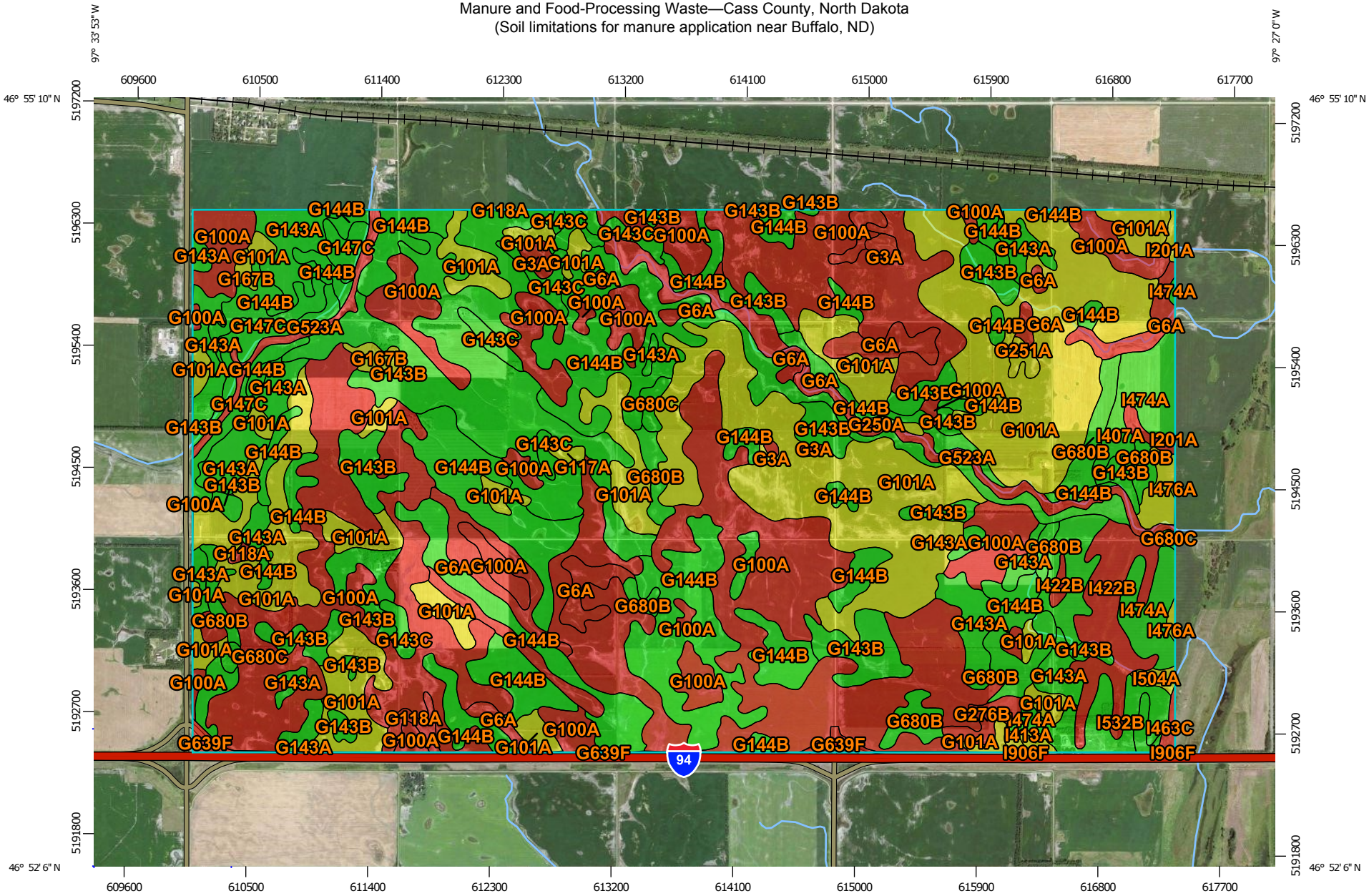
References:

Bluemle, J. P. 1991. The face of North Dakota. Rev. Ed. Educ. Series 21. N.D. Geological Survey. Bismarck.

Harris, K. L. 1987. Surface geology of the Sheyenne River map area. Atlas Series Map 15. N.D. Geological Survey. Bismarck.

Prochnow, N. D., N. J. Lunde, W. J. Terry, and D. P. Opdahl. 1985. Soil survey of Cass County area, North Dakota. Soil Conservation Service. U. S. Gov. Print. Office, Washington, D.C.

Manure and Food-Processing Waste—Cass County, North Dakota
(Soil limitations for manure application near Buffalo, ND)



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cass County, North Dakota
Survey Area Data: Version 15, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Aug 27, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
G3A	Parnell silty clay loam, 0 to 1 percent slopes	Very limited	Parnell (64%)	Slow water movement (1.00)	28.3	0.4%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Vallers (10%)	Depth to saturated zone (1.00)		
				Leaching (0.70)		
			Vallers, moderately saline (9%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Southam (6%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Tonka (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Ferney (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
				Salinity (0.50)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
G6A	Vallers loam, 0 to 1 percent slopes	Very limited	Vallers (67%)	Depth to saturated zone (1.00)	305.6	4.2%
				Leaching (0.70)		
			Vallers, moderately saline (8%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Tonka (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Parnell (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cresbard (2%)	Slow water movement (1.00)		
				Sodium content (0.32)		
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Tonka (28%)	Slow water movement (1.00)	1,933.7	26.8%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Wyard (7%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
			Vallers, moderately saline (7%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cavour (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (46%)	Depth to saturated zone (0.86)	1,499.5	20.8%
			Balaton (7%)	Depth to saturated zone (0.22)		
			Hamerly, moderately saline (5%)	Depth to saturated zone (0.86)		
				Salinity (0.50)		
				Sodium content (0.18)		
G117A	Hamerly loam, saline, 0 to 3 percent slopes	Somewhat limited	Hamerly, moderately saline (55%)	Depth to saturated zone (0.86)	7.1	0.1%
				Salinity (0.50)		
				Sodium content (0.18)		
			Hamerly (8%)	Depth to saturated zone (0.86)		
			Balaton (7%)	Depth to saturated zone (0.22)		
G118A	Vallers loam, saline, 0 to 1 percent slopes	Very limited	Vallers, moderately saline (68%)	Depth to saturated zone (1.00)	27.9	0.4%

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Tonka (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cresbard (4%)	Slow water movement (1.00)		
				Sodium content (0.32)		
			Parnell (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Easby (3%)	Depth to saturated zone (1.00)		
				Salinity (1.00)		
				Sodium content (1.00)		
				Droughty (1.00)		
				Slow water movement (0.50)		
G125A	Cavour-Cresbard loams, 0 to 3 percent slopes	Very limited	Cavour (49%)	Slow water movement (1.00)	5.8	0.1%
				Sodium content (1.00)		
			Cresbard (25%)	Slow water movement (1.00)		
				Sodium content (0.18)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
			Ferney (5%)	Slow water movement (1.00)		
				Sodium content (1.00)		
				Salinity (0.50)		
			Tonka (2%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Vallers, moderately saline (2%)	Depth to saturated zone (1.00)		
				Leaching (0.70)		
				Salinity (0.50)		
				Sodium content (0.32)		
				Droughty (0.03)		
G143A	Barnes-Svea loams, 0 to 3 percent slopes	Not limited	Barnes (39%)		361.0	5.0%
			Svea (38%)			
			Buse (2%)			
G143B	Barnes-Svea loams, 3 to 6 percent slopes	Not limited	Barnes (42%)		784.0	10.9%
			Svea (21%)			
			Buse (9%)			
			Swenoda (3%)			
G143C	Barnes-Buse-Langhei loams, 6 to 9 percent slopes	Not limited	Barnes (24%)		82.9	1.2%
			Buse (23%)			
			Langhei (18%)			
			Svea (14%)			
			Balaton (3%)			
			Lanona (3%)			
G144B	Barnes-Buse loams, 3 to 6 percent slopes	Not limited	Barnes (25%)		1,184.4	16.4%
			Buse (24%)			
			Svea (14%)			
			Balaton (10%)			
			Langhei (4%)			
			Swenoda (3%)			

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
G147C	Buse-Barnes-Darnen loams, 3 to 9 percent slopes	Not limited	Buse (28%)		94.5	1.3%
			Barnes (23%)			
			Darnen (22%)			
			Langhei (7%)			
			Swenoda (3%)			
G167B	Balaton-Wyard loams, 0 to 6 percent slopes	Somewhat limited	Balaton (33%)	Depth to saturated zone (0.22)	25.2	0.3%
			Hamerly (9%)	Depth to saturated zone (0.86)		
G250A	Divide loam, 0 to 2 percent slopes	Somewhat limited	Divide (70%)	Depth to saturated zone (0.86)	5.9	0.1%
			Wyrene (4%)	Depth to saturated zone (0.86)		
				Droughty (0.31)		
G251A	Divide loam, loamy substratum, 0 to 2 percent slopes	Somewhat limited	Divide, loamy substratum (74%)	Depth to saturated zone (0.86)	11.1	0.2%
			Sverdrup, loamy substratum (6%)	Leaching (0.45)		
			Wyrene, loamy substratum (5%)	Depth to saturated zone (0.86)		
G276B	Renshaw-Sioux complex, 2 to 6 percent slopes	Very limited	Renshaw (36%)	Filtering capacity (1.00)	25.2	0.3%
				Droughty (0.52)		
			Sioux (20%)	Filtering capacity (1.00)		
				Leaching (0.45)		
				Droughty (0.18)		
			Fordville (10%)	Filtering capacity (1.00)		
			Sioux (10%)	Filtering capacity (1.00)		
				Leaching (0.45)		
				Droughty (0.15)		
			Osakis (7%)	Filtering capacity (1.00)		
				Droughty (0.90)		
				Leaching (0.45)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
			Warsing (6%)	Filtering capacity (1.00)		
				Droughty (0.01)		
			Arvilla (4%)	Filtering capacity (1.00)		
				Droughty (0.98)		
				Leaching (0.45)		
			Marysland (3%)	Depth to saturated zone (1.00)		
				Leaching (0.70)		
G523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	Very limited	Fluvaquents, channeled, frequently flooded (40%)	Ponding (1.00)	100.5	1.4%
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.90)		
			Lowe, frequently flooded (28%)	Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
			Lowe, moderately saline, frequently flooded (20%)	Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
				Salinity (0.50)		
				Sodium content (0.32)		
			Lowe, very poorly drained, frequently flooded (5%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
G639F	Orthents-Aquents-Urban Land, highway complex, 0 to 35 percent slopes	Very limited	Orthents (41%)	Slope (1.00)	21.3	0.3%
				Slow water movement (0.50)		
				Large stones (0.04)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
			Aquents, clayey (16%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Renshaw (6%)	Filtering capacity (1.00)		
				Droughty (0.52)		
			Parnell (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
G680B	Barnes-Sioux complex, 1 to 6 percent slopes	Not limited	Barnes (39%)		179.9	2.5%
			Buse (7%)			
			Svea (7%)			
			Balaton (6%)			
			Swenoda (6%)			
			Langhei (3%)			
G680C	Barnes-Sioux complex, 3 to 9 percent slopes	Not limited	Barnes (34%)		21.3	0.3%
			Buse (9%)			
			Svea (7%)			
			Lanona (6%)			
			Balaton (6%)			
			Langhei (3%)			
I201A	Glyndon silt loam, 0 to 2 percent slopes	Somewhat limited	Glyndon (80%)	Depth to saturated zone (0.86)	33.3	0.5%
			Glyndon, moderately saline (3%)	Depth to saturated zone (0.86)		
				Salinity (0.50)		
				Sodium content (0.32)		
I407A	Winger silty clay loam, moderately	Very limited	Winger, moderately saline (76%)	Ponding (1.00)	11.2	0.2%

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
	saline, 0 to 1 percent slopes			Depth to saturated zone (1.00)		
				Leaching (0.70)		
				Salinity (0.50)		
				Sodium content (0.32)		
			Winger (14%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.70)		
			Mustinka (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Parnell (2%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
I413A	Lankin loam, 0 to 2 percent slopes	Somewhat limited	Lankin (75%)	Slow water movement (0.41)	7.1	0.1%
			Wyard (8%)	Depth to saturated zone (0.86)		
I422B	Renshaw-Sioux complex, 0 to 6 percent slopes	Very limited	Renshaw (36%)	Filtering capacity (1.00)	130.1	1.8%
				Droughty (0.52)		
				Leaching (0.45)		
			Sioux (20%)	Filtering capacity (1.00)		
				Droughty (0.99)		
				Leaching (0.45)		
			Sioux, sandy loam (10%)	Filtering capacity (1.00)		
				Droughty (0.95)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
				Leaching (0.45)		
			Arvilla (6%)	Filtering capacity (1.00)		
				Droughty (0.99)		
				Leaching (0.45)		
			Osakis (4%)	Filtering capacity (1.00)		
				Droughty (0.90)		
			Marysland (3%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.70)		
l463C	Sioux-Renshaw complex, 6 to 9 percent slopes	Very limited	Sioux (45%)	Filtering capacity (1.00)	7.3	0.1%
				Droughty (0.99)		
				Leaching (0.45)		
			Renshaw (40%)	Filtering capacity (1.00)		
				Droughty (0.52)		
				Leaching (0.45)		
l474A	Gardena-Glyndon silt loams, 0 to 2 percent slopes	Not limited	Gardena (47%)		283.5	3.9%
			Eckman (3%)			
l476A	Glyndon silt loam, moderately saline, 0 to 2 percent slopes	Somewhat limited	Glyndon, moderately saline (80%)	Depth to saturated zone (0.86)	4.0	0.1%
				Salinity (0.50)		
				Sodium content (0.32)		
			Wyndmere, moderately saline (3%)	Depth to saturated zone (0.86)		
				Salinity (0.50)		
				Sodium content (0.32)		
l477A	Antler silty clay loam, moderately saline, 0 to 2 percent slopes	Somewhat limited	Antler, moderately saline (75%)	Depth to saturated zone (0.86)	4.4	0.1%
				Salinity (0.50)		
				Slow water movement (0.41)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
				Sodium content (0.32)		
			Gilby (7%)	Depth to saturated zone (0.86)		
				Slow water movement (0.41)		
			Doran (7%)	Depth to saturated zone (0.86)		
				Slow water movement (0.41)		
I504A	Antler-Wyard loams, 0 to 2 percent slopes	Somewhat limited	Antler (50%)	Depth to saturated zone (0.86)	10.0	0.1%
			Wyard (35%)	Depth to saturated zone (0.86)		
			Gilby, moderately saline (5%)	Depth to saturated zone (0.86)		
				Salinity (0.78)		
				Sodium content (0.50)		
I532B	Fordville-Renshaw loams, 2 to 6 percent slopes	Not limited	Fordville (70%)		10.7	0.1%
I906F	Orthents-Aquents-Urban Land, highway complex, 0 to 35 percent slopes	Very limited	Aquents (25%)	Slow water movement (1.00)	0.1	0.0%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Orthents (25%)	Slope (1.00)		
				Slow water movement (0.81)		
Totals for Area of Interest					**7,206.8**	**100.0%**

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	**Acres in AOI**	**Percent of AOI**
Not limited	3,002.3	41.7%

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	**Acres in AOI**	**Percent of AOI**
Very limited	2,597.0	36.0%
Somewhat limited	1,607.6	22.3%
Totals for Area of Interest	**7,206.8**	**100.0%**

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

March 14, 2016

Karl Rockeman, P.E., Director
Division of Water Quality
North Dakota Department of Health
918 East Divide Avenue, 4th Floor
Bismarck, ND 58501-1947

Dear Mr. Rockeman:

News articles in the Fargo Forum recently highlighted concerns regarding a proposed large hog facility to be located near Buffalo in Section 3 of Howes Township, Cass County. Given the anticipated plans for manure application on local soils from this facility, it is incumbent upon me to comment on the inadequate evaluation of local soil and geological information contained in Public Notice Number: ND-2016-007 posted on the Department of Health website. I have personally inspected many scores of soil profiles, to depths of about 4 feet, in Sections 2, 3, 4, 5, and 8 of Howes Township for both agricultural research and teaching duties since the late 1980s. Some of these observations are germane to the suitability of local soils for manure application.

A soil interpretation map is attached that was created in the NRCS Web Soil Survey application for an area from the Alice I-94 interchange to the western boundary of the Lake Agassiz Campbell beach on the eastern boundary to within one half mile of Buffalo, this area occupies just over 7200 acres. Results of running a manure application rating on this area show that 36% of the land is very limited, largely due to shallow groundwater, ponding potential, or slow water movement in subsoils. Another 22 percent of the area is rated by Web Soil Survey as somewhat limited, but that is likely an underestimate given the nature of soils and sediments in this region of the township, as will be discussed below.

Soil map unit G101A, the Hamerly-Wyard loams, 0 to 3 percent slopes, does not specifically list the Wyard component in the calculations for the rating, but is mapped on nearly 1500 acres of the 7200 acre (20.8%). The limited value (0.86 for depth to saturated zone) for the Wyard soil is listed in the Lankin loam soil map unit (1413A) of the Web Soil Survey report. The Cass County Soil Survey soil scientists mapped the Wyard soil on the till plain of western Cass County and recognized this somewhat poorly drained soil in landscape positions lower than both Hamerly and Svea soils on the landscape. Common redox features, i.e., mottles, which reflect alternating periods of aerobic and anaerobic conditions were identified by soil scientists at depth of 10 inches in the typical pedon used for the soil survey (Prochnow et al., 1985). In the soils of northern Howes Township there is a high likelihood that a significant portion of the Wyard component has a clay enriched B horizon that would be rated as 1.0 for slow water movement (the most limiting condition for manure applications). These observations suggest that the "very limited" rating area of the 7200 acres is probably considerably higher than 36 percent.

In addition to the very limited and somewhat limited ratings identified on the Web Soil Survey report, other sedimentologic evidence suggests that local conditions are not optimum for manure application on a continuing and broad-scale basis. Most of the upland glacial till I have observed in this area consists of stratified lenses around the 2 to 3 foot depth that students often misname "platy structure"; it is not. Instead these laminae result from what field soil scientists recognize as "water worked till", which has much greater lateral rather than vertical hydraulic conductivity. This anisotropic material will allow effluents released from manure application to move laterally

at depth. Even though manure is applied to a Barnes-Buse soil mapping unit, at some point, leachates will move downslope and influence adjacent map units or shallow groundwater.

In Section 5 of Howes Township we have discovered nearly pure lenses of a pebble free heavy silt loam that was obviously deposited in relatively calm water. Dr. John Bluemle (1991) stated in his Face of North Dakota publication that lake sediments have been discovered at elevations higher than the Campbell beachline. Bluemle named these the Norma, Cuba, Fingal, and Alice strandlines (Bluemle, 1991, Table 1, p. 80) and he stated that these are "complex features that are difficult to trace laterally." Such features would certainly affect both vertical and lateral groundwater movement in areas that might be chosen for manure application; these features would not be routinely identified in a county soil survey maps.

Lastly, detailed surficial geology mapping in western Cass county reveal many Quaternary fluvial deposits known as eskers. These coarse textured deposits were formed in flowing streams below glacial ice. In upland areas there would be very poor filtering of applied manure, and given the low surface area of these soil textures, pollutants could move rapidly with excess rainwater or snowmelt. The distribution of eskers near the proposed hog facility is more correctly referred to as an "esker swarm" in geological terms (Fig. 1). The presence and distribution of these eskers, and other coarse textured fluvial channels so close to the proposed livestock facility will certainly cause difficulty in some fields where manure is applied.

From my professional experience, the hog facility is ill-advised in this location.

Respectfully yours,

Dr. David Hopkins
North Dakota Registered Professional Soil Classifier, No. 59
Fargo , ND

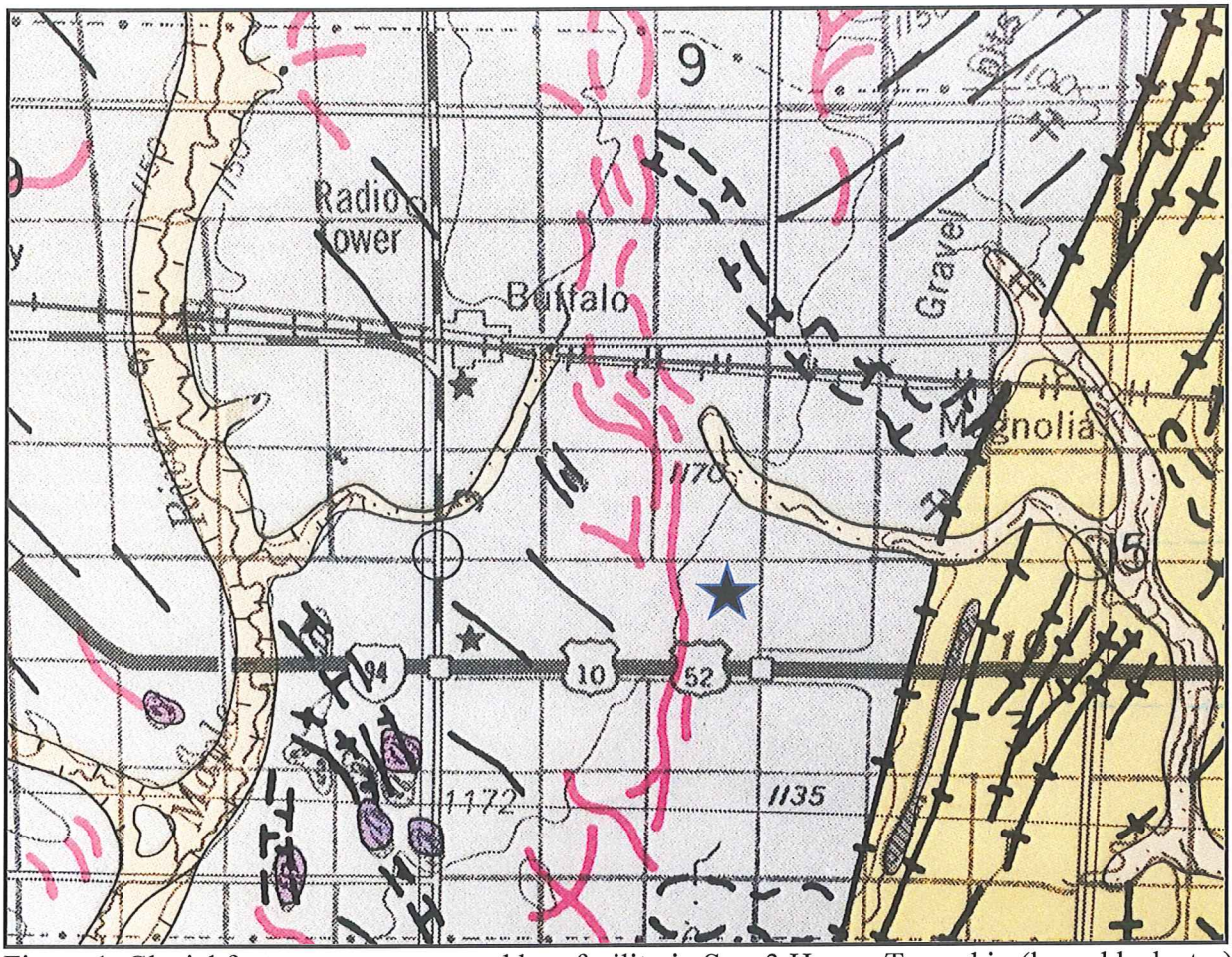


Figure 1. Glacial features near proposed hog facility in Sec. 3 Howes Township (large black star) as shown on a geological map of western Cass County. The map legend states that red thick lines are eskers; and paired black lines are buried meltwater channels, collapsed tunnel valleys, or esker complexes (taken from Harris, 1987).

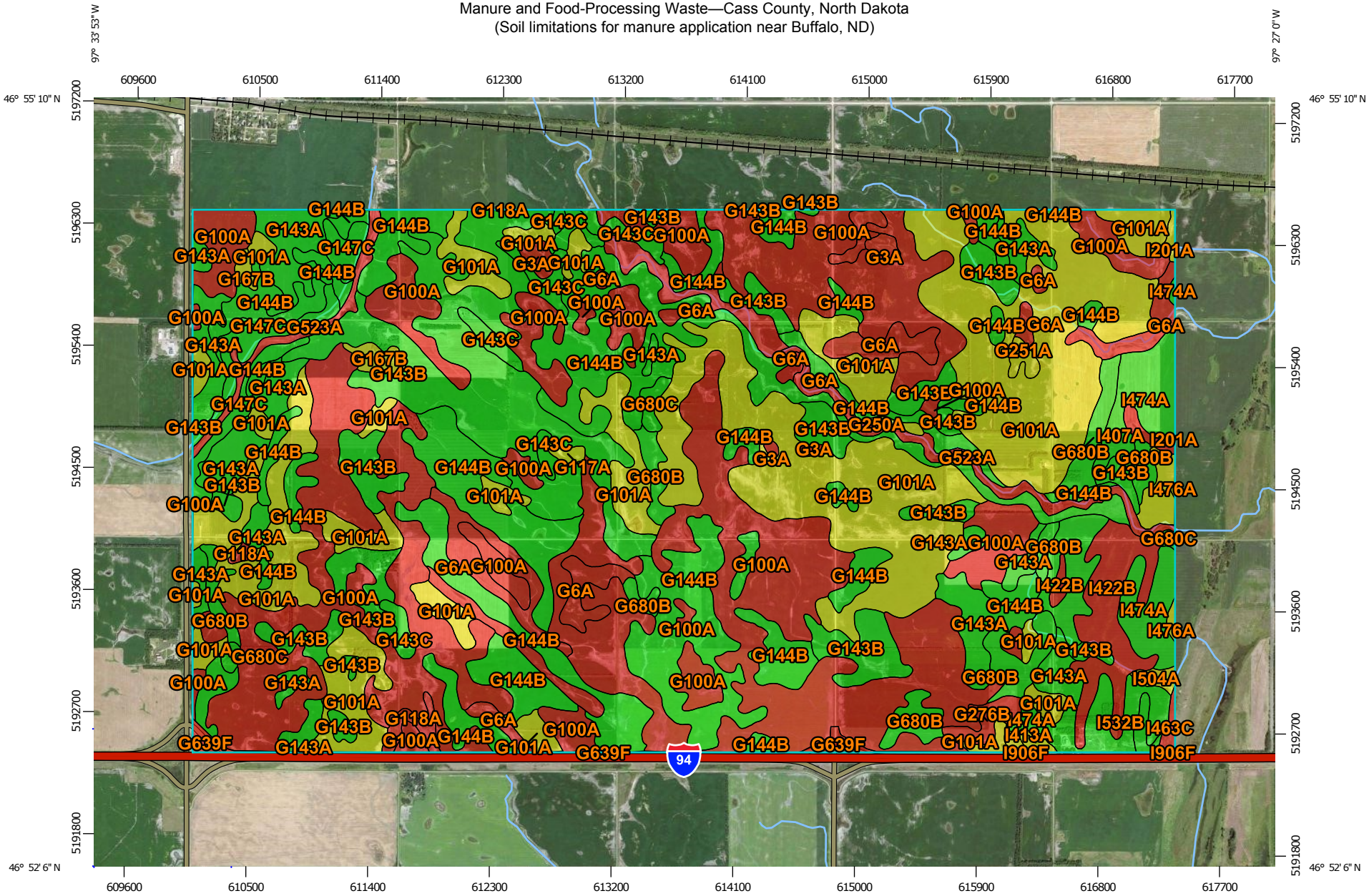
References:

Bluemle, J. P. 1991. The face of North Dakota. Rev. Ed. Educ. Series 21. N.D. Geological Survey. Bismarck.

Harris, K. L. 1987. Surface geology of the Sheyenne River map area. Atlas Series Map 15. N.D. Geological Survey. Bismarck.

Prochnow, N. D., N. J. Lunde, W. J. Terry, and D. P. Opdahl. 1985. Soil survey of Cass County area, North Dakota. Soil Conservation Service. U. S. Gov. Print. Office, Washington, D.C.

Manure and Food-Processing Waste—Cass County, North Dakota
(Soil limitations for manure application near Buffalo, ND)



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cass County, North Dakota
Survey Area Data: Version 15, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Aug 27, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
G3A	Parnell silty clay loam, 0 to 1 percent slopes	Very limited	Parnell (64%)	Slow water movement (1.00)	28.3	0.4%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Vallers (10%)	Depth to saturated zone (1.00)		
				Leaching (0.70)		
			Vallers, moderately saline (9%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Southam (6%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Tonka (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Ferney (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
				Salinity (0.50)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
G6A	Vallers loam, 0 to 1 percent slopes	Very limited	Vallers (67%)	Depth to saturated zone (1.00)	305.6	4.2%
				Leaching (0.70)		
			Vallers, moderately saline (8%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Tonka (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Parnell (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cresbard (2%)	Slow water movement (1.00)		
				Sodium content (0.32)		
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Tonka (28%)	Slow water movement (1.00)	1,933.7	26.8%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Wyard (7%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
			Vallers, moderately saline (7%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cavour (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (46%)	Depth to saturated zone (0.86)	1,499.5	20.8%
			Balaton (7%)	Depth to saturated zone (0.22)		
			Hamerly, moderately saline (5%)	Depth to saturated zone (0.86)		
				Salinity (0.50)		
				Sodium content (0.18)		
G117A	Hamerly loam, saline, 0 to 3 percent slopes	Somewhat limited	Hamerly, moderately saline (55%)	Depth to saturated zone (0.86)	7.1	0.1%
				Salinity (0.50)		
				Sodium content (0.18)		
			Hamerly (8%)	Depth to saturated zone (0.86)		
			Balaton (7%)	Depth to saturated zone (0.22)		
G118A	Vallers loam, saline, 0 to 1 percent slopes	Very limited	Vallers, moderately saline (68%)	Depth to saturated zone (1.00)	27.9	0.4%

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Tonka (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cresbard (4%)	Slow water movement (1.00)		
				Sodium content (0.32)		
			Parnell (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Easby (3%)	Depth to saturated zone (1.00)		
				Salinity (1.00)		
				Sodium content (1.00)		
				Droughty (1.00)		
				Slow water movement (0.50)		
G125A	Cavour-Cresbard loams, 0 to 3 percent slopes	Very limited	Cavour (49%)	Slow water movement (1.00)	5.8	0.1%
				Sodium content (1.00)		
			Cresbard (25%)	Slow water movement (1.00)		
				Sodium content (0.18)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
			Ferney (5%)	Slow water movement (1.00)		
				Sodium content (1.00)		
				Salinity (0.50)		
			Tonka (2%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Vallers, moderately saline (2%)	Depth to saturated zone (1.00)		
				Leaching (0.70)		
				Salinity (0.50)		
				Sodium content (0.32)		
				Droughty (0.03)		
G143A	Barnes-Svea loams, 0 to 3 percent slopes	Not limited	Barnes (39%)		361.0	5.0%
			Svea (38%)			
			Buse (2%)			
G143B	Barnes-Svea loams, 3 to 6 percent slopes	Not limited	Barnes (42%)		784.0	10.9%
			Svea (21%)			
			Buse (9%)			
			Swenoda (3%)			
G143C	Barnes-Buse-Langhei loams, 6 to 9 percent slopes	Not limited	Barnes (24%)		82.9	1.2%
			Buse (23%)			
			Langhei (18%)			
			Svea (14%)			
			Balaton (3%)			
			Lanona (3%)			
G144B	Barnes-Buse loams, 3 to 6 percent slopes	Not limited	Barnes (25%)		1,184.4	16.4%
			Buse (24%)			
			Svea (14%)			
			Balaton (10%)			
			Langhei (4%)			
			Swenoda (3%)			

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
G147C	Buse-Barnes-Darnen loams, 3 to 9 percent slopes	Not limited	Buse (28%)		94.5	1.3%
			Barnes (23%)			
			Darnen (22%)			
			Langhei (7%)			
			Swenoda (3%)			
G167B	Balaton-Wyard loams, 0 to 6 percent slopes	Somewhat limited	Balaton (33%)	Depth to saturated zone (0.22)	25.2	0.3%
			Hamerly (9%)	Depth to saturated zone (0.86)		
G250A	Divide loam, 0 to 2 percent slopes	Somewhat limited	Divide (70%)	Depth to saturated zone (0.86)	5.9	0.1%
			Wyrene (4%)	Depth to saturated zone (0.86)		
				Droughty (0.31)		
G251A	Divide loam, loamy substratum, 0 to 2 percent slopes	Somewhat limited	Divide, loamy substratum (74%)	Depth to saturated zone (0.86)	11.1	0.2%
			Sverdrup, loamy substratum (6%)	Leaching (0.45)		
			Wyrene, loamy substratum (5%)	Depth to saturated zone (0.86)		
G276B	Renshaw-Sioux complex, 2 to 6 percent slopes	Very limited	Renshaw (36%)	Filtering capacity (1.00)	25.2	0.3%
				Droughty (0.52)		
			Sioux (20%)	Filtering capacity (1.00)		
				Leaching (0.45)		
				Droughty (0.18)		
			Fordville (10%)	Filtering capacity (1.00)		
			Sioux (10%)	Filtering capacity (1.00)		
				Leaching (0.45)		
				Droughty (0.15)		
			Osakis (7%)	Filtering capacity (1.00)		
				Droughty (0.90)		
				Leaching (0.45)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
			Warsing (6%)	Filtering capacity (1.00)		
				Droughty (0.01)		
			Arvilla (4%)	Filtering capacity (1.00)		
				Droughty (0.98)		
				Leaching (0.45)		
			Marysland (3%)	Depth to saturated zone (1.00)		
				Leaching (0.70)		
G523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	Very limited	Fluvaquents, channeled, frequently flooded (40%)	Ponding (1.00)	100.5	1.4%
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.90)		
			Lowe, frequently flooded (28%)	Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
			Lowe, moderately saline, frequently flooded (20%)	Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
				Salinity (0.50)		
				Sodium content (0.32)		
			Lowe, very poorly drained, frequently flooded (5%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
G639F	Orthents-Aquents-Urban Land, highway complex, 0 to 35 percent slopes	Very limited	Orthents (41%)	Slope (1.00)	21.3	0.3%
				Slow water movement (0.50)		
				Large stones (0.04)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
			Aquents, clayey (16%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Renshaw (6%)	Filtering capacity (1.00)		
				Droughty (0.52)		
			Parnell (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
G680B	Barnes-Sioux complex, 1 to 6 percent slopes	Not limited	Barnes (39%)		179.9	2.5%
			Buse (7%)			
			Svea (7%)			
			Balaton (6%)			
			Swenoda (6%)			
			Langhei (3%)			
G680C	Barnes-Sioux complex, 3 to 9 percent slopes	Not limited	Barnes (34%)		21.3	0.3%
			Buse (9%)			
			Svea (7%)			
			Lanona (6%)			
			Balaton (6%)			
			Langhei (3%)			
I201A	Glyndon silt loam, 0 to 2 percent slopes	Somewhat limited	Glyndon (80%)	Depth to saturated zone (0.86)	33.3	0.5%
			Glyndon, moderately saline (3%)	Depth to saturated zone (0.86)		
				Salinity (0.50)		
				Sodium content (0.32)		
I407A	Winger silty clay loam, moderately	Very limited	Winger, moderately saline (76%)	Ponding (1.00)	11.2	0.2%

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
	saline, 0 to 1 percent slopes			Depth to saturated zone (1.00)		
				Leaching (0.70)		
				Salinity (0.50)		
				Sodium content (0.32)		
			Winger (14%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.70)		
			Mustinka (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Parnell (2%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
I413A	Lankin loam, 0 to 2 percent slopes	Somewhat limited	Lankin (75%)	Slow water movement (0.41)	7.1	0.1%
			Wyard (8%)	Depth to saturated zone (0.86)		
I422B	Renshaw-Sioux complex, 0 to 6 percent slopes	Very limited	Renshaw (36%)	Filtering capacity (1.00)	130.1	1.8%
				Droughty (0.52)		
				Leaching (0.45)		
			Sioux (20%)	Filtering capacity (1.00)		
				Droughty (0.99)		
				Leaching (0.45)		
			Sioux, sandy loam (10%)	Filtering capacity (1.00)		
				Droughty (0.95)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
				Leaching (0.45)		
			Arvilla (6%)	Filtering capacity (1.00)		
				Droughty (0.99)		
				Leaching (0.45)		
			Osakis (4%)	Filtering capacity (1.00)		
				Droughty (0.90)		
			Marysland (3%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.70)		
l463C	Sioux-Renshaw complex, 6 to 9 percent slopes	Very limited	Sioux (45%)	Filtering capacity (1.00)	7.3	0.1%
				Droughty (0.99)		
				Leaching (0.45)		
			Renshaw (40%)	Filtering capacity (1.00)		
				Droughty (0.52)		
				Leaching (0.45)		
l474A	Gardena-Glyndon silt loams, 0 to 2 percent slopes	Not limited	Gardena (47%)		283.5	3.9%
			Eckman (3%)			
l476A	Glyndon silt loam, moderately saline, 0 to 2 percent slopes	Somewhat limited	Glyndon, moderately saline (80%)	Depth to saturated zone (0.86)	4.0	0.1%
				Salinity (0.50)		
				Sodium content (0.32)		
			Wyndmere, moderately saline (3%)	Depth to saturated zone (0.86)		
				Salinity (0.50)		
				Sodium content (0.32)		
l477A	Antler silty clay loam, moderately saline, 0 to 2 percent slopes	Somewhat limited	Antler, moderately saline (75%)	Depth to saturated zone (0.86)	4.4	0.1%
				Salinity (0.50)		
				Slow water movement (0.41)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
				Sodium content (0.32)		
			Gilby (7%)	Depth to saturated zone (0.86)		
				Slow water movement (0.41)		
			Doran (7%)	Depth to saturated zone (0.86)		
				Slow water movement (0.41)		
I504A	Antler-Wyard loams, 0 to 2 percent slopes	Somewhat limited	Antler (50%)	Depth to saturated zone (0.86)	10.0	0.1%
			Wyard (35%)	Depth to saturated zone (0.86)		
			Gilby, moderately saline (5%)	Depth to saturated zone (0.86)		
				Salinity (0.78)		
				Sodium content (0.50)		
I532B	Fordville-Renshaw loams, 2 to 6 percent slopes	Not limited	Fordville (70%)		10.7	0.1%
I906F	Orthents-Aquents-Urban Land, highway complex, 0 to 35 percent slopes	Very limited	Aquents (25%)	Slow water movement (1.00)	0.1	0.0%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Orthents (25%)	Slope (1.00)		
				Slow water movement (0.81)		
Totals for Area of Interest					**7,206.8**	**100.0%**

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	**Acres in AOI**	**Percent of AOI**
Not limited	3,002.3	41.7%

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	**Acres in AOI**	**Percent of AOI**
Very limited	2,597.0	36.0%
Somewhat limited	1,607.6	22.3%
Totals for Area of Interest	**7,206.8**	**100.0%**

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

RECEIVED
JAN 25 2016
DIV. OF WATER QUALITY

North Dakota Department of Health
Bismarck, North Dakota

To Whom It May Concern:

I live approximately one mile from the proposed confinement facility for 9,000 swine located south of Buffalo.

I am requesting accurate information from your agency about public and environmental safety issues that may result from a swine operation of this large scale. At the present time I have very little knowledge or experience about such facilities.

Thank you for considering a meeting to provide me and my family with more information.

LeRoy Cromwell
3503 142nd Ave SE
Buffalo, ND 58011

Strommen, Rachel A.

From: Hal Grieve [htgrieve@far.midco.net]
Sent: Wednesday, January 20, 2016 9:40 PM
To: Glatt, Dave D.; Rockeman, Karl H.; Kosse, Myra J.; Radig, Scott A.; loclair@nd.gov; -Info-Dept. of Health
Subject: Buffalo ND

To Whom It May Concern,

I am writing to express my concerns over the hog operation proposed to be built outside of Buffalo, ND. I became aware of the venture only a few days ago. Unfortunately this leaves little time to research this type of business and contact you if I have concerns.

My research has found nothing positive in a hog operation of this magnitude. The environmental impacts of air, water and soil pollution are of great concern. I read about fumes emitted into the air, odor reducing chemicals changing the composition of manure and when combined and entering the air have an adverse effect on the environment. Hydrogen sulfide, ammonia, other gases, vapors, particle pollution, decreased lung function, cardiovascular ailments, headaches, fatigue, burning eyes and on and on. How can this be good for the air, water, land or humans?

I don't understand how something of this magnitude to the community and surrounding area has gotten this far with most everyone being left in the dark. If it is such a good opportunity it seems those involved would have been happy to share the news with those that live here.

Who oversees this type of operation? Are there inspections, regulations, fines and penalties? If regulations are not followed, then what? Does the process to remedy the situation, if even possible, have teeth or is taking the penalty a better business decision than finding a solution to the problem.

Several residents have health issues, including my mother who has COPD and a heart condition. How will this affect her? I'm concerned my daughter will no longer allow my grandson to visit us for weeks at a time as he has done all his life. Will I be able to continue daily walks and bike rides, which often take me within a mile of the proposed site? If I do, what risks am I taking? What long term effects may there be?

We, the people, are concerned for our community. We have a personal interest to be good neighbors and stewards of our land and community. Investors do not live here; they do not have this same desire. Not only do we not want to see our health put at risk, we do not want to see the community as a whole put at risk; including being torn apart with dissension and concern.

I ask you to read the letters you will be receiving from our community and consider all concerns; health, environmental, odor, declining property values. I trust you will do the right thing for the community of Buffalo which has been around for 135 years rather than the right thing for a corporate hog operation from another state and its investors. Buffalo has many things to offer its current residents. Hopefully that continues for decades to come.

I appreciate your time and consideration.

Terryl Grieve

204 4th Ave S, Buffalo, ND 58011

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March 19, 2016

Karl Rockeman
Director of the Division of Water Quality
North Dakota Department of Health
918 East Divide Avenue
Bismarck, ND 58501-1947

Re: Comments of Concerned Citizens of Buffalo on Rolling Green Family Farms RE, LLP's application for an Animal Feeding Operation Permit

Dear Mr. Rockeman,

Thank you for the opportunity to comment on the North Dakota Department of Health's ("Department" or "NDDH") draft Approval to Operate a Concentrated Animal Feeding Operation for Rolling Green Family Farms RE, LLP ("Rolling Green"). This letter contains formal comments submitted by the undersigned counsel on behalf of the Concerned Citizens of Buffalo ("Concerned Citizens"), a group which includes Bob & Judy VonBank, Arnetta Frueh & the Frueh Family, Jerry & Jackie Marcks, Tracie Zaun, Deb Coon, Carol Beilke, Terry Grieve, Antoinette Babcock, Cynthia Berget Allen, Alan & Carolyn Dostert, Betty Fraase, Sherry Peterson, the Roy Thompson Family, Liane Stout, Bill Marcks, Kathy Tyler, Randy Coon, Craig Wendt, Lee Fraase, Tim Frueh, Lois Smith, Roy Thompson, Lee Fischer, and a significant portion of the Buffalo community. All of the Concerned Citizens live and work in the vicinity of the proposed Rolling Green facility.

I. Introduction

We have carefully reviewed Rolling Green's application for this permit, Rolling Green's design plans and schematics, and the Department's draft permit. Based on our review of this information, consultation with experts, and the Concerned Citizens' extensive knowledge of the land and natural resources in their community, we are alarmed that the Department plans to approve this permit. It is illegal for myriad reasons, does not protect the Buffalo community, and should be withdrawn immediately. Our basic conclusions, which will be described in detail throughout these comments, are as follows:

1. Rolling Green must obtain a NPDES permit, not an Animal Feeding Operation Permit, and construction of the facility without a NPDES permit is illegal. Construction without a NPDES permit would also place Rolling Green at risk of citizen suit under North Dakota's implementation of the Clean Water Act;

2. The project will cause unlawful groundwater pollution due to critical flaws in the facility's design;

3. The permit does not account for several water wells within a mile of the confinement facility that almost certainly exist at abandoned farmsteads, each of which could serve as a conduit for pollution from the facility to enter into groundwater;

4. The project will cause unlawful surface water pollution due to significant over-application of manure at non-agronomic rates;

5. The project will cause pollution of the Maple River and adjacent wetlands due to over-application of manure near drain tile that drains directly into this waterbody;

6. The project will cause pollution of an intermittent stream and adjacent wetlands, none of which were accounted for in Rolling Green's permit application;

7. The project, as planned, poses very serious medical risks to the community, as described by the community's doctors and experts at Johns Hopkins University;

II. Index of documents expressly incorporated by reference and attached to these comments

This letter expressly incorporates by reference the following documents, testimony, and reports, each of which are attached to this letter. For ease of reference, these documents have all been bates numbered in the lower-right hand corner of each page. Documents written or otherwise prepared directly by or on behalf of Concerned Citizens are presented in bold in the following index:

1. Attachment A, Application Information, 000001 – 000343
    a. 000001 – 000004: Completed NDDH Application Form
    b. 000004 – 000039: Rolling Green facility design schematics and maps
    c. 000040 – 000343: Rolling Green's Full Application
2. **Attachment B, Buffalo Community Medical Information, 000344– 000787**
    a. **000346 – 000355: Letter from John's Hopkins University health experts to NDDH on behalf of members of Buffalo community**
    b. **000355 – 000456: Health records, physician records, and supporting public health information from members of the Buffalo community**
    c. **000457 – 00475: Petition of 194 Buffalo community members in opposition to Rolling Green project**
    d. 000476 - 000475: Twenty-Nine Public Health Scientific/research documents
        i. 000477 – 000502: Understanding Concentrated Animal Feeding Operations and Their Impact on Communities
        ii. 000503 – 000517: Industrial Hog Production and the Hog-barn Neighbourhood Effect in Lethbridge County, Alberta

iii. 000518 – 000527: The Public Health Impacts of Concentrated Animal Feeding Operations on Local Communities
iv. 000528 – 000545: An Agricultural Economist's Public Concerns About CAFOs
v. 000546 – 000550: Health Effects of Airborne Exposures from Concentrated Animal Feeding Operations
vi. 000551 – 000558: Environmental and Health Problems in Livestock Production: Pollution in the Food System
vii. 000559 – 000563: Adverse Health Effects of Hog Production A Literature Review
viii. 000564 – 000571: Neighbor Health and Large-scale Swine Production
ix. 000572 – 000580: Public Health Concerns for Neighbors of Large-Scale Swine Production Operations
x. 000582 – 000592: High-Density Livestock Operations, Crop Field Application of Manure, and Risk of Community-Associated Methicillin-Resistant Staphylococcus aureus Infection in Pennsylvania
xi. 000593: Exposure to Pig Farms and Manure Fertilizers Associated with MRSA Infections
xii. 000594 – 000615: The Community Effects of Industrialized Farming: Social Science Research and Challenges to Corporate Farming Laws
xiii. 000616 – 000619: Precautionary Moratorium on New Concentrated Animal Feed Operations
xiv. 000620 – 000666: Factory Farm Nation 2015 Edition
xv. 000667 – 000676: Community and Health Concerns in Pork Production: A review
xvi. 000677 – 000689: Industrial Food Animal Production Community Health
xvii. 000690 – 000692: CAFOs and Public Health: Emissions and the Respiratory Health of Neighbors
xviii. 000693 – 000699: Multidrug-Resistant and Methicillin Resistant Staphylococcus aureau (MRSA) in Hog Slaughter and Processing Plant Workers and Their Community in North Carolina
xix. 000700 – 000706: High-Density Livestock Production and Molecularly Characterized MRSA Infections in Pennsylvania
xx. 000707 – 000710: Air Pollution and Odor in Communities Near Industrial Swine Operations
xxi. 000711 – 000713: Land Application of Treated Sewage Sludge: Community Health and Environmental Justice
xxii. 000714: Factory Farming's Effect on Rural Communities
xxiii. 000715 – 000718: Food Program Waste Management

xxiv. Relative Exposure to Swine Animal Feeding Operations and Childhood Asthma Prevalence in an Agricultural Cohort 000719
xxv. 000720 – 000736: Research Relevant to Health Effects of Swine Operations
xxvi. 000737 – 000739: Residential Proximity to Large Numbers of Swine in Feeding Operations is Associated with Increased Risk of Methicillin-Resistant Staphylococcus aureaus Colonization at Time of Hospital Admission in Rural Iowa Veterans
xxvii. 000740 – 000746: Beyond Factory Farming – Various Articles
xxviii. 000747 – 000748: MRSA Prevalent in Canadian Pig Farms and Pig Farmers
xxix. 000749 – 000766: Relevant Laws, Regulations and Decisions

k. 000767 – 000787: Additional Letters to NDDH from the Buffalo Community

3. **Attachment C, Letters to North Dakota Department of Health from Bill Marcks, Liane Rakow Stout, 000788 – 000792.**
4. **Attachment D, Nutrient Management Plan Comments, 00793 – 001378**
   a. 000798 – 000799: Natural Resources Conservation Service – Web Soil Survey, Manure and Food-Processing Waste
   b. 000800 – 00808: Agronomic Concerns, Pesticide and Nutrient Leaching
   c. 000809 – 000816 Detailed Comments of Concerned Citizens on Rate of Manure Application
      i. 000817 – 000824: Appendix A – Land Application Easements – Containing 6 Manure Spreading Agreements
      ii. 000825 – 000840: Appendix B – Containing 15 Water Quality Risk Assessment Maps
      iii. 000841 – 001069: Appendix C – References and Supporting Documentation – Containing 20 Scientific Documents
      iv. Appendix D:
      001070 – 001139: Nutrient Management Plan
      001140 – 001152: Concerns Regarding the Nutrient Management Plan for Rolling Green Family Farms Containing Appendix A
      v. 001153 – 001330: Appendix E NRCS Waste Management Soils Maps
      vi. 001331 – 001378: Letter from Craig Wendt to the North Dakota Department of Health with 46 pages of signed documents refusing easements for manure application.
5. **Attachment E, Comments on water issues, zoning, and wind rose, 001379 – 001440**
   a. 001380 – 001403: Detailed Comments of Concerned Citizens on water issues, including photos, location maps, lidar topography maps, and information to locate undocumented wells.

   b. **001404 – 001439: Statement from Kent Beilke with Howes Township Zoning Ordinance Documents**
   c. **001440: Wind rose data for Rolling Green site location**
6. **Attachment F, Review of Site Design Deficiencies and Stormwater Issues, 001441 – 001540**
   a. **001380 – 001403: Detailed Comments on design deficiencies**
   b. **001470 – 001540: Comments of Roger Gluck, PE, on stormwater issues**
7. **Attachment G, Other Concerns, 001541 – 001549**
   a. **Petitions 001547 – 001549**
8. **Attachment H, Letter by Lee Fischer, 001550 – 001551**
9. **Attachment I, Email from Karl Rockeman, 001552**
10. **Attachment J, Expert Report of Kathy Martin, PE, on Rolling Green Permit Deficiencies, 001553-001737**
    a. **001553-001566, Expert Report of Kathy Martin**
    b. **001567-001569, Curriculum Vitae of Kathy Martin**
    c. **001570-001737, Supporting Technical Documents**
11. Attachment L, Additional scientific documents, 001738-001824
12. **Attachment K, Additional letters from Buffalo Community, EPA My Waters Map, and NDDH Power Point, 001825-001826**

III. Rolling Green must obtain a NPDES permit, not an Animal Feeding Operation Permit, and construction of the facility without a NPDES permit is illegal.

NDAC 33-16-03.1-05 is the Department's regulation that explains whether a facility must obtain an animal feeding operation permit or a NPDES permit. Specifically, it states that:

> 1. Any animal feeding operation that has been defined as a concentrated animal feeding operation in section 33-16-03.1-03 or designated a concentrated animal feeding operation under section 33-16-03.1-04 must obtain a North Dakota pollutant discharge elimination system permit pursuant to chapter 33-16-01.
>
> 2. Any medium animal feeding operation where manure or process wastewater from the operation causes or is likely to cause water pollution or those that are located within one-fourth mile [.40 kilometer] of a stream or surface water that contains water, except for infrequent periods of severe drought, must apply for a state animal feeding operation permit pursuant to this chapter or a "no potential to pollute" determination pursuant to section 33-16-03.1-06. Waters completely contained on an owner's property and which do not combine or effect a junction with natural surface or underground waters are not included.
>
> . . . .

In other words, any facility defined as both an animal feeding operation and either a large or medium concentrated animal feeding operation must obtain a NPDES permit. This is also unequivocally stated in the Department's regulatory definition of "concentrated animal feeding operation," which provides that "[a]ll concentrated animal feeding operations are required to obtain a North Dakota pollutant discharge elimination system permit pursuant to chapter 33-16-01." NDAC 33-16-03.1-03(4).

Applying these regulations to Rolling Green, there is no question that Rolling Green must obtain a NPDES permit.

i. Rolling Green meets the definition of an animal feeding operation: animals will be stabled or confined for more than 45 days each year at the confinement facility; animals will be fed or maintained at the confinement facility for more than 45 days each year; Crops, vegetation, forage growth, or post-harvest residues will not be sustained in the normal growing season over any portion of animal confinement facility.

ii. Rolling Green meets the Definition of a large concentrated animal feeding operation: Rolling Green will have 8,256 pigs weighing more than fifty-five pounds. This number exceeds the 2,500 pig threshold for large CAFO status under the definition of Large CAFO.

Because both requirements are met, Rolling Green is a "concentrated animal feeding operation." CAFOs must obtain NPDES permits as opposed to animal feeding operation permits. NDAC 33-16-03.1-03(4); NDAC 33-16-03.1-05(1).

The Rolling Green draft permit prepared by NDDH is not a NPDES permit; it is a basic state-only Animal Feed Operation permit, which is the wrong type of permit for a large CAFO under the Department's rules. Specifically, the permit's heading/title states that it is an "Approval to Operate a Concentrated Livestock Operation." The permit's fact sheet states that it is an "approval of a livestock waste system." Upon inquiry to Karl Rockeman as to the type of permit the Department prepared for Rolling Green, he stated that "the permit is a state issued animal feeding operation approval to operate." 001552. The application for the permit was on the Department's Animal Feeding Operation permit form and not on any of its NPDES forms. Further, the draft permit is missing numerous requirements that must be included in a NPDES permit. *See generally* 40 CFR 123.25, NDAC 33-16-01. These include, but by no means are limited to the following:

1. It does not contain technology based effluent limitations ("TBELs");
2. It does not contain water quality based effluent limitations ("WQBELs"), which is especially important given that impaired waters exist in the area of Rolling Green's project, which will be explained in more detail *infra*.

3. It does not contain standard reporting protocols for NPDES permits, including submittal of discharge monitoring reports.
4. It is missing duty to comply requirements, signatory requirements, and federal enforceability requirements.
5. It does not contain a provision that would make the nutrient management plan federally enforceable.

Upon further review of the Department's rules, it is also apparent that the need for Rolling Green to obtain a NPDES permit is further derived from NDAC 33-16-01-01.1. (captioned "Additional point sources subject to regulation"). NDAC 33-16-01-01.1 states that "The 40 Code of Federal Regulations, part 122.23, concentrated animal feeding operations, [40 CFR 122.23], as it exists on February 12, 2003, is incorporated into this chapter by reference." This is an explicit adoption of EPA's 2003 CAFO rules into North Dakota's federally approved NPDES program. Importantly, EPA's 2003 rules require all large CAFOs, except for those that have explicitly received notice that they have no potential to discharge under any circumstances or climatic conditions, to obtain NPDES permits. 40 C.F.R. 122.23(d),(f) (2003 and 2004). This is commonly referred to as the "duty to apply" requirement.

Both the applicant and the Department have made a significant error by applying for and approving as a draft permit, respectively, an Animal Feeding Operation permit for Rolling Green as opposed to a NPDES permit. This is plainly incorrect under NDAC 33-16-03.1-03(4) and NDAC 33-16-03.1-05(1) and is in violation of the Department's own rules. Further, because the Department is not issuing Rolling Green a NPDES permit (and Rolling Green did not apply for a NPDES permit), if Rolling Green constructs its facility without such a permit it could face significant compliance risks, including risk of citizen suit under North Dakota's implementation of the Clean Water Act.

IV. The project will cause unlawful groundwater pollution due to critical flaws in the facility's design.

Rolling Green's project, as described in the plans submitted to the Department, will cause groundwater pollution due to critical flaws in the facility's plans. For detailed discussion of these issues, please review the oral testimony of Alan Dostert as stated before the Department on March 17, 2016 and Attachment F (# 001441 – 001540). A summary of these issues is included here.

First, some context is helpful. The size of the proposed facility is massive. Just one of the CAFO buildings (there are six in total) is the size of all of downtown Buffalo. 001447 (pink highlighting indicating size). The total footprint of the facility is almost as large as the Fargodome.

The deep manure pits of these animal confinement structures will be constructed <u>below</u> the groundwater table with at least 4.1-5.9 feet of exposure to the groundwater table. 001457. The

facility is in fact being constructed into a number of wetlands. Although drain tile (referred to by applicant as part of its "Clean Water Diversion") will be placed below the animal confinement structures, the facility design is simply inadequate to address hydrostatic pressure under the concrete slabs. 001458. This significantly increases the likelihood of leaks in the concrete. Significant re-design is needed to resolve these issues, as described in 001458. This is particularly true because any leaks from this facility will be directly into groundwater, which are waters of the state. Any discharge of pollutants into these waters is illegal.

While the applicant states that its drain tile system may help it determine if and when a leak is present, the applicant has not provided any information in its application indicating that the drain tile is a leak/pollution *control* system. Moreover, there is no defensible way to use the drain tile system as a leak detection system because the record indicates that the applicant has not obtained any background groundwater quality samples at the site location. Given that the applicant intends to use this drain tile and sump system as a warning system to indicate leaks from the concrete structure, the Department should require the applicant to collect baseline groundwater samples at the site and keep records of water quality samples from the water diversion and sump system on a monthly basis.

The type of concrete and rebar for the deep pits is also insufficient. It is well known that swine manure and feces contain high levels of sulfates, which can eat away at concrete and rebar through corrosion. 001738-001752. The facility's plans simply reference ACI standard 318 for its concrete specifications. 000090. This is extremely vague (ACI 318 contains hundreds of pages and numerous different standards, some of which are sulfate resistant and some of which are not). The Department must mandate that the applicant use sulfate-resistant concrete, such as that reinforced with fly ash, and epoxy coated rebar to withstand the high sulfate levels in its deep pits. *See* 001738-001752; 001458-001459. Further, the facility's plans do not indicate expansion and control joints, and with North Dakota's extreme temperature variations the facility can therefore be expected to encounter 5" of temperature movement. 001459. All of these issues will almost certainly lead to cracks in the concrete deep pits, leading to groundwater pollution. These are critical design flaws that must be fixed in order to protect waters of the state.

Given the saturated soil conditions at the site location, the facility is also at high risk of differential settling (i.e., causing part of the building to settle into the ground to a larger or smaller extent than other parts of the facility). 001462. This is particularly true because, as previously explained, Rolling Green's animal confinement structures are massive in size. This differential settling would very likely cause cracks in the concrete manure and urine deep pits, also leading to groundwater pollution. In order to resolve these issues, it is imperative that the facility be raised above the water table. *See* 001460. It is also imperative that the Department mandate that the applicant use additional fill material below the structures to mitigate the effects of settling.

Concerned Citizens have also identified no less than 17 points in the facility's design plans where there is no reference whatsoever to material requirements and an additional two conflicts in material requirements for this facility. 001449-001451. The quantity of errors is cause for concern about the quality of the application in general. Each of these errors must be corrected. If the applicant is unable to provide an application that indicates even basic information such as the type of material that will be used to build its structure, then there is no way for the Department to know if the structure will prevent pollution of waters of the state and comply with the Departments' interpretation of its rules in its Livestock Program Design Manual. Approval of such this permit without essential underlying information would result in an arbitrary decision, unsupported by facts, and therefore would violate the Administrative Agencies Practices Act. N.D.C.C. 28-32-46(5).

Given the high likelihood of leaks from the deep pits, it is also likely that fecal matter and urine well leak into the "Clean Water Diversion" system. Because this system will contain manure, urine, process wastewater, and other contaminants, the Department must treat the water in this system as polluted and therefore must require that the surface impoundment containing this water be treated as a Manure Storage Structure as defined at N.D.A.C. 33-16-03.1-03(16). The surface impoundment is not currently designed to the specifications required of a Manure Storage Structure under the Department's rules, and this must be corrected.

In addition, Concerned Citizens is attaching to these comments the opinion of Kathy Martin, an Oklahoma engineer with extensive experience on CAFO design and hydrogeology. 001553-001737. Her comments focus on odor and air pollution concerns (including emission calculations of ammonia and H2S) with recommendations for odor control equipment, failure of the applicant to adequately identify the shallow groundwater system at the animal confinement location, and lack of sufficient design information for the facility's compost facility.

Finally, Concerned Citizens is also attaching to these comments the opinion of Roger Kluck, a North Dakota engineer with experience in stormwater issues. 001470-001540. Mr. Kluck was not provided with Rolling Green's Stormwater Pollution Prevention Plan ("SWPPP") in time for these comments, but was provided with Rolling Green's application for its Animal Feeding Operation Permit. His comments are directed both to Rolling Green's application for an Animal Feeding Operation Permit as well as its application for coverage under the Department's general stormwater permit for construction activities. Even though Mr. Kluck did not review the facility's SWPPP, Concerned Citizens nonetheless believe that the vast majority of his comments mandate revisions to the facility's SWPPP because he completed independent research and calculations that show likely stormwater pollution problems at the facility.

V. The permit does not account for several water wells within a mile of the confinement facility that almost certainly exist at abandoned farmsteads, each of which could serve as a conduit for pollution from the facility to enter into groundwater.

Page 24 of the NDDH Design Manual requires that "distance to existing wells" "shall be considered when evaluating the location of a livestock facility." Here, Rolling Green has failed to make any attempt to locate such wells except for referring to State Water Commission data. State Water Commission data almost always fails to include older wells. There are three abandoned farmsteads within a mile of Rolling Green's facility, each of which almost certainly has an abandoned water well that was used for domestic use. This fact is indicated through USDA historical imagery taken in 1962. 001398. Document 001398 shows the location of Rolling Green's proposed animal confinement facilities (indicated with the number "4") along with the three abandoned farmsteads (each highlighted in yellow). All three farmsteads are less than one mile from Rolling Green's confinement structures. One, located to the southeast of the animal confinement buildings, is directly in the drainage of Rolling Green's planned discharges from its clean water diversion. 001383 (Lidar imagery indicating topography/drainage). These wells must be investigated prior to siting this facility to ensure that these wells will not act as conduits for groundwater pollution. This is especially true for the abandoned farmstead to the southeast of the confinement facilities.

VI. The project will cause unlawful surface water pollution due to significant over-application of manure at non-agronomic rates.

Concerned Citizens have attached detailed separate comments explaining that the swine effluent will be more nutrient laden than the calculations put forward by the applicant and that ammonia volatization will be less than assumed due to the sealed manure storage pits and knife injection application. Analysis and Supporting Documents of Randy Coon (Attachment D, 00793 – 001378). In addition to overstating the amount of manure necessary for reasonably beneficial use, Rolling Green has grossly overstated the amount of acreage in its control that is suitable for manure application. Rolling Green cannot discharge into surface water or saturated soils, but the tracts listed in the Nutrient Management Plan have little else. The nutrient imbalance of the swine effluent will result in excess nutrient loading. The fields contain soils that the NRCS has identified as prone to leaching and ponding; additionally, the water table is so near the surface in this region that there are over one hundred nationally inventoried wetlands within the proposed application tracts whose hydric soils are by definition saturated and provide a ready pathway for dissolution of nutrients and pathways for migration both across the surface and through the subsurface. EPA My Waters Map, 001827. The combination of glacial soils and high water table in the area of the proposed project require a hard look at the concentration of nutrients that are suggested for injection in the context of their solubility and potential to migrate through groundwater and surface runoff. The Applicant proposes to inject nearly 2200 gallons of effluent per acre per year on land that cannot contain such a discharge in the short term or sustain it in the long term.

The science of agronomy focuses on crop growth and soil health. The purpose of applying manure is its beneficial effect on the growth of plants. If application is done for this purpose, it is properly characterized as an agricultural activity. The right to the public trust resource of groundwater depends on beneficial use. A nutrient management plan must rely on the agronomic rate of plant utilization and take into account the properties of its soils. The purpose of a nutrient management plan is to promote plant and soil health. Factors such as the cost of transport and cost of supplemental fertilizers have no place in this analysis.

The policy of the state of North Dakota is "to act in the public interest to protect, maintain, and improve the quality of the waters in the state for . . . legitimate beneficial uses. . ." N.D.C.C. § 61-28-01. 'Waters of the State' is expansively defined in the Century Code to include "all streams, lakes, ponds, impounding reservoirs, marshes, watercourses, waterways, and all other bodies or accumulations of water on or under the surface of the earth, natural or artificial, public or private, situated wholly or partly within or bordering upon the state, except those private waters that do not combine or effect a junction with natural surface or underground waters just defined." N.D.C.C. § 61-28-02(15). The areas of proposed swine effluent application abound with marshes, watercourses, and subsurface percolating waters. Significantly, North Dakota has incorporated this definition into its implementation of the Federal Water Pollution Control Act ("Clean Water Act"). N.D.A.C. 33-16-01-01(5)(b). If land application exceeds a reasonable agronomic rate, it crosses the line from a beneficial agricultural practice to become solid waste disposal. Solid waste disposal becomes water pollution when it leaches into the water table. See Cmty. Ass'n for Restoration of the Env't, Inc. v. Cow Palace, LLC, 80 F. Supp. 3d 1180, 1223-26 (E.D. Wash. 2015) (granting summary judgment on plaintiffs' allegations that leaking storage lagoons which were built to NRCS specifications and the operator's non-beneficial application of manure were properly characterized as abandoned solid waste that was having deleterious effects on groundwater quality under RCRA). There is no vested right of spoliation; that is the antithesis of a usufruct. This reasoning is further supported by the North Dakota Century Code's definition of 'waste' which includes "agricultural pollution introduced into any waters of the state." N.D.C.C. § 61-28-02 (14). The Century Code defines 'pollution' as any man-induced alteration of the physical, chemical, biological [or] integrity of any waters of the state. *Id*. at (7). If swine effluent is injected into the many hydric soils in the proposed application sites, any nutrients that are not taken up by each planting will leach and/or migrate into adjacent waters of the state, altering its chemical integrity and degrading already impaired watersheds in violation of N.D.A.C. § 33-16-03.1-12(5). As stated by Linderman of NDSU, "The worst case scenario for the incidence of surface runoff would be the application of liquid manure by rates that exceed the infiltration rate of the soil." 000922. This reasoning is reflected in the NDDH Design Manual at §7.6.3:

> "When irrigating with manure or process wastewater, the application rate shall not exceed the estimated soil infiltration rate, or the nutrient requirements of the crop. Irrigation application rates shall be adjusted to avoid significant ponding of manure or process waste water in surface depressions or seasonal drainage ways."

Rolling Green completely failed to submit numerous requirements listed in the NDDH Design Manual. Section 7.3 requires Rolling Green to submit soil maps of the proposed application sites, the location of sensitive resources such as waterways and high water table areas, precautions to be used to prevent manure from impacting surface water, and any Best Management Practices to be implemented to manage nutrients effectively and efficiently. Instead, Rolling Green submitted some area photographs, misrepresented the underlying soil types, omitted any mention of acres of surface waters, and generally ignored its obligations and the damaging impacts that is likely to result.

In support of its Application, Rolling Green submitted a series of self-serving evaluations of the tracts proposed for manure effluent application. The documents should be taken at face value with particular attention paid to the disclaimer on each one that states that it "**IS <u>NOT</u> INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.**" See e.g. 001093 (emphasis in original).

The NRCS has surveyed and classified soils in the area based on their suitability for the application of manure. "The ratings are based on the soil properties that effect absorption, plant growth, microbial activity, erodibility, the rate at which waste is applied, and the method by which the waste is applied. . . The rating class terms indicate the extent to which the soils are limited by all of the features that effect agricultural waste management. . . 'Somewhat limited' indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. 'Very limited' indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected." 001165. Attached to these comments are Natural Resource Conservation Service (NRCS) soil survey maps of each of the proposed manure effluent application sites. See Attachment D, 00153-001378. Nearly half of the proposed acreage is unfavorable for this use because of the soil types and proximity to surface and underground waters. Rolling Green's submission claims to have access to over three thousand acres available to spread effluent, but over one thousand four hundred of these acres are not favorable for this activity according to the NRCS. Six hundred forty more acres will require special planning and maintenance to engage in the planned activity. This means that fully two thirds of the proffered application area is limited by soil type. This unsuitability is compounded by the presence of a persistently high water table. Both geology and hydrology counsel against a grant of the proposed permit.

Further, as is noted in the record, the owners of over thirty thousand acres in the vicinity of the proposed site and application areas have stated that they will not permit a pipeline to cross their property, let alone permit swine effluent to be placed on their land. Attachment D, 001331-001378. Some of the proposed application sites are over seven miles from the facility, and the operator will have to travel even further afield to locate lands willing to receive any

swine effluent, and will be unable to install pipelines to most locations, requiring it to truck its manure miles from the central facility.

Fields one and two are in Section 9 of Howe's Township and comprise a total of 280.5 acres. 001088, 001091. The NRCS characterizes 171.4 acres of this land as unfavorable for the application of manure because of the depth to the saturated zone and tendency for ponding and leaching while only 110 acres is deemed favorable. 0001156, 001163. Any approved rate of application must consider the documented propensity of these soils for leaching and migration.

Also of concern in these parcels is the presence of an intermittent stream that does not appear in Rolling Green's water resource setback submissions. According to data maintained by the United States Environmental Protection Agency, there is a tributary to the Embden Dam Watershed of Buffalo Creek that begins near latitude 46.8714 longitude -97.5002 (in field 1) that heads east through one inventoried wetland that shares a surface connection with the stream and near another wetland that likely shares a hydrologic connection with the same navigable waterway. See EPA MyWaters Mapper, http://watersgeo.epa.gov, Feature ID# ND-09020205-009-S_00, for wetlands filter, select from "other EPA water data" dropdown menu.[1] The stream turns south near latitude 46.8711 longitude -97.4939 until it tracks west from latitude 46.8621 longitude -97.4942 back into field one before turning south at latitude 46.8617 longitude -97.4977. This watercourse joins with another tributary at latitude 46.8547 longitude -97.4996. The Department of Health must require Rolling Green to revise its surface water resource setback submissions to include at least a one hundred foot setback on each side of this navigable waterway and its nearby inventoried wetlands that share a significant nexus with it. NDDH Design Manual, §7.6.2; See Slide 16, Department of Health Presentation in Buffalo, ND, Mar. 17, 2016 (001843).

Given the underlying nature of these soils and the fact that the State of North Dakota and the Cass County Water District have invested millions in remediating this watershed recently, a larger setback distance and required implementation of Best Management Practices is appropriate. *See, e.g.*, Maple River Watershed Project Phase II, Cass County Soil Conservation District (using $2.5 million in federal and state funds to remediate e. coli impairment in the Buffalo Creek sub watershed); N.D.A.C. 33-16-03.1-08(c).

Fields three, eighteen, and nineteen of the Applicant's Nutrient Management Plan are even more problematic. Claiming an aggregate of 469.7 spreadable acres, the Applicant forgets it plans to place a structure the size of the FargoDome on the parcel and that this structure will have a building footprint reduces the acreage available for manure spreading. Even after that, 260 acres are characterized by the NRCS as unfavorable for the Applicant's proposed activity. 001169-70, 001176-77, 001183-84. Further, in this section alone, there are no fewer than thirty-three inventoried wetlands of varying sizes. The Applicant proposes that effluent will not be spread into saturated soils, but the areas within the nutrient management plan are limited by their depth to the saturation zone, ponding, and leaching.

[1] All references to inventoried wetlands can be verified using this process.

Fields four and five (N1/2 Section 36 T140N, R55W) fare slightly better in terms of soil types—of the 282.8 acre proposed application area, only 84.5 are deemed unfavorable while just over 80 acres are deemed favorable. 001176-77, 001183-84. Most of this proposed area is classified as "somewhat limited" and will require special planning, design, and installation to achieve "fair performance" with moderate maintenance. *Id*. This special planning will need to account for the watercourse (which does not appear in Rolling Green's water resource setback submissions) that meanders across both of these parcels, and its sensitivity is magnified by the fact that it is underlain with Hamerly-Tonka complex soils that exhibit leaching properties. Feature ID# ND 09020205-020-S_00; Subwatershed 09020205000346. This watercourse drains into the Maple River. The parcels that drain into the Maple River share another cause for concern that will be discussed in the next section. These parcels also contain a total of sixteen inventoried wetlands that likely exhibit a hydrological link that affects the quality of the stream's waters. Setbacks will need to be maintained around all of these.

Field six, the western half of the southwest quarter of Section 12, T139N, R55W, claims to provide 78 spreadable acres. Less than 25 of them are favorable while over half are rated unfavorably for manure application. 001189-1192. These soils exhibit persistent saturation, ponding, and leaching. *Id*. This tract also contains a freshwater pond and six emergent wetlands that share a hydrological link by feeding its waters. North Dakota has incorporated its definition of "waters of the state" into its enforcement provisions of the Federal Water Pollution Control Act. N.D.A.C. 33-16-01-01(5)(b). Setbacks need to be established and enforced around these sensitive areas.

Fields seven and eight (NE¼ Section 32, T13N9, R55W) claim to provide 141.2 spreadable acres. 001101. Less than one tenth (12.6) of them are favorable for land application of manure. 47.8 acres in this tract contain G110A Hamerly-Tonka complex soils that exhibit ponding, slow water movement, and a short depth to the saturation zone. 001197-1201.

Field nine (SE¼ Section 32, T139N, R55W) claims to provide 150.1 spreadable acres. 001103. While 28.2 of those acres are favorable for land application, more than twice that number (54.1) are not; this is due to, among other things, the filtering capacity of the soil. 001206-09. Saturation is exhibited by the presence of three inventoried wetlands on the tract.

Field ten (NE¼ Section 14, T139N, R55W) claims to provide 140.2 spreadable acres, but this is another overstatement. 001105. While 88 acres are favorable, 60 are not. 001215-18. The parcel does contain a navigable waterway and three inventoried wetlands, at least one of which shares a significant nexus with the waterway. Feature ID# ND 09020205-009-S_00; HUC 09020205000307. Appropriate setbacks must be maintained around these areas.

Field eleven (SE¼ Section 10, T140N, R55W) purports to provide 158 acres to receive swine effluent manure. 001108. The NRCS soil surveys explains that 32.2 of these are favorable, 16.9 acres are somewhat limited for this use, and 98.7 are unfavorable. 001223-24. The prevalent soils in this section are characterized by leaching propensity, ponding, and a short depth to the saturated zone. This parcel contains twelve inventoried wetlands that likely filter

water that feed the already impaired Maple River. This will be more fully discussed in the next section.

Field twelve (NW¼ Section 14, T140N, R55W) also sits astride the Maple River and contains a watercourse that shares a surface connection with two inventoried wetlands. Two other wetlands exist on this tract. 64.8 acres of the 112.3 acres in this tract are unfavorable for application of manure for reasons such as salinity, poor drainage, frequent flooding, ponding, and depth to the saturated zone. 001230-32.

Fields thirteen, fourteen, and fifteen (Section 11 T140N, R55W) claim to provide 488.4 acres for effluent spreading. 001111, 001113, 001115. 281.6 of these proposed acres have soils that are very limited for manure application, and 51.4 are somewhat limited in this proposed use. Hamerley-Tonka soils are found in this region. 001230-32, 001237-39, 001244-46, 001251-53. Further complicating Rolling Green's proposal is the presence of three watercourses and three wetlands. Field thirteen borders the Maple River and contains two tributaries that flow into it. While the southerly one appears to have been provided a setback, the northern one has been omitted from the Applicant's submission. ND 09020205-020-S_00, HUC 09020205000078.

Field sixteen and seventeen (NE¼ Section 2, T139, R55W) asserts to provide 146.9 acres for manure spreading, but only 106.6 is favorable. 001120, 001122, 0012363-69. There are two wetlands on the parcel. The impaired Maple River flows near this land's western boundary.

Field twenty (SE¼ Section 11 T140N, R55W) claims to offer 57.6 acres for receipt of manure, but this is overstating this site's potential. 001128. The Applicant does acknowledge one feature of percolating water, but does not include the six other saturated areas on the site. 21.9 acres are very limited for manure application, while 21.1 are somewhat limited. 001258-60. The soil saturation is illustrated by the presence of seven inventoried wetlands.

Field twenty-one (NW¼ Section 12, T139N, R55W) purports to provide 107.7 acres for swine effluent. However, only 27 acres are favorable for application of manure according to the NRCS. 67 acres are very limited for this use due to the Hamerley-Tonka soil. 001292-95.

Fields twenty-two, twenty-three, and twenty-four (Section 2,9 T140N, R55W) claim to provide 557.7 acres, but once again this goal is limited by soil types and persistent surface water. 001132, 001134, 001136. 93.4 acres have soils that are very limited for effluent application while 91.3 acres are somewhat limited. 001300-02, 001307-09, 001314-15, 001320-23. The complication with this site is the presence of a stream that begins in field 22 at latitude 46.9090 longitude -97.5140 that meanders southeast and departs field 23 at latitude 46.9047 longitude -97.5011. ND 09020205-008-S_00, HUC 09020205000294. A setback will need to be established for this stream. This waterway continues through field twenty-five and eventually joins a larger body of water in the Buffalo Creek sub-watershed at latitude 46.8879 longitude -97.4265. Saturation of the site is confirmed by the presence of twenty-two wetlands on the section.

Field twenty-five (NE¼ Section 32 T140N, R54W) states that 150 acres are available for effluent application. 001138. 35.8 of these acres are very limited for application. 001328. The

stream referenced in the previous fields flows through this tract, and there is a wetland to the northeast of its course.

Because of the prevalence of soil types that the NRCS describes as very limited for the purpose of effluent application, in many instances nutrients will not be taken up by crops. Nitrogen will dissolve and permeate the groundwater, and phosphorous will pond on the surface and leach to navigable waters and/or other waters of the state. This migration will result in waste and have no agronomic benefit. The lack of agronomic utility requires that the rate and volume of effluent be limited in areas that are prone to ponding, leaching, and areas with a saturation zone on or near the surface. See NDDH Design Manual at 7.6.3.

VII. The project will cause pollution of the Maple River and adjacent wetlands due to over-application of manure.

The Maple River is Already an Impaired Water with a High Priority TMDL Designation

Limiting potential surface and groundwater impacts is especially important in areas that are near flowing waters. As mentioned above, the state and federal government have invested significant resources in attempting to remediate the Buffalo Creek sub-watershed. The application sites that drain into the Maple River do so at an area of the river that is a high priority TMDL reach that begins just north of fields 11-15. *See* North Dakota 2014 Integrated Section 305(b) Water Quality Assessment Report and Section 303(d) List of Waters Needing Total Maximum Daily Loads ("NDTMDL"), VI-20. North Dakota is expected to publish an e. coli TMDL for this area in its biennial report due April 1, 2016. NDTMDL II-1. Siting of application areas in saturated areas that are very limited in their absorption and storage capacity around the Maple River and its tributaries will not only counteract the beneficial role of its supporting wetlands, but also actively degrade the water quality further, violating the narrative standards of N.D.C.C.33-16-02.1-08, and negate any progress at meeting the appropriate numerical standard. While it is true that the survival of e coli bacteria is limited outside of their preferred habitat, their survival rate is lengthened in aqueous sediments that inhibit UV penetration. The clustering of proposed fields eleven through fifteen, if allowed, will place tons of the very thing that has degraded the river within one quarter mile downstream from the targeted area for rehabilitation—instead of remediating water quality in an area of concern, these sites will exacerbate the problem.

VIII. The project will cause pollution of an intermittent stream and adjacent wetlands, none of which were accounted for in Rolling Green's permit application.

The applicant has stated that the closest watercourse to its confinement facility is an "unnamed tributary to Maple River, 2 miles to the NW." 000048. This is incorrect. The closest watercourse is an intermittent stream approximately one mile to the north of the confinement structures that drains to the southeast and runs through a number of fields that the applicant intends to land apply manure to. A map indicating this watercourse is attached at 001827 from

EPA's My Waters Mapper tool. This stream has also been confirmed to exist by landowners who testified at the public hearing for this permit and flows for more than three months out of each year. It is a tributary that ultimately leads to the Red River. Due to over-application of manure as described in Section VI of this comment, this intermittent stream and adjacent wetlands would be exposed to non-agronomic nutrient loading from Rolling Green's project.

IX. The project, as planned, poses very serious medical risks to the community, as described by the community's doctors and experts at Johns Hopkins University.

Concerned Citizens are deeply concerned about health impacts of this facility. There are a number of highly sensitive individuals in the area, including individuals with asthma, COPD, cancer, lupis, and other diseases, many of which would be exacerbated by the siting of Rolling Green's facility in this community. Concerned Citizens has attached a letter to these comments from public health experts at Johns Hopkins University describing the serious health risks that this facility poses to the Buffalo community. 000345-000354. Additionally, a number of members of the Buffalo community wish to make the Department of Health explicitly aware of the risks that they face from this facility due to existing health issues in the community, and many have chosen to attach their personal health summaries to these comments. 000355 – 000456. These health summaries show that the community is at risk for health impacts that would be exacerbated by the facility, as described by the Johns Hopkins letter.

X. Conclusion

As described in these comments, permitting this facility poses numerous risks to the Buffalo community. These risks include likelihood of groundwater pollution at the animal confinement facilities, likelihood of surface water pollution due to significant over-application of manure at non-agronomic rates and at unsuitable locations, facility design flaws, severe odor issues due to emissions of 35 tons per year of ammonia from the confinement facilities, stormwater pollution issues, failure to identify nearby water wells, failure to identify wetlands and intermittent streams at land application areas, and serious public health risks. Apart from the real health issues and risks posed by this facility, the permit itself is also not even the correct *type* of permit. The Department's rules require a NPDES permit for a large CAFO, not a significantly less protective Animal Feeding Operation permit. Because the facility has not met the Department's rules for granting an Animal Feeding Operation permit, let alone the more stringent rules for granting a NPDES permit, the Department must deny this permit.

Finally, Concerned Citizens understand that the Applicant has twenty days to respond to these comments. If the applicant provides additional information which the Department relies upon to approve this permit during this twenty day period, then the permit must be re-noticed to the public so that the public has the ability to respond to this additional information in accordance with the Department's rules and due process.

Respectfully submitted this 19th Day of March,

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NORTH DAKOTA DEPARTMENT OF HEALTH
Division of Water Quality
Bismarck, ND

SFN 8296 (6/96)

APPLICATION FOR APPROVAL OF LIVESTOCK WASTE SYSTEM

NAME OF APPLICANT: *Rolling Green Family Farms RE, LLP*
INDIVIDUAL _____ LIMITED LIABILITY PARTNERSHIP *X* PARTNERSHIP _____

NAME OF LIVESTOCK OPERATION: *Rolling Green Family Farms RE, LLP*

ADDRESS OF OWNER OR APPLICANT: *1300 S. Hwy 75,*
(RR, STREET, or PO Box No.)

Pipestone, MN *56164* *507-825-4211* (City)
(Zip Code) (Telephone No.)

LOCATION OF LIVESTOCK ENTERPRISE: (Legal Land Description)

SE 1/4 *NW* 1/4 Section *4* Township *139 - N* Range *54 - W*

County *Cass County* Lat. *46° 53'5"* Long. *97°30'22"*
(If available)

TYPE OF FACILITY:
(a) Existing *0* Planned *9,056 hd sow facility* Addition _____

(b) Confined in barn *9,056 hd total* Have access to outside lot *0*

(c) Unpaved or dirt *0* Hard surfaced *0*
Other *0*

TYPE AND NUMBER OF LIVESTOCK:

Days/year livestock concentrated on-site: *365 days* (for example, Dec. - May, 180 days)

Existing number, and maximum number of livestock at the facility:

Existing Number	Maximum Design Number	Type	Average Weight
0	*800*	*Nursery Pigs*	*45 lbs*
0	*1,344*	*Farrowing Sows*	*400 lbs.*
0	*5,312*	*Gestation Sows*	*400 lbs.*
0	*1,600*	*Finish Pigs*	*150 lbs.*

BASIC INFORMATION:

List area of any outside livestock lots: *0* acres.

Area contributing surface flow from outside the lot (not diverted): *0.0* acres.

Is the runoff from a 25-year/24-hour rain event contained on the property:

N/A (This varies across the State from 3.5 to 4.1 in. of rain).

Soil type at waste storage site and livestock lot: (From soil investigation)

Sandy lean clay (CL) and silty sand (SM), Sandy Silt (ML), Clay Sand (SC)

Depth from ground surface to the seasonal high water table at:

Isloation Barn 5.5 ft Gestation Barn *4.7 ft* Farrowing Barn *7.6 ft.*

This was determined by: (check one) Soil boring *X* Estimate ___

How much land is available for disposing of waste: *3,420.9 (3,312.4 after setbacks)* acres.

How will dead animals be disposed of? *Composting*

The maps and site information submitted should be as detailed and accurate as possible. Incomplete information may result in delays with the approval, or future problems at the site.

A. Submit the following information with this application form:

1. A topographic map of the area with at least a two-mile radius. *(See Section 3, Map A & B)*

2. A current map of the area with at least a two-mile radius that has the following marked to the best of your knowledge: *(See Section 3, Map A & B)*

   a. All inhabitable farms or dwellings. *(See Section 3, Map A & B)*

   b. All land within this two-mile radius on which waste will be applied. *(See Section 3, Map A & B)*

   c. Any livestock waste ponds and dugouts. *(See Section 3, Map A & B)*

   d. Any well within 1/4 mile and any public or irrigation wells within 2 miles. Also, list any abandoned wells you are aware of and their status. *(See Section 3, Map A & B)*

   e. If dead animals are disposed of on-site, indicate on the map where this is done. *(N/A)*

3. A sketch of the facility site with the following information: *(See Section 4)*

   a. Dimensions and distances, include depth of wells on-site. *(See Section 4, Page 3)*

   b. All existing and proposed structures, with labels (e.g., barns, diversions, fences). *(See Sect. 4, Pg.*3)

   c. Identify drainage patterns through the facility site. *(See Section 4, Pages 3 & 4)*

B. Please check on the following information and, if it is available, include it when submitting this application:

1. Any applicable zoning requirements (city, county, township). *(See Section 6)*

2. Any water quality information you are aware of, such as: *(See Section 7)*

   a. Well water quality analyses. *(See Section 7)*

   b. Surface water analyses (stock ponds, creeks, etc.). *(See Section 7)*

   c. Analyses of livestock waste or runoff. *(See Section 7)*

3. Any geologic/hydraulic or soils information you are aware of: *(See Section 8)*

   a. Well logs for wells at the facility. *(See Section 8)*

   b. Geologic, ground water, or surface water studies done in the area and who did the studies.*(See Sect.8)*

   c. Personal observation (gravel pits, wetlands, etc.). *(See Section 8)*

C. Give a brief description of the proposed livestock waste system, including how waste and/or runoff will be collected, stored, and land applied. Indicate if waste is incorporated into the soil and, if so, how is this done. (Use a separate sheet, if necessary).

(See Section 3.1) The facility will be an 9,056 head swine sow facility. The farrowing facility will utilize total slatted floors which will discharge waste into a pit recharge system that will drain into the gestation pit. The gestation barns and the isolation barns are total slatted barns that drain into concrete pits. The concrete pits will store over 365 days of waste from the facility's barns. The waste from the facility will be disposed of on surrounding cropland via an injection applicator system at agronomic rates

I certify that, to the best of my knowledge, this information is correct and accurate.

Barry R. Kinkaid 11-25-15

(Applicant Signature) (Date)

APPLICATION FOR PRELIMINARY APPROVAL OF A LIVESTOCK WASTE SYSTEM:
The Department of Health has the responsibility to review and approve concentrated livestock facilities to ensure surface and ground waters are protected from pollution by livestock waste. The first step to initiate the evaluation process is to complete this application form and return it to the Department with the information requested.

The application should be completed as accurately and completely as possible. Incomplete information will slow down the process. If you have any questions, contact the Department at 701-328-5219 for assistance.

ABOUT THE APPLICATION:
The application requests information on the proposed facility location, size, and other operational information. Maps with the information requested may be available at various places such as your County Extension Office, or the County Auditors Office. Soils information may be found at your local Natural Resources Conservation Service (NRCS) Office. If you cannot find all the information requested, you can contact the Health Department for assistance. Please be sure all of the information requested is included with the application.

PART A: Requests maps and sketches. Please make sure all requested information is clearly marked. If waste is to be applied to a neighbor's land, indicate whether a signed or verbal agreement has been made.

PART B: Requests information that you may personally be aware of. You do not need to collect any new data. If a ground water, surface water, or geologic study was completed in the area, indicate when the study was done and who did it. The Department can then get the data collected from the study.

PART C: This gives us an overview of the operation, including how waste is land applied, as well as provide information on any unique features at the site. We encourage producers to test the waste for nutrient content so it can be applied according to the needs of the crop being grown. Over-applying waste can lead to nitrogen being leached into the ground water or waste and nutrients being washed off the field and into lakes or streams.

FINAL APPROVAL:
The Department will review the application and respond with an evaluation of the site, including any areas of concern for surface or ground water impacts. This is done to allow operators to address areas of water quality concerns in the facility design. This detailed design plan of the facility and livestock waste system should then be submitted to the Department. It must include specifics on the volume of waste produced, the volume of waste that can be stored, dimensions of the storage structure, diversions, and embankments and also include method and rate waste is land applied. An operation and maintenance plan should be included to ensure the waste storage facility does not overflow and that waste is properly land applied.

If the final detailed design plan is already completed when submitting the application, it can be submitted, along with this preliminary application.

ROLLING GREEN FAMILY FARMS RE, LLP

ENGINEERING PLAN SHEETS

PIPESTONE VET

NW 1/4, SECTION 4, T 139 N, R 54 W

CASS COUNTY, ND

DATE: DECEMBER 2, 2015

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PAGE 2 – EXISTING SITE PLAN
PAGE 3 – PROPOSED SITE PLAN
PAGE 4 – PROPOSED SITE SUBGRADE PLAN VIEW
PAGE 5 – PROPOSED SITE FINAL PLAN VIEW
PAGE 6 – PROPOSED SITE PLAN CROSS SECTION AND ANNOTATION DETAILS
PAGE 7 – GDU BARN CROSS SECTIONS
PAGE 8 – BARN CROSS SECTIONS
PAGE 9 – BARN CROSS SECTIONS
PAGE 10 – BARN CROSS SECTION & CLEANWATER DIVERSION
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PAGE 12 – GESTATION, FARROWING, & GDU BARN PLAN VIEW
PAGE 13 – GESTATION BARN FOUNDATION PLAN
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ADDENDUM 2 – CONCRETE DETAILS
ADDENDUM 3 – FARROWING BARN PHASE II DETAILS
ADDENDUM 4 – CLEANWATER DIVERSIONS 1A & 2B DETAAILS

NOTE: IT IS THE DUTY OF THE LANDOWNER IF SUBSURFACE INVESTIGATION OR CONSTRUCTION IS PROPOSED TO:
1. Notify the utility company of time, place, and type of work to be done.
2. Request that the buried utility be located and staked on the ground both horizontally and verticially by the utility owner. Dig Safe phone number is: 1–800–795–0555
3. Request that a representative of the utility company be present during excavation operations.
4. Notify the contractor of the location of the utility in relation to the job work area.

GENERAL NOTES

REGISTERED PROFESSIONAL ENGINEER
NATHAN A. PESTA
PE-6254
DATE 12/10/15
NORTH DAKOTA

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

No.	Revision/Issue	Date

DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
PO Box 522 | Mandan, ND | 58554

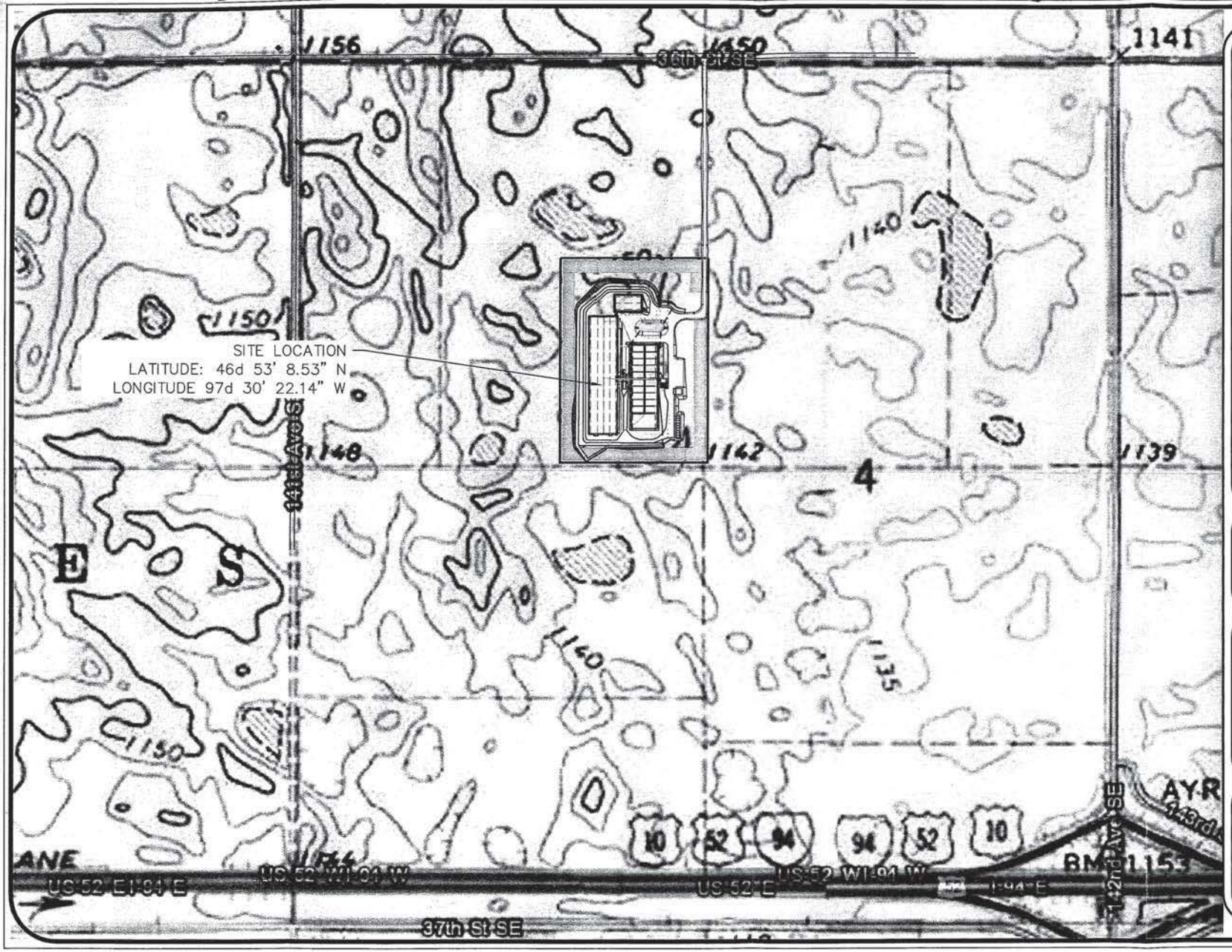
ROLLING GREEN FAMILY FARMS RE, LLP

NW 1/4, SECTION 4, T 139 N, R 54 W
CASS COUNTY, ND

COVER

DATE: AUG 24, 2015	SHEET: COVER
SCALE: NONE	
DRAWN BY: DDR	
CHECKED BY: NAP	

FILE NAME: ND PROJECT FILES/SWINE/ROLLING GREEN/CFILES/PLAN



GENERAL NOTES

LEGEND

SCALE, FEET

0 300 600 900 1200

REGISTERED PROFESSIONAL ENGINEER
NATHAN A. PESTA
PE-6254
DATE 12/10/15
NORTH DAKOTA

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

No.	Revision/Issue	Date
1	COMPOST BARN	12/02/15

DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
PO Box 522 | Mandan, ND | 58554

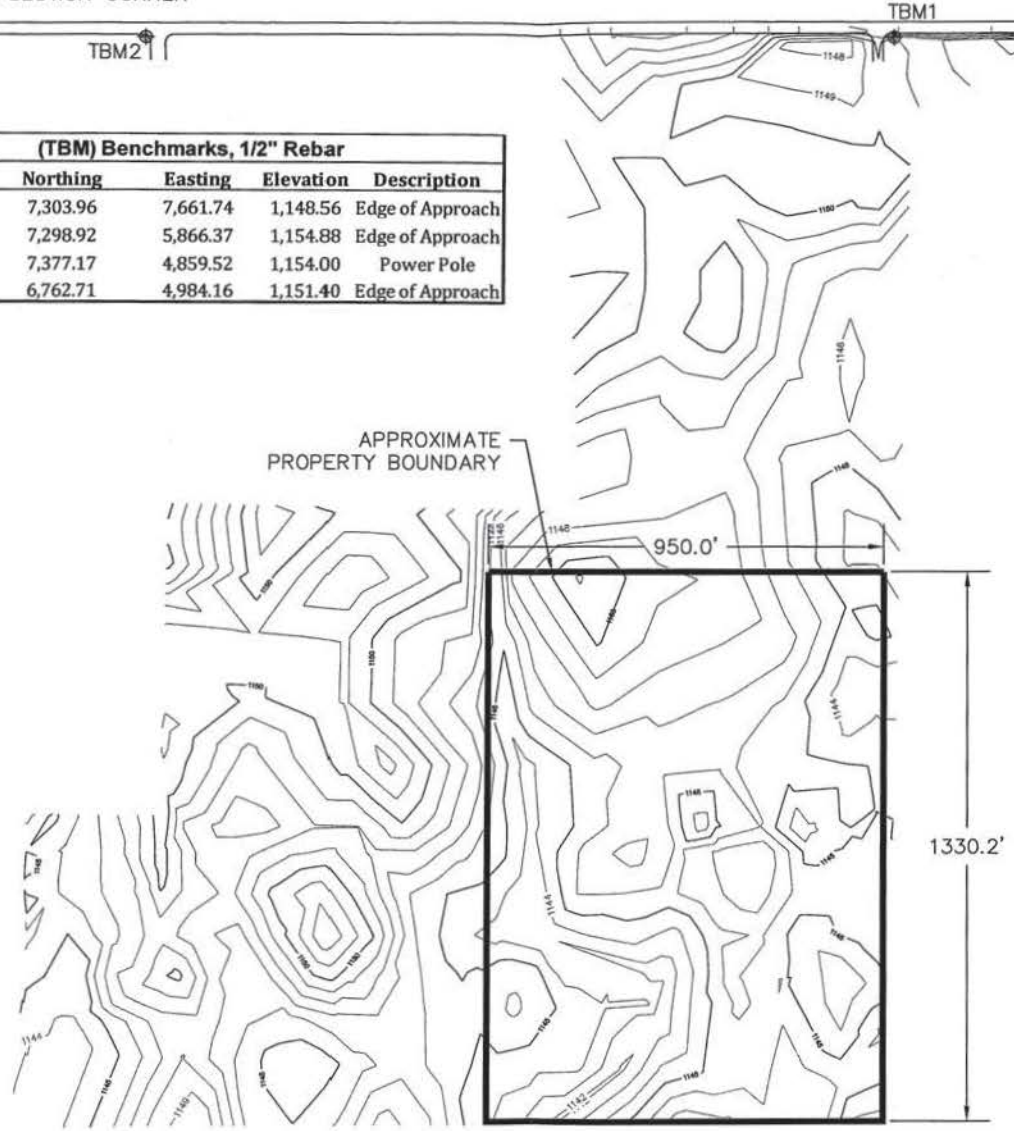
ROLLING GREEN FAMILY FARMS RE, LLP

NW 1/4, SECTION 4, T 139 N, R 54 W
CASS COUNTY, ND

USGS SITE LOCATION

DATE: JULY 7, 2015	SHEET: 1
SCALE: 1" = 600'	
DRAWN BY: DDR	
CHECKED BY: NAP	

FILE NAME: ND PROJECT FILES/SWINE/ROLLING GREEN/CFILES/PLAN



(TBM) Benchmarks, 1/2" Rebar				
TBM #	Northing	Easting	Elevation	Description
1	7,303.96	7,661.74	1,148.56	Edge of Approach
2	7,298.92	5,866.37	1,154.88	Edge of Approach
3	7,377.17	4,859.52	1,154.00	Power Pole
4	6,762.71	4,984.16	1,151.40	Edge of Approach

GENERAL NOTES

LEGEND

SCALE, FEET

0 150 300 450 600

REGISTERED PROFESSIONAL ENGINEER
NATHAN A. PESTA
PE-6254
DATE 12/10/15
NORTH DAKOTA

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

No.	Revision/Issue	Date

DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
PO Box 522 | Mandan, ND | 58554

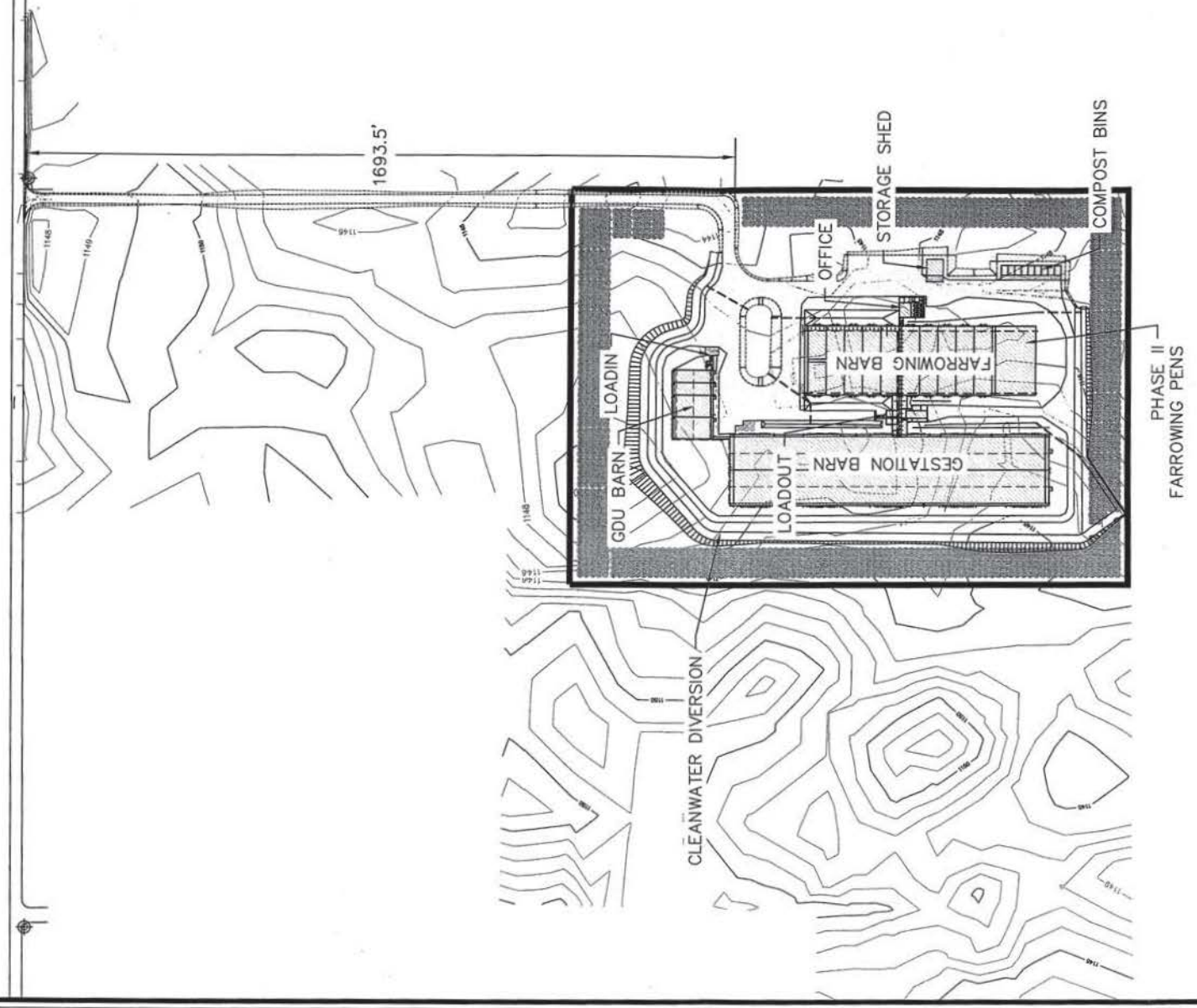
ROLLING GREEN FAMILY FARMS RE, LLP

NW 1/4, SECTION 4, T 139 N, R 54 W
CASS COUNTY, ND

EXISTING SITE PLAN

DATE: AUG 13, 2015	SHEET: 2
SCALE: 1" = 300'	
DRAWN BY: DDR	
CHECKED BY: NAP	

FILE NAME: ND PROJECT FILES/SWINE/ROLLING GREEN/CFILES/PLAN



GENERAL NOTES

LEGEND

- BENCHMARK
- BUILDINGS
- GRAVEL PROPOSED
- CULVERT/PIPE
- DRAINAGE ARROW

SCALE, FEET

0 125 250 375 500

REGISTERED PROFESSIONAL ENGINEER
NATHAN A. PESTA
PE-6254
DATE 12/10/15
NORTH DAKOTA

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

No.	Revision/Issue	Date
1	COMPOST BARN LOC	12/03/15

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Consulting Engineers
PO Box 522 | Mandan, ND | 58554

ROLLING GREEN FAMILY FARMS RE, LLP

NW 1/4, SECTION 4, T 139 N, R 54 W
CASS COUNTY, ND

PROPOSED SITE PLAN

DATE: JUL 7, 2015	SHEET: 3
SCALE: 1" = 250'	
DRAWN BY: DDR	
CHECKED BY: NAP	

FILE NAME: ND PROJECT FILES/SWINE/ROLLING GREEN/DFILES/PLAN

6:1 CUT SIDE SLOPE
4" DRAIN TILE
GDU BARN
SUBGRADE EL. 1138.8
BUILDING PAD 4' WIDER
ON EACH SIDE
176.5'
174.5'
TILE INLET EL. 1138.0
CLEANWATER
DIVERSION 1D
40.0'
114.7'
106.0'
40.0'
113.2'
6" END TILE
15.7'
6.7'
6:1 SIDE SLOPE
TILE OUTLET
& LIFT STATION
TILE OUTLET
EL, 1137.0
187.5'
FARROWING BARN PAD
10' WIDER ON EACH SIDE
4:1 SIDE SLOPE
GESTATION BARN
SUBGRADE EL. 1138.8
FARROWING BARN
SUBGRADE EL. 1148.6
OFFICE SUBGRADE
EL. 1150.5
770.0'
50.0'
4" DRAIN
TILE
570.7'
60.0'
40.0'
40.0'
40.0'
SHOP SUBGRADE
EL. 1149.3
40.0'
24.0'
COMPOST BARN
SUBGRADE EL. 1148.5
141.7'
181.5'
40.0'
18.5'
TILE INLET
EL. 1138.0
SIDE SLOPES TO BE CUT
STRAIGHT UP AND DOWN
FOR THE FIRST FOUR FEET AND
THEN 1:1 FOR BUILDING CONSTRUCTION
GENERAL NOTES
LEGEND
BENCHMARK
BUILDINGS
GRAVEL PROPOSED
CULVERT/PIPE
DRAINAGE ARROW
SCALE, FEET
0
50
100
150
200
DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE
REGISTERED PROFESSIONAL ENGINEER
NATHAN A. PESTA
PE-6254
DATE 12/9/15
NORTH DAKOTA
No.
Revision/Issue
Date
1
BARN WIDTHS
12/03/15
DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
PO Box 522 | Mandan, ND | 58554
ROLLING GREEN FAMILY
FARMS RE, LLP
NW 1/4, SECTION 4, T 139 N, R 64 W
CASS COUNTY, ND
PROPOSED SITE SUBGRADE
PLAN VIEW
DATE:
JUL 7, 2015
SCALE:
1" = 100'
DRAWN BY:
DDR
CHECKED BY:
NAP
SHEET:
4
FILE NAME: N:\PROJECT FILES\SWINE\ROLLING GREEN\DFILES\PLAN

GENERAL NOTES

LEGEND

- BENCHMARK
- BUILDINGS
- GRAVEL PROPOSED
- CULVERT/PIPE
- DRAINAGE ARROW

SCALE, FEET

0 50 100 150 200

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

No.	Revision/Issue	Date
1	PHASE II	12/03/15

REGISTERED PROFESSIONAL ENGINEER
NORTH DAKOTA
NATHAN A. PESTA
PE-6254
DATE 12/01/15

DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
PO Box 522 | Mandan, ND | 58554

ROLLING GREEN FAMILY FARMS RE, LLP

NW 1/4, SECTION 4, T 139 N, R 54 W
CASS COUNTY, ND

PROPOSED SITE FINAL PLAN VIEW

DATE:	JUL 7, 2015
SCALE:	1" = 100'
DRAWN BY:	DDR
CHECKED BY:	NAP
SHEET:	5

FILE NAME: K:\PROJECT FILES\DRIVE\ROLLING GREEN\CFILES\PLAN

000010

GENERAL NOTES

LEGEND

- BENCHMARK
- BUILDINGS
- GRAVEL PROPOSED
- CULVERT/PIPE
- DRAINAGE ARROW

SCALE, FEET

0 50 100 150 200

REGISTERED PROFESSIONAL ENGINEER
NATHAN A. PESTA
PE-6254
DATE 12/10/15
NORTH DAKOTA

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

No.	Revision/Issue	Date
1	DIVERSION PATHS	12/03/15

DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
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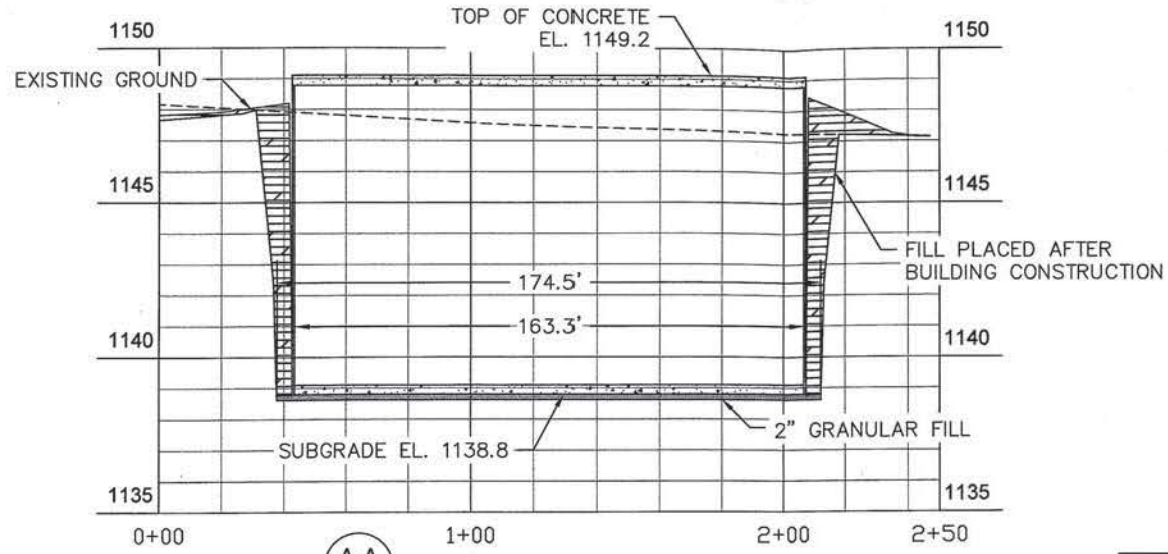
ROLLING GREEN FAMILY FARMS RE, LLP

NW 1/4, SECTION 4, T 139 N, R 54 W
CASS COUNTY, ND

PROPOSED SITE PLAN
CROSS SECTION DETAILS

DATE: AUG 17, 2015	SHEET: 6
SCALE: 1" = 100'	
DRAWN BY: DDR	
CHECKED BY: NAP	

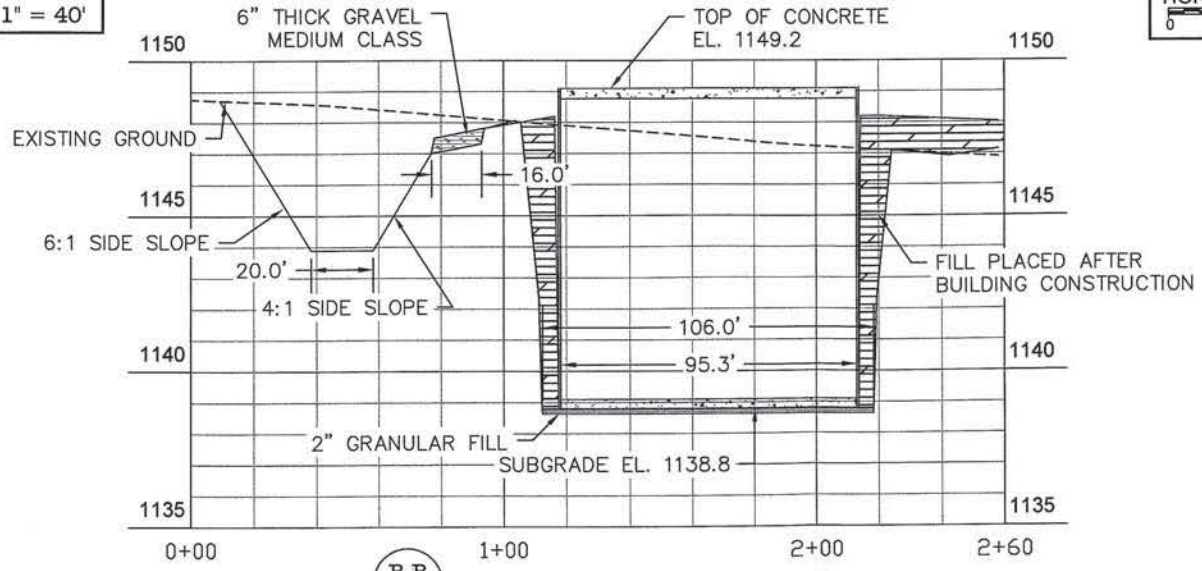
FILE NAME: ND PROJECT FILES/SWINE/ROLLING GREEN/CFILES/PLAN



A-A / 6 BARN CROSS SECTION

SCALE:
VERTICAL: 1" = 4'
HORIZONTAL: 1" = 40'

VERTICAL SCALE, FEET
0 2 4 6 8
HORIZONTAL SCALE, FEET
0 20 40 60 80



B-B / 6 BARN CROSS SECTION

GENERAL NOTES

LEGEND
- GRAVEL
- FILL
- CONCRETE
- STRIPPING
- EXISTING GROUND

REGISTERED PROFESSIONAL ENGINEER
NATHAN A. PESTA
PE-6254
DATE 12/10/15
NORTH DAKOTA

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

No.	Revision/Issue	Date
1	B-B CROSS SECTION	12/3/15

DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
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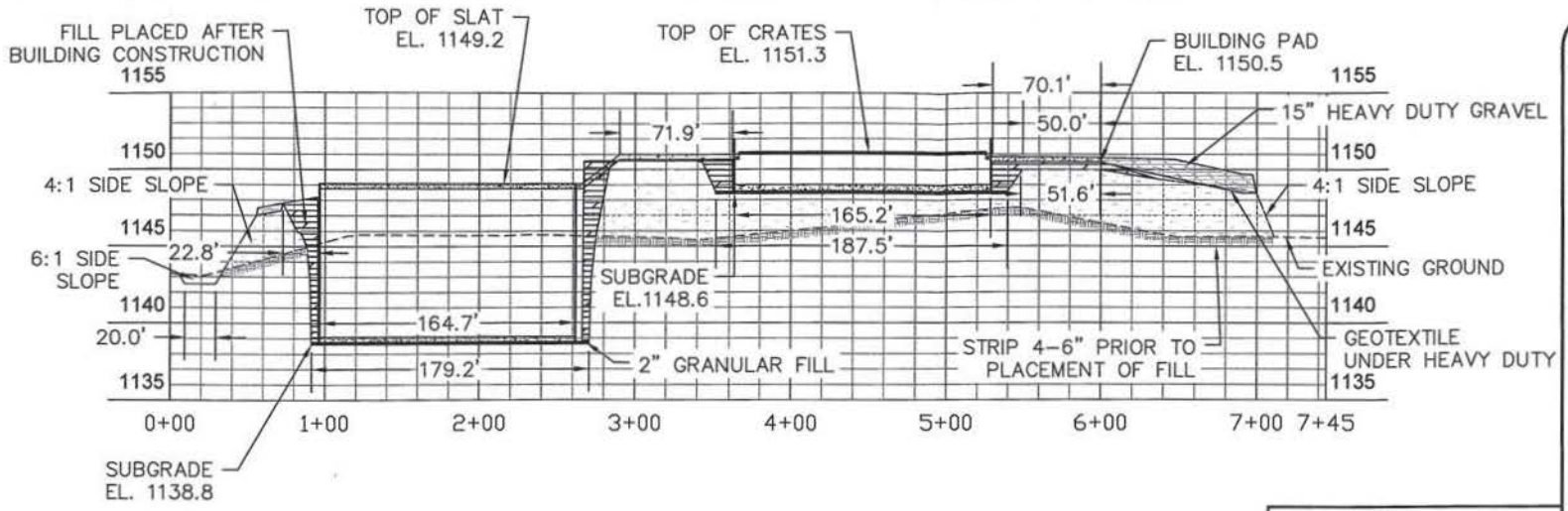
ROLLING GREEN FAMILY FARMS RE, LLP

NW 1/4, SECTION 4, T 139 N, R 54 W
CASS COUNTY, ND

GDU BARN
CROSS SECTIONS

DATE: AUG 18, 2015	SHEET: 7
SCALE: AS SHOWN	
DRAWN BY: DDR	
CHECKED BY: NAP	

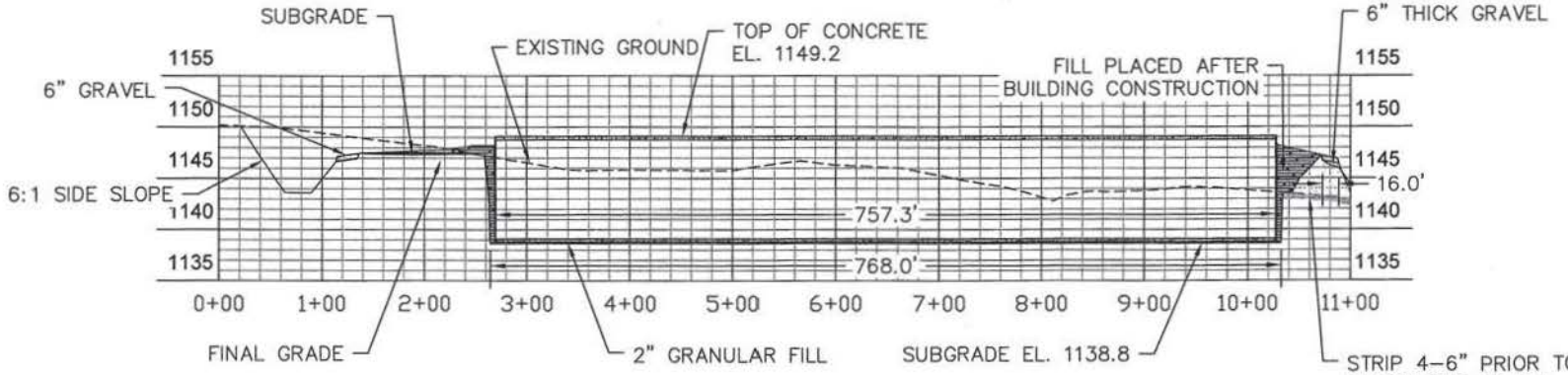
FILE NAME: ND PROJECT FILES/SWINE/ROLLING GREEN/CFILES/PLAN



SCALE:
VERTICAL: 1" = 8'
HORIZONTAL: 1" = 80'

C-C / 6 BARN CROSS SECTION

VERTICAL SCALE, FEET
0 4 8 12 16
HORIZONTAL SCALE, FEET
0 40 80 120 160



SCALE:
VERTICAL: 1" = 12'
HORIZONTAL: 1" = 120'

D-D / 6 BARN CROSS SECTION

VERTICAL SCALE, FEET
0 6 12 18 24
HORIZONTAL SCALE, FEET
0 60 120 180 240

GENERAL NOTES

LEGEND
- GRAVEL
- FILL
- CONCRETE
- STRIPPING
- EXISTING GROUND

REGISTERED PROFESSIONAL ENGINEER
NATHAN A. PESTA
PE-6254
DATE 12/16/15
NORTH DAKOTA

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

No.	Revision/Issue	Date
1	BACKFILL EL.	12/03/15

DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
PO Box 522 | Mandan, ND | 58554

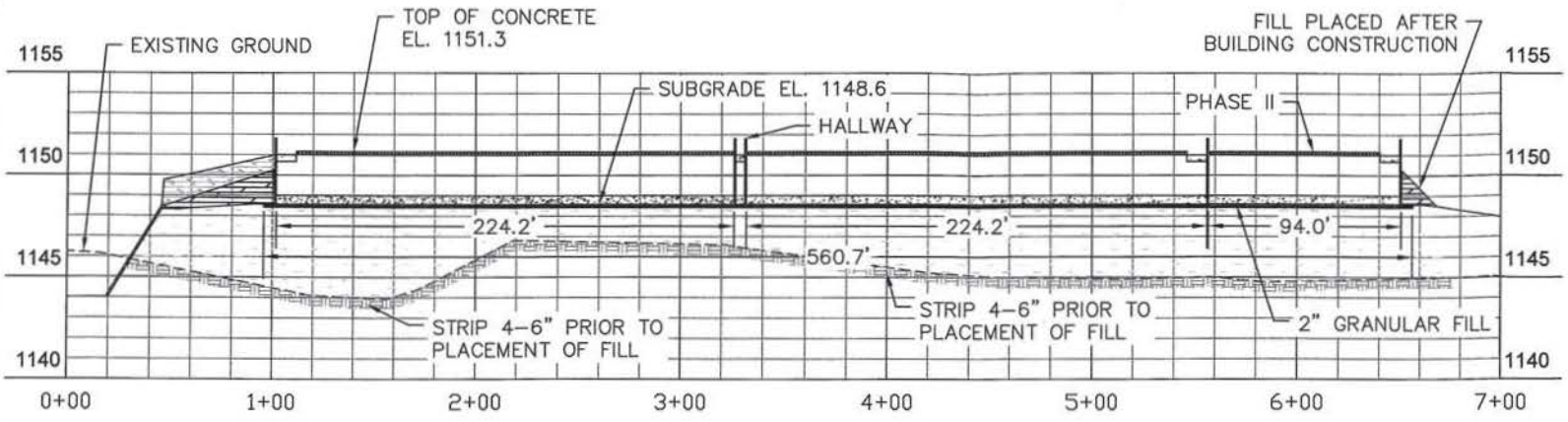
ROLLING GREEN FAMILY FARMS RE, LLP

NW 1/4, SECTION 4, T 139 N, R 54 W
CASS COUNTY, ND

BARN CROSS SECTIONS

DATE: AUG 18, 2015
SCALE: AS SHOWN
DRAWN BY: DDR
CHECKED BY: NAP
SHEET: 8

FILE NAME: ND PROJECT FILES/SWINE/ROLLING GREEN/CFILES/PLAN

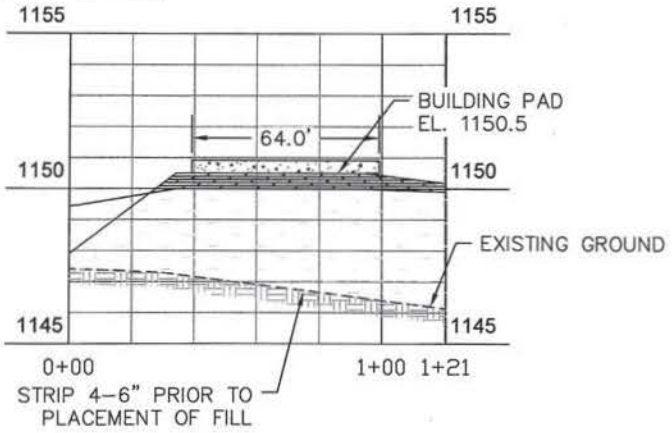


SCALE:
VERTICAL: 1" = 6'
HORIZONTAL: 1" = 60'

F-F / 6 BARN CROSS SECTION

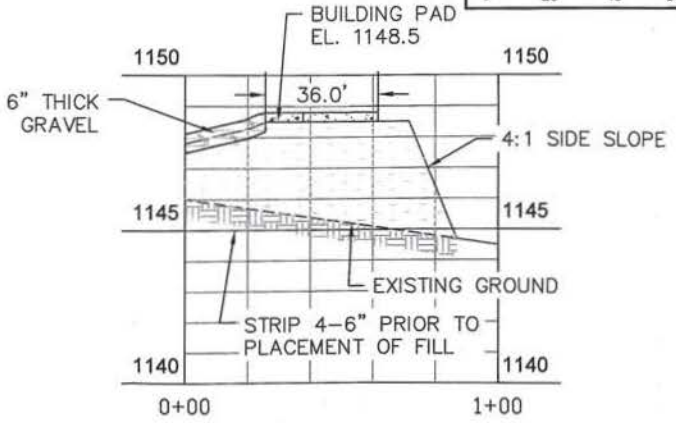
VERTICAL SCALE, FEET
0 3 6 9 12
HORIZONTAL SCALE, FEET
0 30 60 90 120

SCALE:
VERTICAL: 1" = 4'
HORIZONTAL: 1" = 40'



E-E / 6 BARN CROSS SECTION

VERTICAL SCALE, FEET
0 2 4 6 8
HORIZONTAL SCALE, FEET
0 20 40 60 80



G-G / 6 BARN CROSS SECTION

GENERAL NOTES

LEGEND
- GRAVEL
- FILL
- CONCRETE
- STRIPPING
- EXISTING GROUND

REGISTERED PROFESSIONAL ENGINEER
NATHAN A. PESTA
PE-6254
DATE 12/10/15
NORTH DAKOTA

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

No.	Revision/Issue	Date
1	G-G CROSS SECTION	12/3/15

DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
PO Box 522 | Mandan, ND | 58554

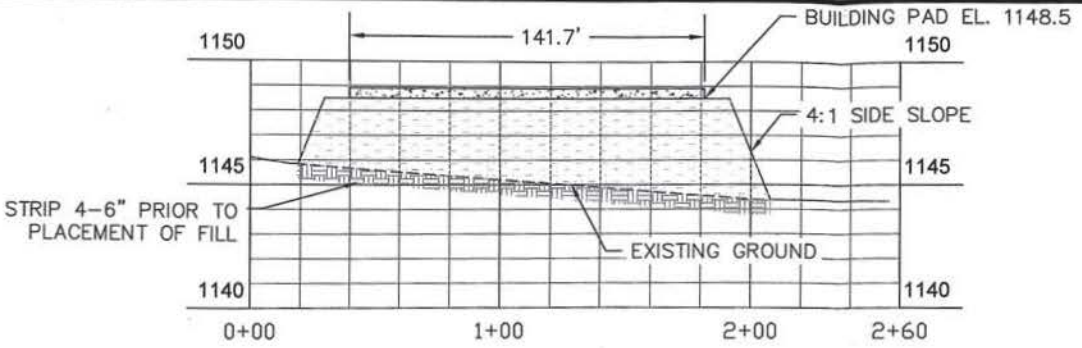
ROLLING GREEN FAMILY FARMS RE, LLP

NW 1/4, SECTION 4, T 139 N, R 54 W
CASS COUNTY, ND

BARN CROSS SECTIONS

DATE: AUG 18, 2015	SHEET: 9
SCALE: AS SHOWN	
DRAWN BY: DDR	
CHECKED BY: NAP	

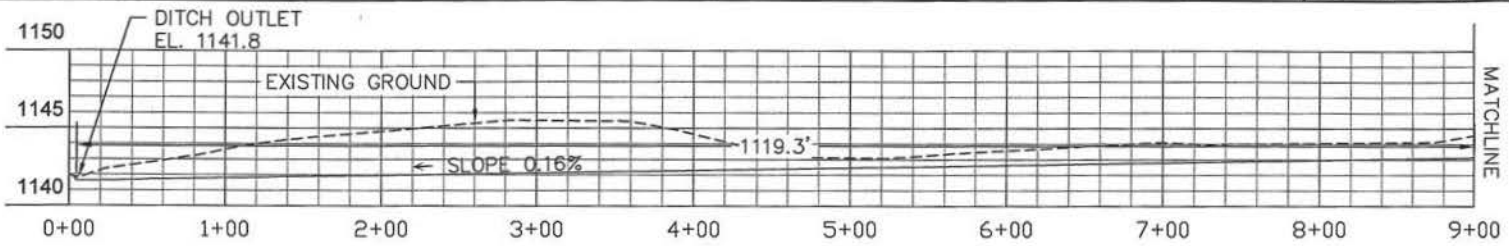
FILE NAME: ND PROJECT FILES/SHANE/ROLLING GREEN/CFILES/PLAN



SCALE:
VERTICAL: 1" = 5'
HORIZONTAL: 1" = 50'

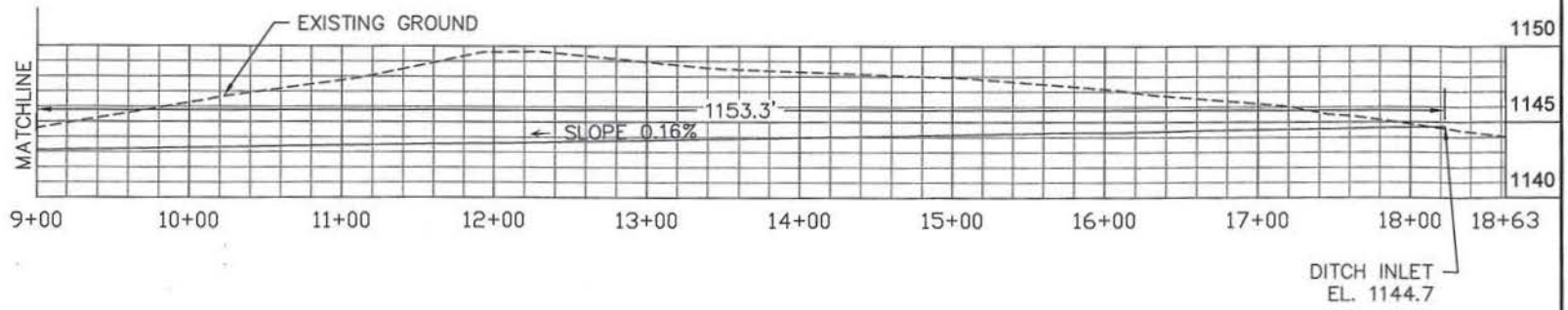
H-H 6 BARN CROSS SECTION

VERTICAL SCALE, FEET
0 5 10 15 20
HORIZONTAL SCALE, FEET
0 50 100 150 200



SCALE:
VERTICAL: 1" = 12'
HORIZONTAL: 1" = 120'

VERTICAL SCALE, FEET
0 5 10 15 20
HORIZONTAL SCALE, FEET
0 50 100 150 200



CLEANWATER DIVERSION 1D PROFILE

GENERAL NOTES

LEGEND
- GRAVEL
- FILL
- CONCRETE
- STRIPPING
- EXISTING GROUND

REGISTERED PROFESSIONAL ENGINEER
NATHAN A. PESTA
PE-6254
DATE 12/10/15
NORTH DAKOTA

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

No.	Revision/Issue	Date
1	H–H CROSS SECTION	12/3/15

DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
PO Box 522 | Mandan, ND | 58554

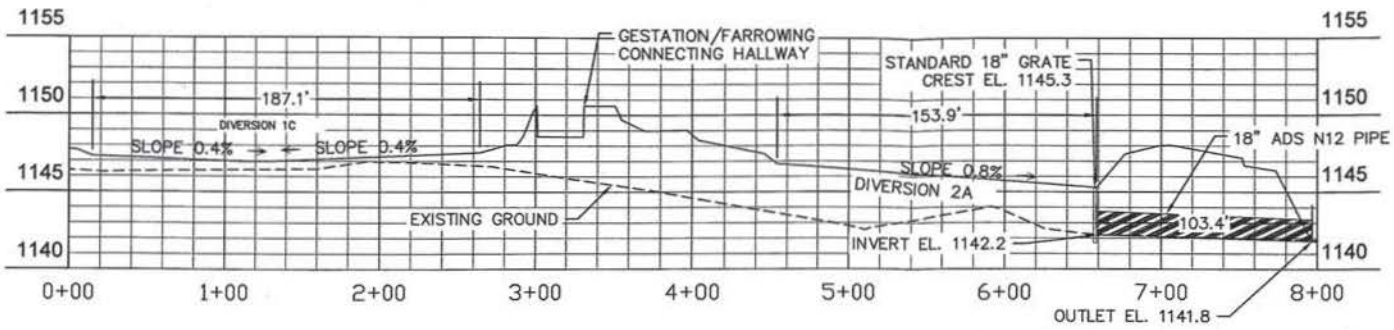
ROLLING GREEN FAMILY FARMS RE, LLP

NW 1/4, SECTION 4, T 139 N, R 54 W
CASS COUNTY, ND

BARN CROSS SECTION & CLEANWATER DIVERSION

DATE: AUG 18, 2015	SHEET: 10
SCALE: AS SHOWN	
DRAWN BY: DDR	
CHECKED BY: NAP	

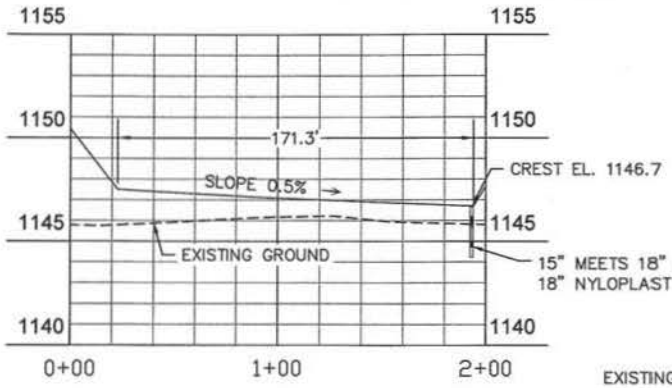
FILE NAME: ND PROJECT FILES/SWINE/ROLLING GREEN/CFILES/PLAN



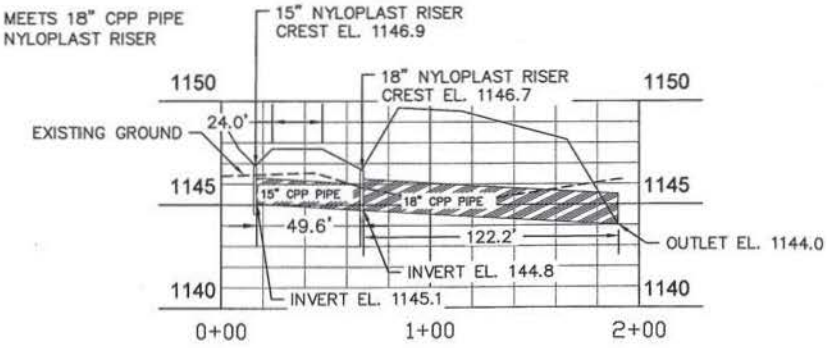
DIVERSION 1C- DIVERSION 2A PROFILE

SCALE:
VERTICAL: 1" = 6'
HORIZONTAL: 1" = 60'

VERTICAL SCALE, FEET
0 3 6 9 12
HORIZONTAL SCALE, FEET
0 30 60 90 120



DIVERSION 1B PROFILE



DIVERSION 1C-1B PIPE PROFILE

SCALE:
VERTICAL: 1" = 6'
HORIZONTAL: 1" = 60'

VERTICAL SCALE, FEET
0 3 6 9 12
HORIZONTAL SCALE, FEET
0 30 60 90 120

GENERAL NOTES

LEGEND

---- EXISTING GROUND

REGISTERED PROFESSIONAL ENGINEER
NATHAN A. PESTA
PE-6254
DATE 12/10/15
NORTH DAKOTA

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

No.	Revision/Issue	Date
1	New Profiles	12/9/15

DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
PO Box 522 | Mandan, ND | 58554

ROLLING GREEN FAMILY FARMS RE, LLP

NW 1/4, SECTION 4, T 139 N, R 54 W
CASS COUNTY, ND

DIVERSION INLET DETAILS

DATE: AUG 18, 2015	SHEET: 11
SCALE: AS SHOWN	
DRAWN BY: DDR	
CHECKED BY: NAP	

FILE NAME: ND PROJECT FILES/SWINE/ROLLING GREEN/CFILES/PLAN

GDU BARN: 320 HEAD

(20) 40 HEAD PENS
(17'4" x 13'6") ea.
(20) 40 HEAD PENS
(17'4" x 24'6") ea.

FARROWING BARN PHASE 1: 1120 HEAD

(1120) 5'6" x 7'6" CRATES
20 ROOMS (56 CRATES EACH)

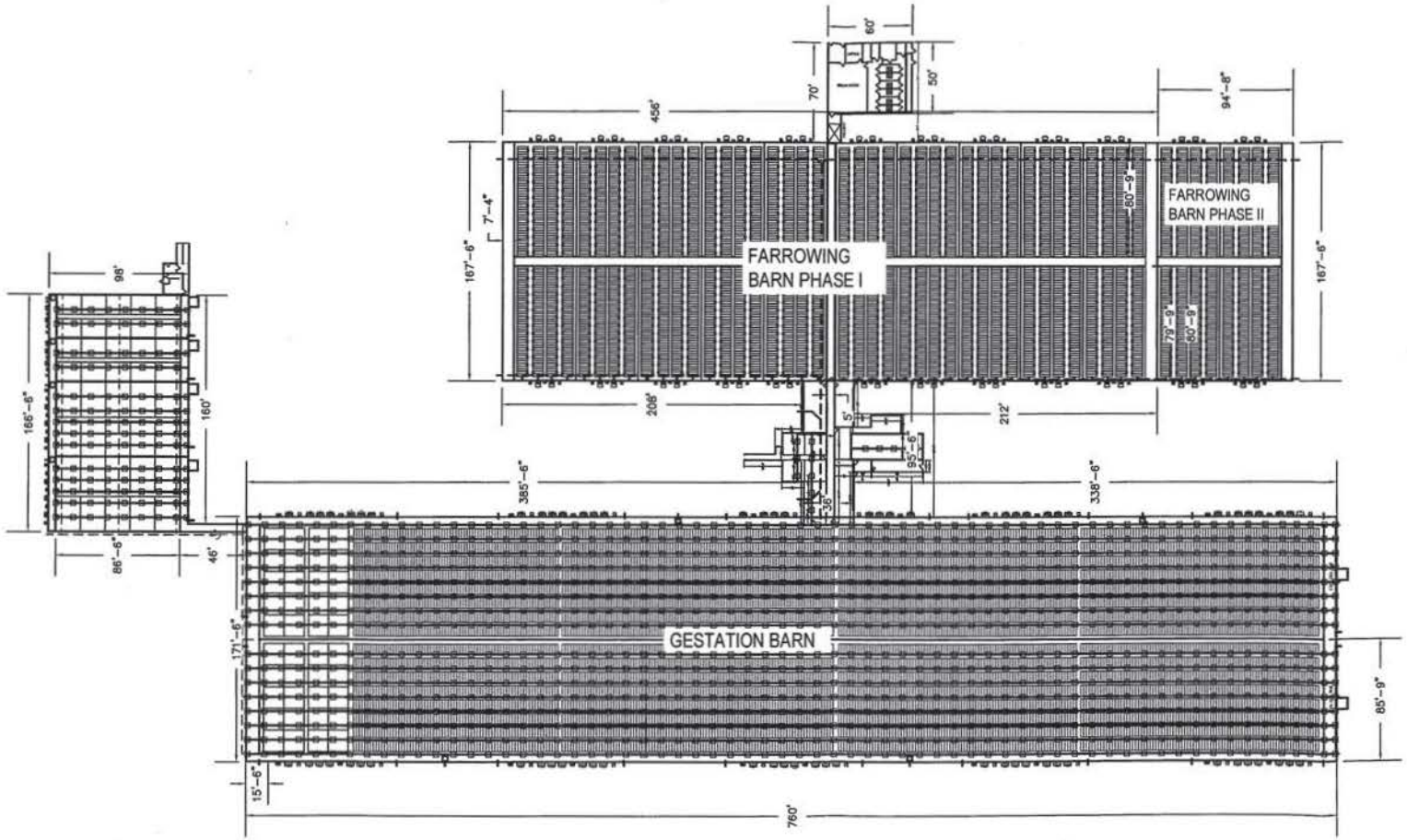
FARROWING BARN PHASE 2: 224 HEAD
(224) 5'6" x 7'6" CRATES
4 ROOMS (56 CRATES EACH)

GESTATION BARN:

(40) 20 HEAD PENS
(14' x 15'2") ea.
5083 STALLS (24" x 88") ea.
222 STALLS (23" x 88") ea.

SHOP

COMPOST BARN



GENERAL NOTES

SCALE, FEET
0 40 80 120 160

REGISTERED PROFESSIONAL ENGINEER
NATHAN A. PESTA
PE-6254
DATE 12/10/15
NORTH DAKOTA

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

No.	Revision/Issue	Date
1	Gestation: Fans/Pits	11/17/15

DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
PO Box 522 | Mandan, ND | 58554

ROLLING GREEN FAMILY FARMS RE, LLP

NW 1/4, SECTION 4, T 139 N, R 54 W
CASS COUNTY, ND

GESTATION, FARROWING & GDU BARN PLAN VIEW

DATE: AUG 10, 2015
SCALE: 1" = 80'
DRAWN BY: DDR
CHECKED BY: NAP
SHEET: 12

FILE NAME: ND PROJECT FILES/SWINE/ROLLING GREEN/CFILES/PLAN

000017

1. CONCRETE: ***(UNLESS OTHERWISE NOTED)***
   A. CONCRETE COLUMNS, WALLS, FLOORS, BEAMS, COLUMNS & PUMPOUTS: 4000 PSI MINIMUM 28 DAY STRENGTH
   B. CONCRETE FOOTINGS: 4000 PSI MINIMUM 28 DAY STRENGTH
   C. ALL CONCRETE TO BE AIR ENTRAINED
   D. 3"–4" CONCRETE SLUMP ON HORIZONTAL POURS PRIOR TO ADDITIVES
   E. 5" MAXIMUM CONCRETE SLUMP ON VERTICAL POURS PRIOR TO ADDITIVES
   F. PIT WALL CONCRETE DESIGN BASED OFF OF A 9'–6" BACKFILL DEPTH AGAINST THE 10'–0" PIT WALL
   G. REFER TO ENGINEER SPECIFICATIONS FOR ADDITIONAL CONCRETE CONSTRUCTION REQUIREMENTS

2. REINFORCING STEEL: ***(UNLESS OTHERWISE NOTED)***
   A. ALL REBAR GRADE 60
   B. LAP ALL REINFORCING BAR SPLICES A MIN. OF 40 DIAMETERS
   C. PROVIDE BENT BARS AT ALL CORNERS AND WALL INTERSECTIONS TO MATCH THE HORIZONTAL REINFORCING STEEL (SEE DETAILS)
   D. EXTERIOR WALL FOOTING: THREE RUNS OF CONTINUOUS #4 HORIZONTAL REBAR
   E. COLUMN: SIX RUNS #6 VERTICAL REBAR
      HORIZONTAL #3 GRADE 40 SQUARE TIES @ 10" O.C.
   F. 14" COLUMN: SIX RUNS #7 VERTICAL REBAR
      HORIZONTAL #3 GRADE 40 SQUARE TIES @ 10" O.C.
   G. PIT FLOORS: #4 REBAR @ 18" O.C. BOTH WAYS
      BENEATH COLUMNS 3 – #4 REBAR BOTH WAYS
   H. EXTERIOR PIT WALLS: #5 VERTICAL REBAR @ 12" O.C.
      #5 HORIZONTAL REBAR @ 15" O.C.
   I. PUMPOUT PIT WALLS: #5 VERTICAL REBAR @ 7" O.C.
      #5 HORIZONTAL REBAR @ 17" O.C.
   J. CENTER PIT WALL: #5 VERTICAL REBAR @ 10" O.C. DOUBLE MAT
      #5 HORIZONTAL REBAR @ 12" O.C. DOUBLE MAT
   K. 1' DIVIDER PIT WALL: #5 VERTICAL REBAR @ 12" O.C. (EACH SIDE)
      #5 HORIZONTAL REBAR @ 15" O.C. (ALTERNATE SIDES)
   L. 4' STEM WALL WITH PIT WALL: #5 VERTICAL REBAR @ 12"O.C.
      #4 HORIZONTAL REBAR @ 12" O.C
   M. 4' STEM WALL ON FLOOR: #4 VERTICAL REBAR @ 12"O.C.
      #4 HORIZONTAL REBAR @ 12" O.C
   N. 6"X6" STEM WALL: 2–#4 CONTINUOUS REBAR

3. COLD JOINTS (UNLESS OTHERWISE NOTED)
   A. WALLS (SEE DETAIL)
   B. PIT SLAB (SEE DETAIL)

4. CONTROL JOINTS (UNLESS OTHERWISE NOTED)
   A. WALLS (NONE)
   B. PIT SLAB (NONE)

5. MISC. (UNLESS OTHERWISE NOTED)
   A. KEYWAY TO BE USED ON ALL PIT SLAB/PIT WALL JOINTS (SEE DETAILS)
   B. WATERSTOP TO BE USED ON ALL EXTERIOR PIT SLAB/PIT WALL JOINTS (SEE DETAILS)
   C. LINTEL KNOCKOUT ROUGH OPENINGS: 10" W x 10" H x 2" D
   D. FIELD VERIFY LOCATION OF FRESH WATER PIPE KNOCKOUT: R.O. 6" DIA.

GENERAL NOTES

N

SCALE, FEET
0 25 50 75 100

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

REGISTERED PROFESSIONAL ENGINEER
NORTH DAKOTA
NATHAN A. PESTA
PE-6254
DATE 11/17/15

No.	Revision/Issue	Date
1	Gestation: Fans/Pits	11/17/15

DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
PO Box 522 | Mandan, ND | 58554

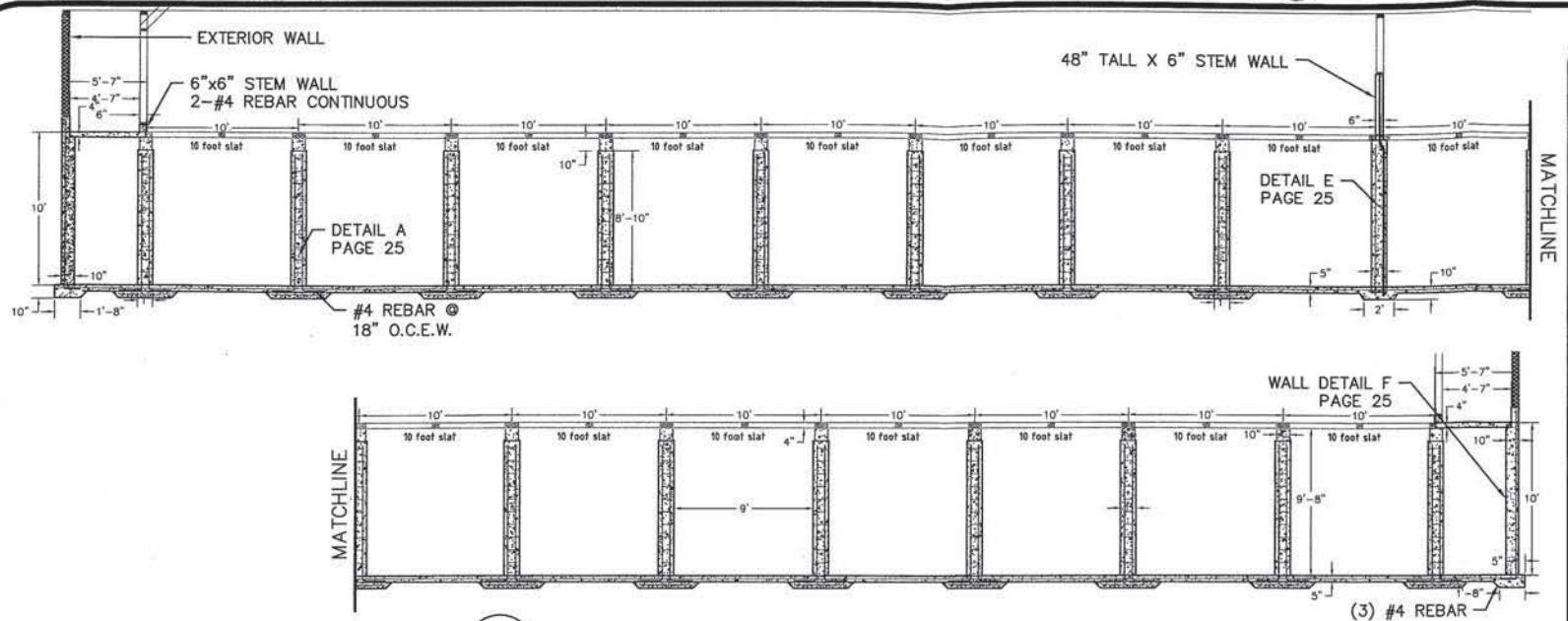
ROLLING GREEN FAMILY FARMS RE, LLP
NW 1/4, SECTION 4, T 159 N, R 54 W
CASS COUNTY, ND

GESTATION BARN FOUNDATION PLAN

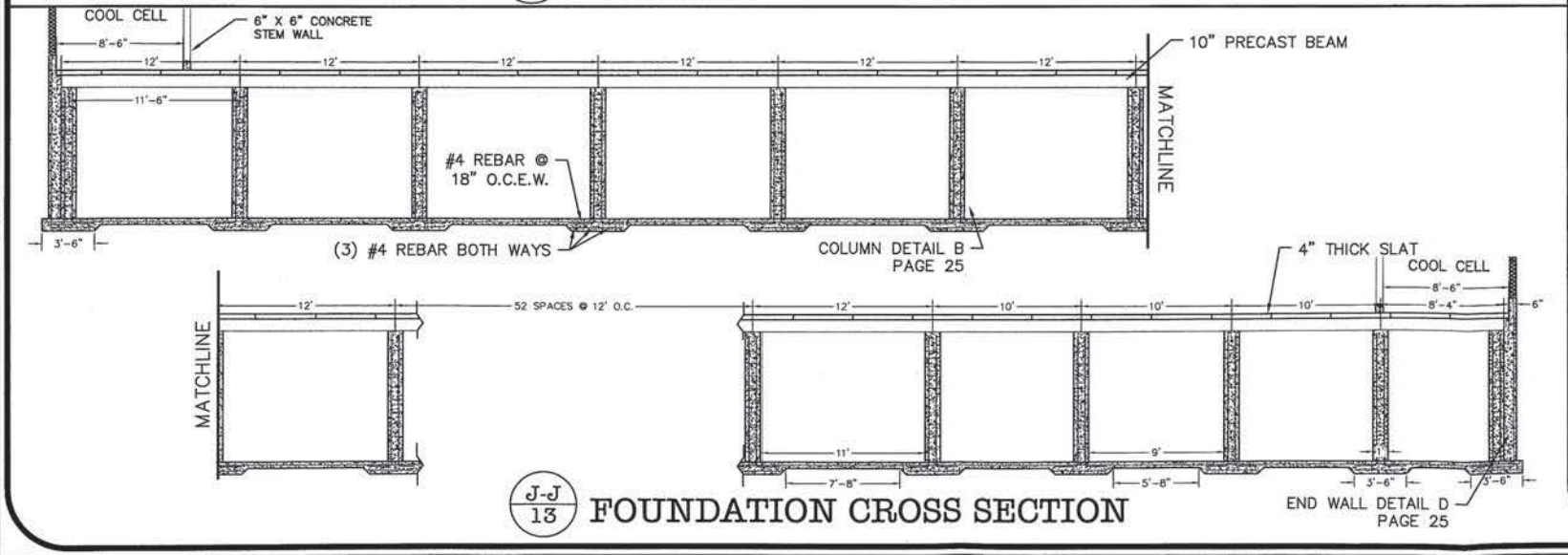
DATE: AUG 10, 2015
SCALE: 1" = 50'
DRAWN BY: DDR
CHECKED BY: NAP
SHEET: 13

FILE NAME: NO PROJECT FILES/PWNG/ROLLING GREEN/CFILES/PLAN

000018



I-I / 13 FOUNDATION CROSS SECTION



J-J / 13 FOUNDATION CROSS SECTION

GENERAL NOTES

SCALE, FEET
0 4 8 12 16

REGISTERED PROFESSIONAL ENGINEER
NATHAN A. PESTA
PE-6254
DATE 2/1/15
NORTH DAKOTA

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

No.	Revision/Issue	Date
1	Section I: Fan Bank	11/17/15

DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
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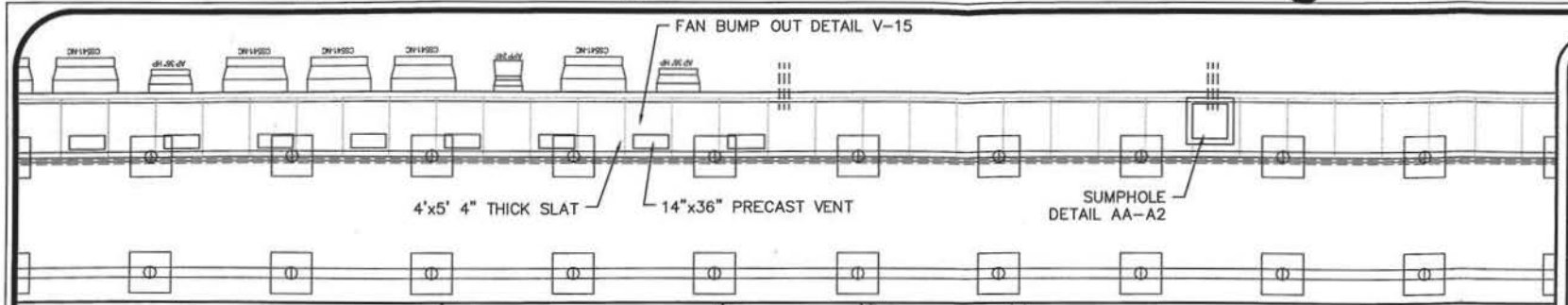
ROLLING GREEN FAMILY FARMS RE, LLP

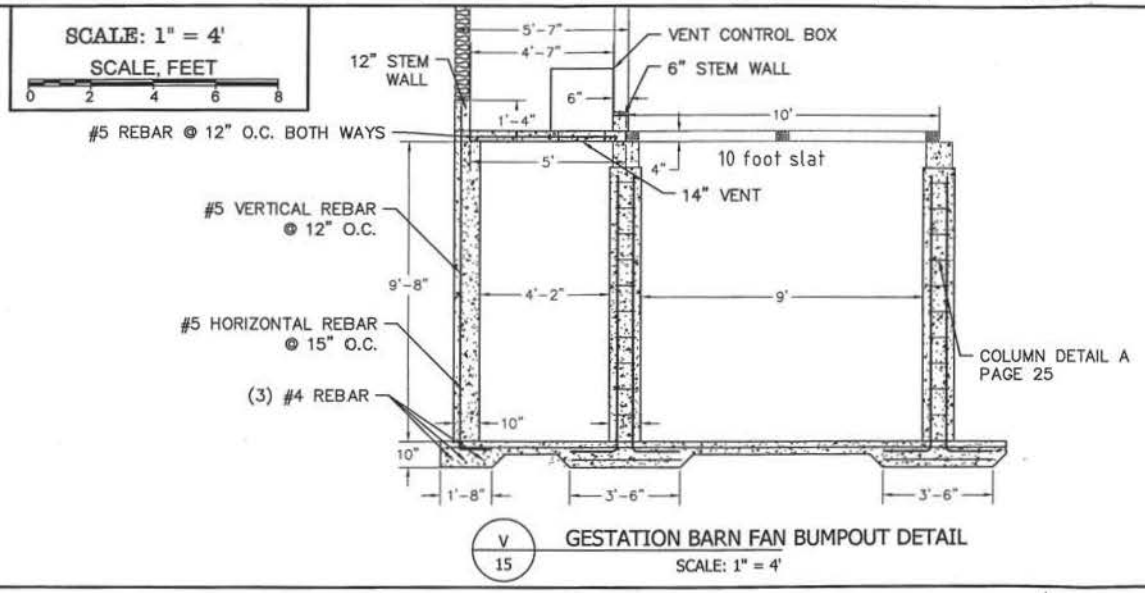
NW 1/4, SECTION 4, T 139 N, R 54 W
CASS COUNTY, ND

GESTATION BARN
CROSS SECTIONS

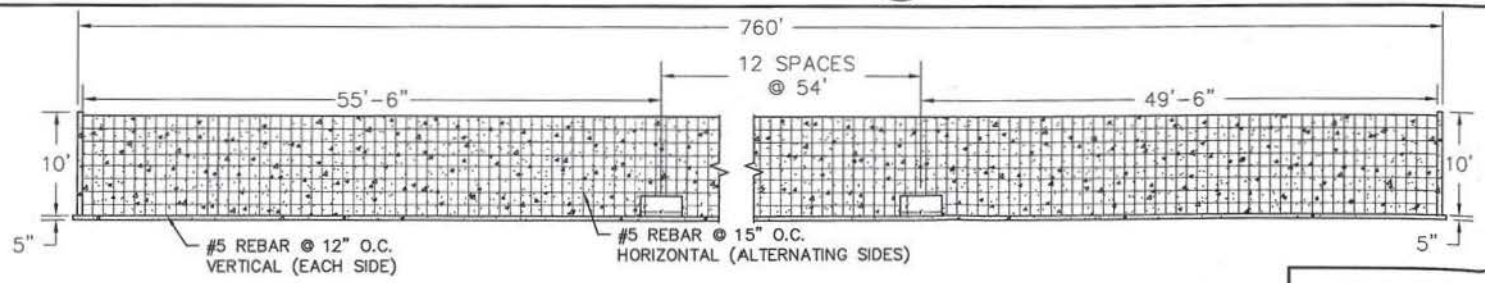
DATE: AUG 11, 2015	SHEET: 14
SCALE: 1" = 8'	
DRAWN BY: DDR	
CHECKED BY: NAP	

FILE NAME: ND PROJECT FILES/SWINE/ROLLING GREEN/CFILES/PLAN





V / 15 GESTATION BARN FAN BUMPOUT DETAIL
SCALE: 1" = 4'



GESTATION BARN DIVIDER WALL SECTION

SCALE: 1" = 12'
SCALE, FEET
0 6 12 18 24

GENERAL NOTES

REGISTERED PROFESSIONAL ENGINEER
NATHAN A. PESTA
PE-6254
DATE 12/14/15
NORTH DAKOTA

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

No.	Revision/Issue	Date
1	FAN EMBANKMENT	12/03/15

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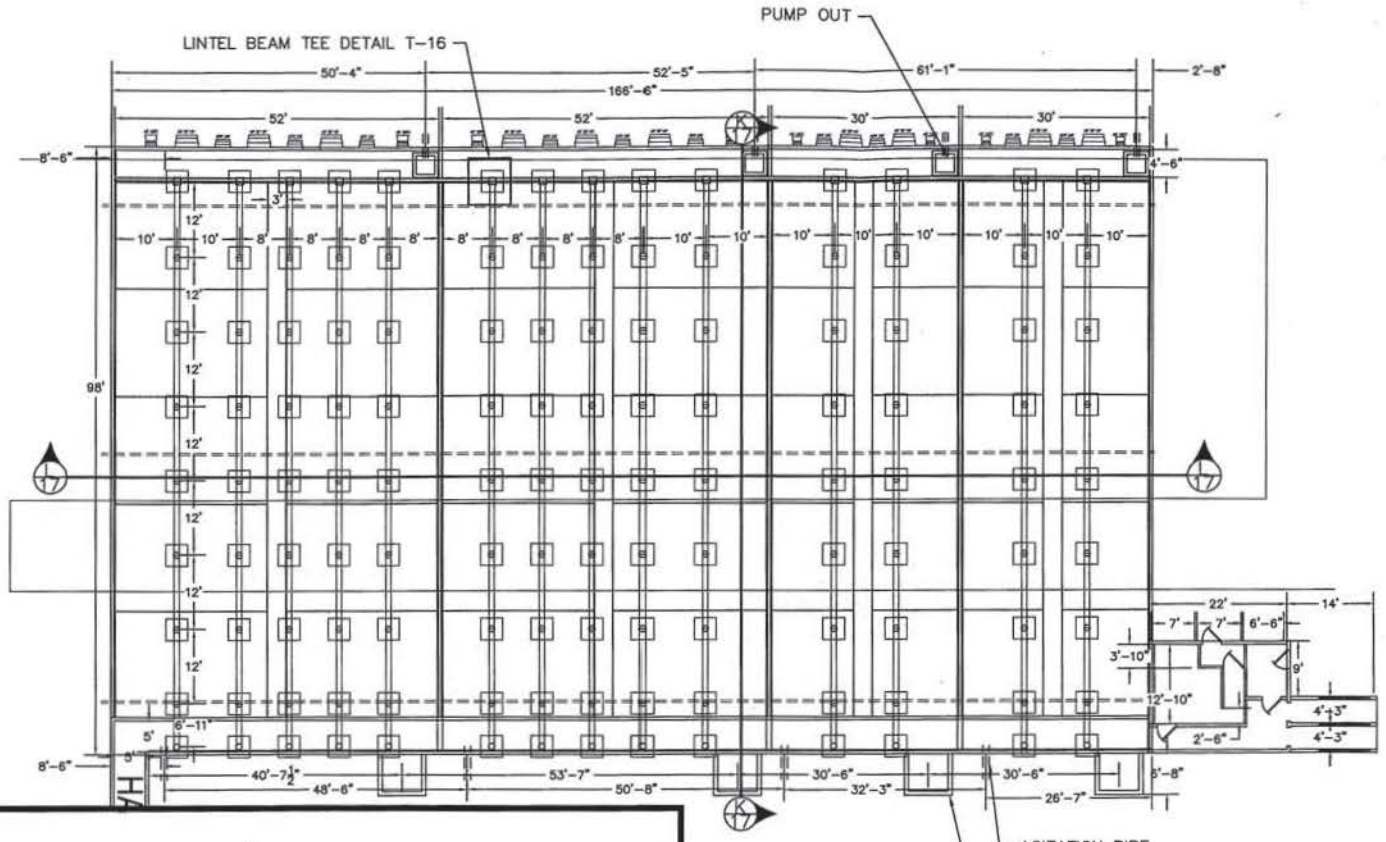
ROLLING GREEN FAMILY FARMS RE, LLP

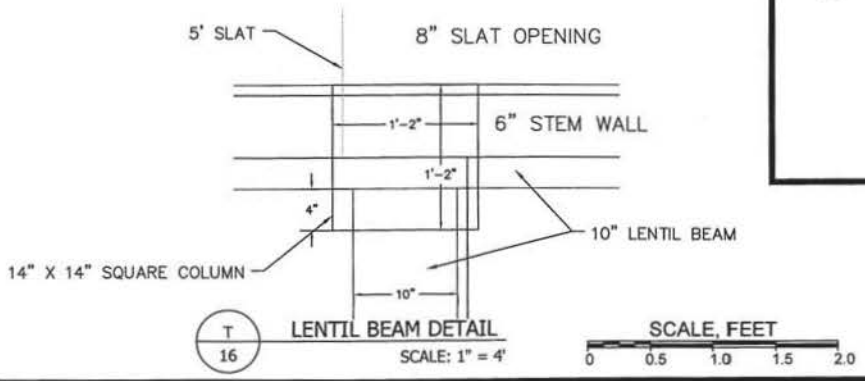
NW 1/4, SECTION 4, T 139 N, R 54 W
CASS COUNTY, ND

GESTATION BARN CONCRETE DETAILS

DATE: AUG 11, 2015	SHEET: 15
SCALE: AS SHOWN	
DRAWN BY: DDR	
CHECKED BY: NAP	

FILE NAME: ND PROJECT FILES/SWINE/ROLLING GREEN/CFILES/PLAN





GENERAL NOTES

SCALE, FEET
0 10 20 30 40

REGISTERED PROFESSIONAL ENGINEER
NATHAN A. PESTA
PE-6254
DATE 2/10/15
NORTH DAKOTA

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

No.	Revision/Issue	Date
1	BARN WIDTH	12/03/15

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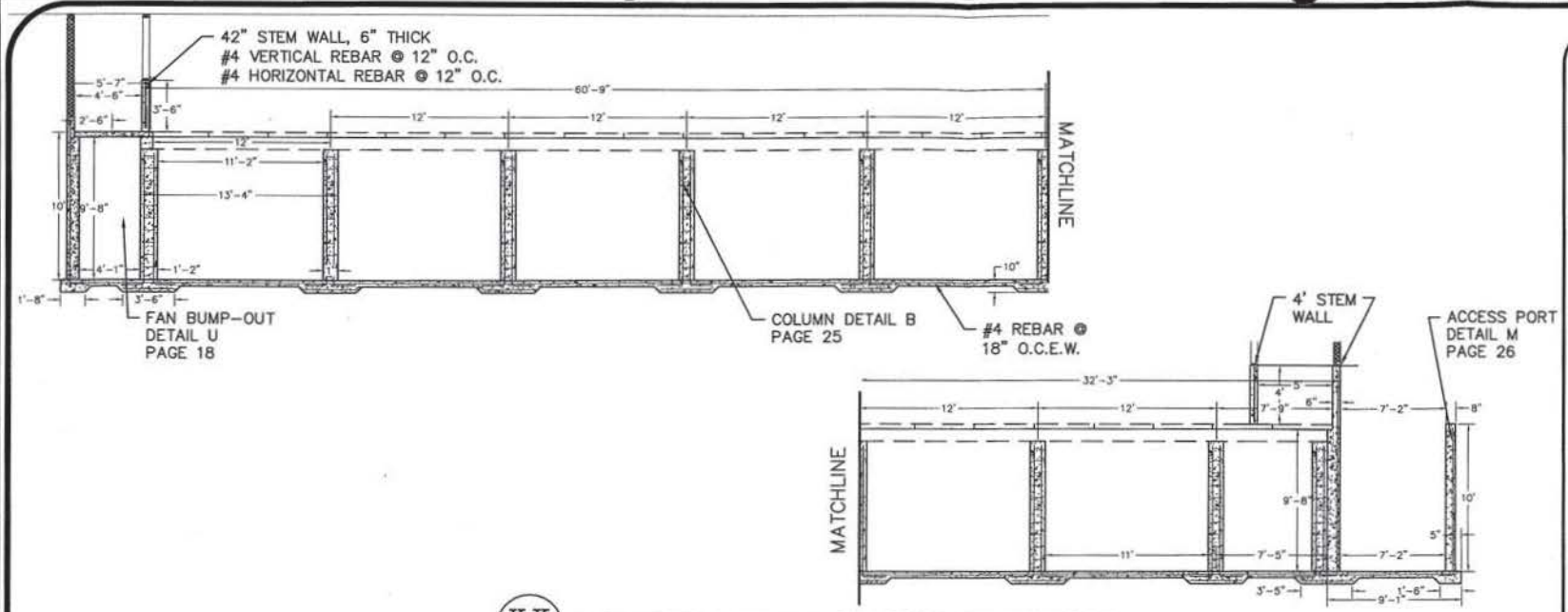
ROLLING GREEN FAMILY FARMS RE, LLP

NW 1/4, SECTION 4, T 139 N, R 54 W
CASS COUNTY, ND

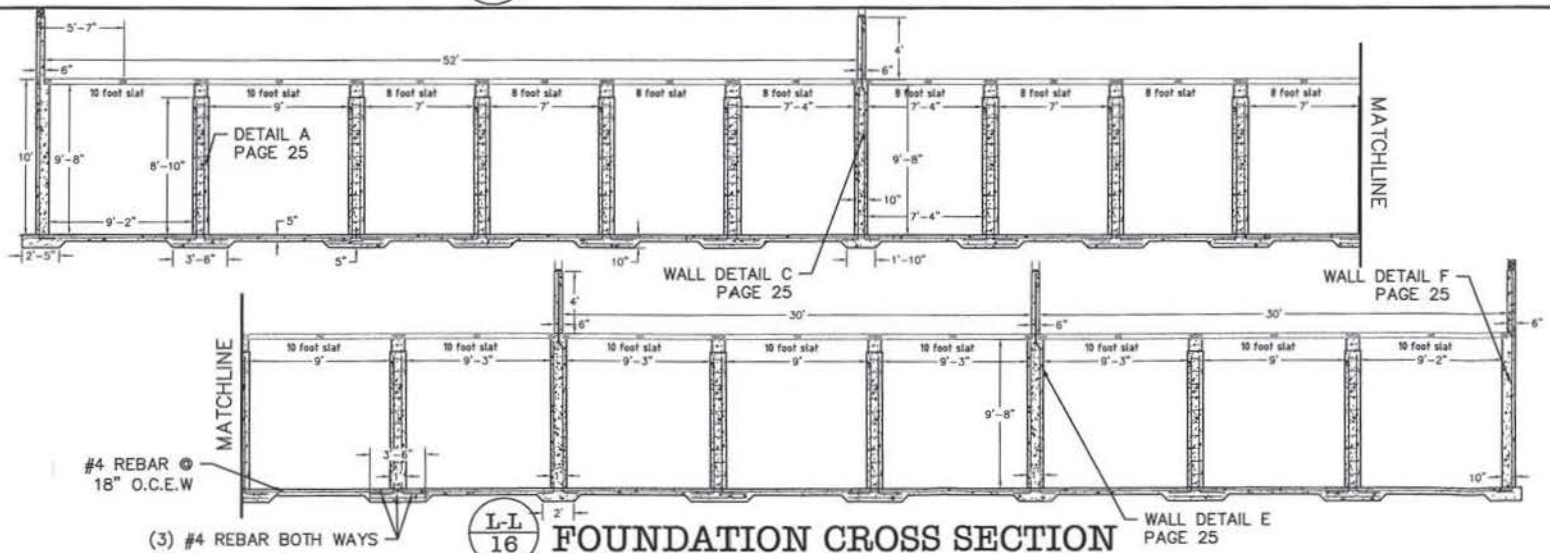
GDU BARN
FOUNDATION DETAILS

DATE: AUG 11, 2015	SHEET: 16
SCALE: AS SHOWN	
DRAWN BY: DDR	
CHECKED BY: NAP	

FILE NAME: ND PROJECT FILES/SWINE/ROLLING GREEN/CFILES/PLAN



K-K / 16 FOUNDATION CROSS SECTION



L-L / 16 FOUNDATION CROSS SECTION

GENERAL NOTES

SCALE, FEET
0 4 8 12 16

REGISTERED PROFESSIONAL ENGINEER
NATHAN A. PESTA
PE-6254
DATE 2/10/15
NORTH DAKOTA

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

No.	Revision/Issue	Date
1	Fan Bank, Lintel Beam	11/24/15

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Consulting Engineers
PO Box 522 | Mandan, ND | 58554

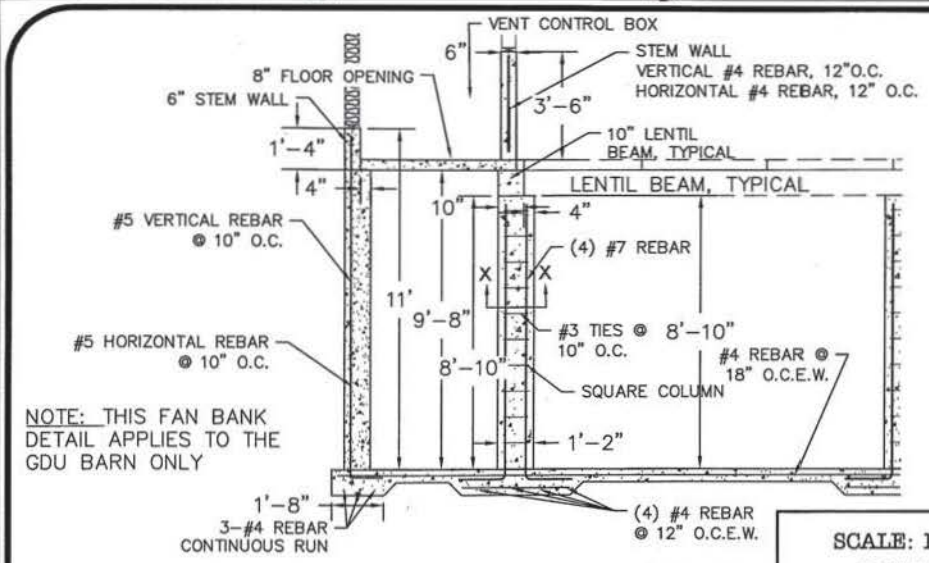
ROLLING GREEN FAMILY FARMS RE, LLP

NW 1/4, SECTION 4, T 139 N, R 54 W
CASS COUNTY, ND

GDU BARN
CROSS SECTIONS

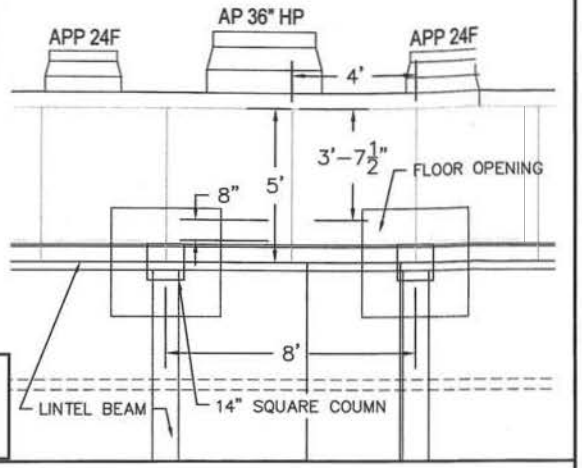
DATE: AUG 11, 2015	SHEET: 17
SCALE: 1" = 8'	
DRAWN BY: DDR	
CHECKED BY: NAP	

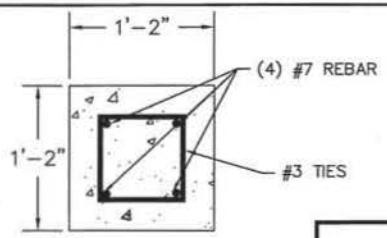
FILE NAME: ND PROJECT FILES/DWNE/ROLLING GREEN/CFILES/PLAN



FAN BUMP OUT DETAIL U

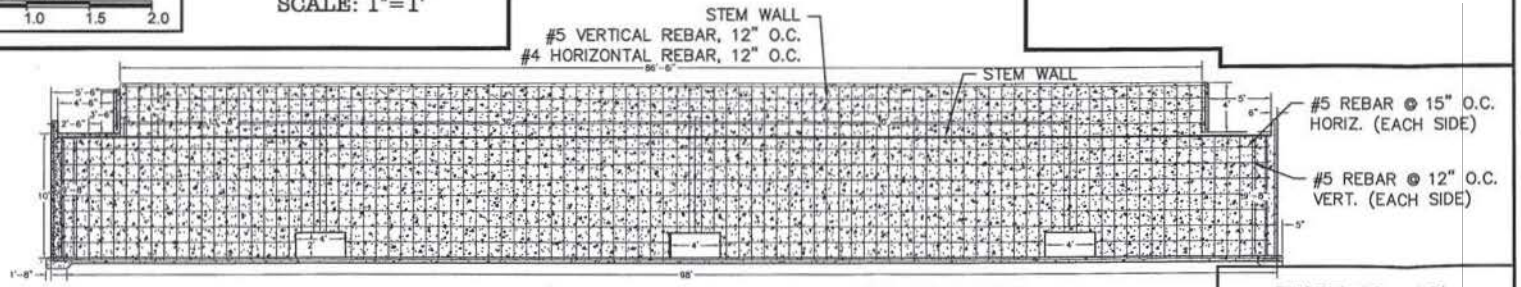
SCALE: 1" = 4'
SCALE, FEET
0 2 4 6 8





SCALE: 1" = 1'
SCALE, FEET
0 0.5 1.0 1.5 2.0

COLUMN DETAIL X-X
SCALE: 1"=1'



GDU BARN 10" DIVIDER WALL SECTION

SCALE: 1" = 10'
SCALE, FEET
0 5 10 15 20

GENERAL NOTES

REGISTERED PROFESSIONAL ENGINEER
NATHAN A. PESTA
PE-6254
DATE 12/10/15
NORTH DAKOTA

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

No.	Revision/Issue	Date
1	SLATS	12/03/15

DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
PO Box 522 | Mandan, ND | 58554

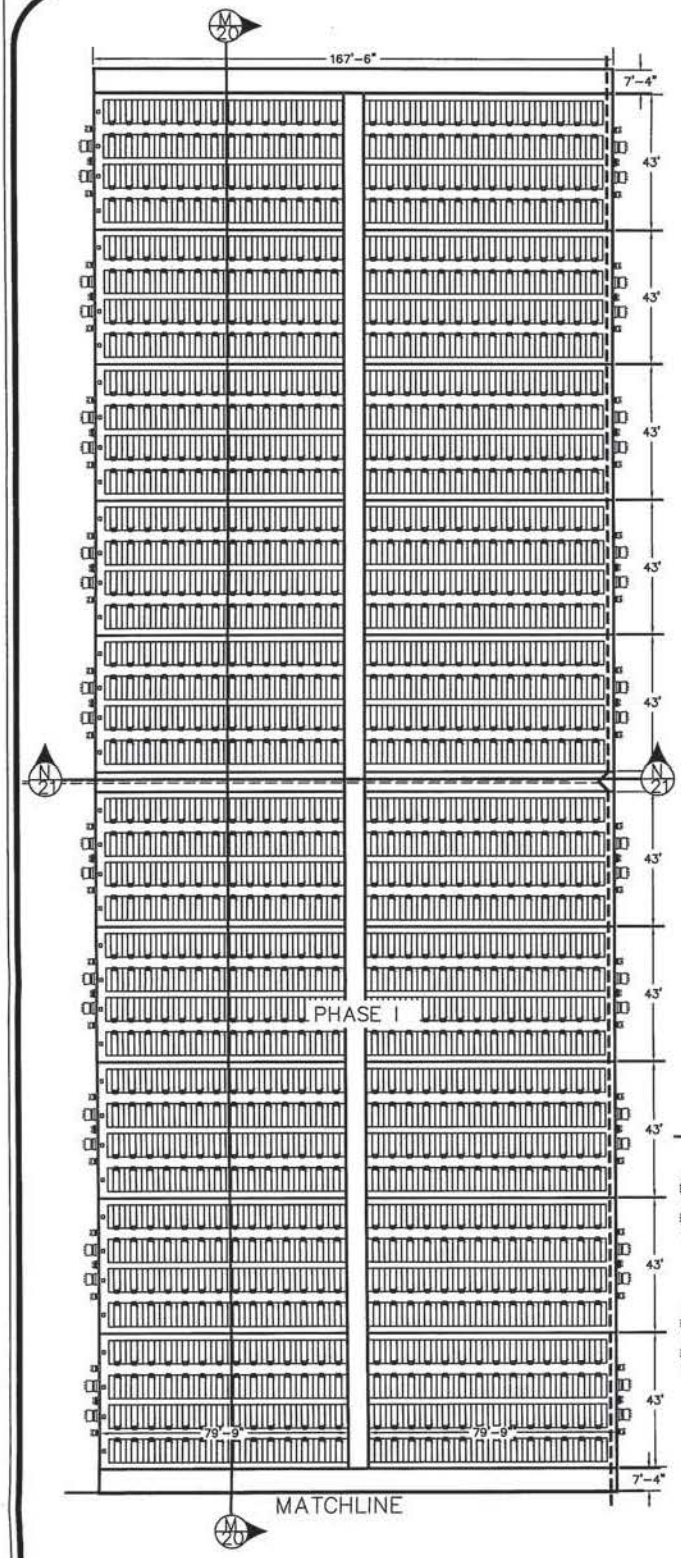
ROLLING GREEN FAMILY FARMS RE, LLP

NW 1/4, SECTION 4, T 139 N, R 54 W
CASS COUNTY, ND

GDU BARN
CONCRETE DETAILS

DATE: AUG 11, 2015	SHEET: 18
SCALE: AS SHOWN	
DRAWN BY: DDR	
CHECKED BY: NAP	

FILE NAME: ND PROJECT FILES/SWINE/ROLLING GREEN/CFILES/PLAN



FARROWING BARN CONCRETE DETAILS

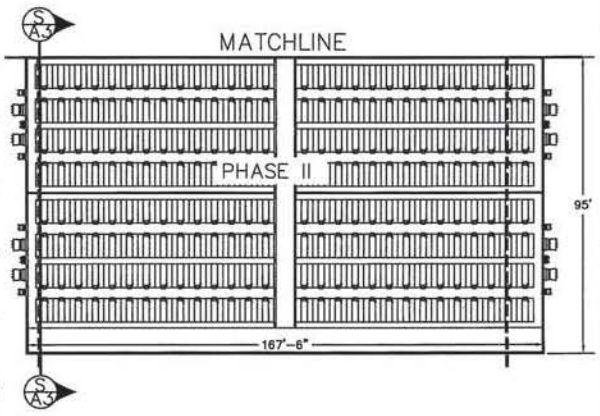
1. CONCRETE: ***(UNLESS OTHERWISE NOTED)***
   - A. CONCRETE COLUMNS, WALLS, FLOORS, BEAMS, FOOTINGS: 4000 PSI MINIMUM 28 DAY STRENGTH
   - c. ALL CONCRETE TO BE AIR ENTRAINED
   - D. 3"-4" CONCRETE SLUMP ON HORIZONTAL POURS PRIOR TO ADDITIVES
   - E. 5" MAXIMUM CONCRETE SLUMP ON VERTICAL POURS PRIOR TO ADDITIVES
   - F. PIT WALL CONCRETE DESIGN BASED OFF OF A 1'-6" BACKFILL DEPTH AGAINST THE 2'-0" PIT WALL
   - G. REFER TO ENGINEER SPECIFICATIONS FOR ADDITIONAL CONCRETE CONSTRUCTION REQUIREMENTS

2. REINFORCING STEEL: ***(UNLESS OTHERWISE NOTED)***
   - A. ALL REBAR GRADE 60
   - B. LAP ALL REINFORCING BAR SPLICES A MIN. OF 40 DIAMETERS
   - C. PROVIDE BENT BARS AT ALL CORNERS AND WALL INTERSECTIONS TO MATCH THE HORIZONTAL REINFORCING STEEL (SEE DETAILS)
   - D. EXTERIOR WALL FOOTING: TWO RUNS OF CONTINUOUS #4 HORIZONTAL REBAR
   - E. PIT FLOORS: #4 REBAR @ 18" O.C. BOTH WAYS
   - F. 3' AND 2' WALKWAY FLOORS: #4 REBAR @ 16" O.C. AND #4 REBAR @ 12" O.C.
   - G. 4' WALKWAY FLOORS: #5 REBAR @ 14" O.C. AND #4 REBAR @ 16" O.C.
   - H. EXTERIOR PIT WALLS: #4 VERTICAL REBAR @ 12" O.C. #4 HORIZONTAL REBAR @ 12" O.C.
   - I. INTERIOR PIT WALLS: #4 HORIZONTAL REBAR @12" O.C. #4 VERTICAL REBAR @ 16" O.C.
   - J. STEM WALLS: #4 HORIZONTAL REBAR @12" O.C. #4 VERTICAL REBAR @ 12" O.C.

3. COLD JOINTS (UNLESS OTHERWISE NOTED)
   - A. WALLS (SEE DETAIL)
   - B. PIT SLAB (SEE DETAIL)

4. CONTROL JOINTS (UNLESS OTHERWISE NOTED)
   - A. WALLS (NONE)
   - B. PIT SLAB (NONE)

5. MISC. (UNLESS OTHERWISE NOTED)
   - A. KEYWAY TO BE USED ON ALL PIT SLAB/PIT WALL JOINTS (SEE DETAILS)
   - B. WATERSTOP TO BE USED ON ALL EXTERIOR PIT SLAB/PIT WALL JOINTS (SEE DETAILS)
   - C. FIELD VERIFY LOCATION OF FRESH WATER PIPE KNOCKOUT: R.O. 6" DIA.



GENERAL NOTES

SCALE, FEET
0 20 40 60 80

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

REGISTERED PROFESSIONAL ENGINEER
NATHAN A. PESTA
PE-6254
DATE 12/10/15
NORTH DAKOTA

No.	Revision/Issue	Date
1	STEM WALLS	12/03/15

DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
PO Box 522 | Mandan, ND | 58554

ROLLING GREEN FAMILY FARMS RE, LLP

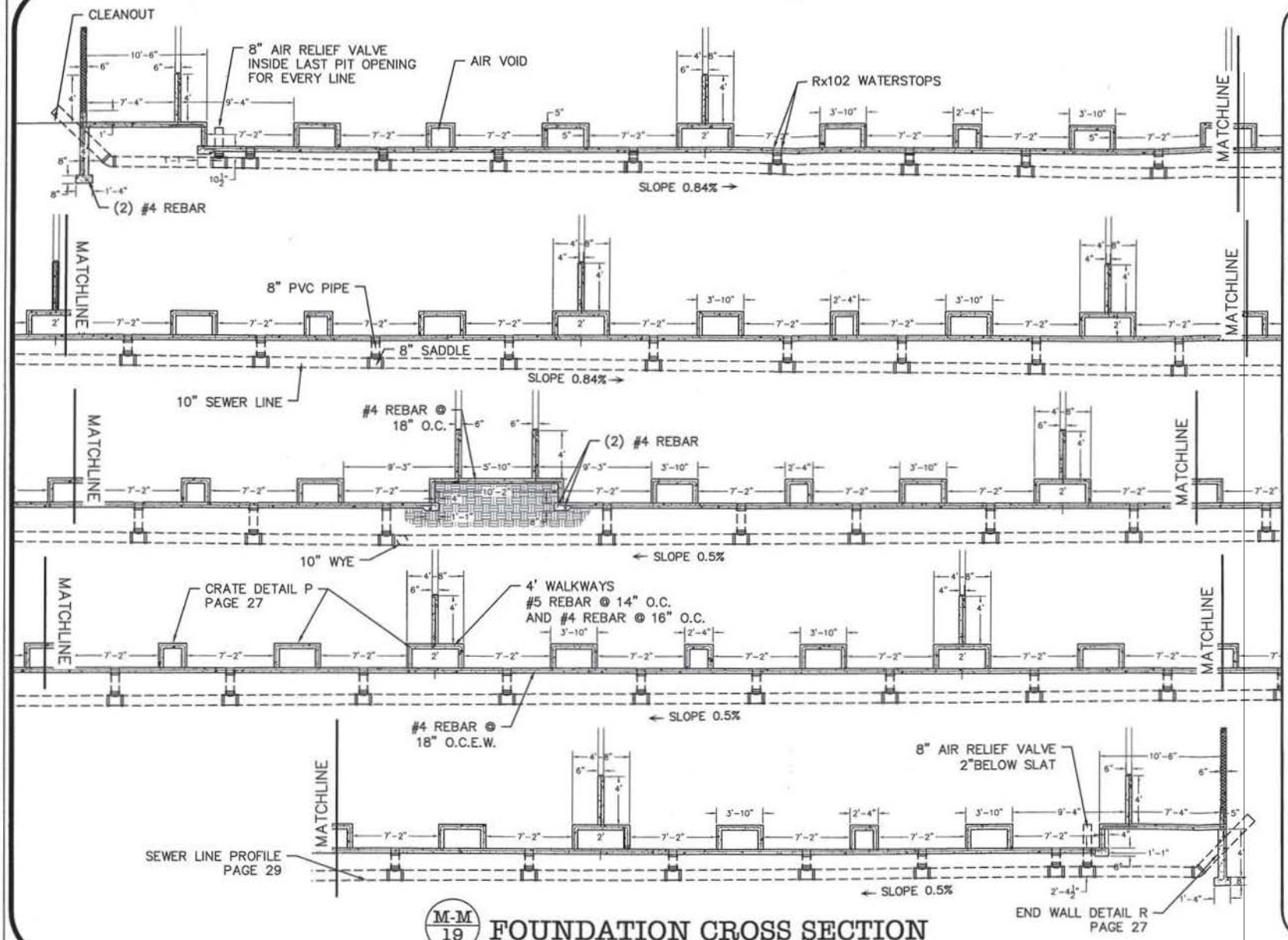
NW 1/4, SECTION 4, T 139 N, R 84 W
CASS COUNTY, ND

FARROWING BARN PHASE I
FOUNDATION PLAN

DATE: AUG 11, 2015
SCALE: 1" = 40'
DRAWN BY: DDR
CHECKED BY: NAP
SHEET: 19

FILE NAME: NO PROJECT FILES/SWINE/ROLLING GREEN/CFILES/PLAN

0000024



M-M 19 **FOUNDATION CROSS SECTION**

GENERAL NOTES

SCALE, FEET
0 4 8 12 16

REGISTERED PROFESSIONAL ENGINEER
NATHAN A. PESTA
PE-6254
DATE 12/10/15
NORTH DAKOTA

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

No.	Revision/Issue	Date
1	SEWER LINE	12/03/15

DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
PO Box 522 | Mandan, ND | 58554

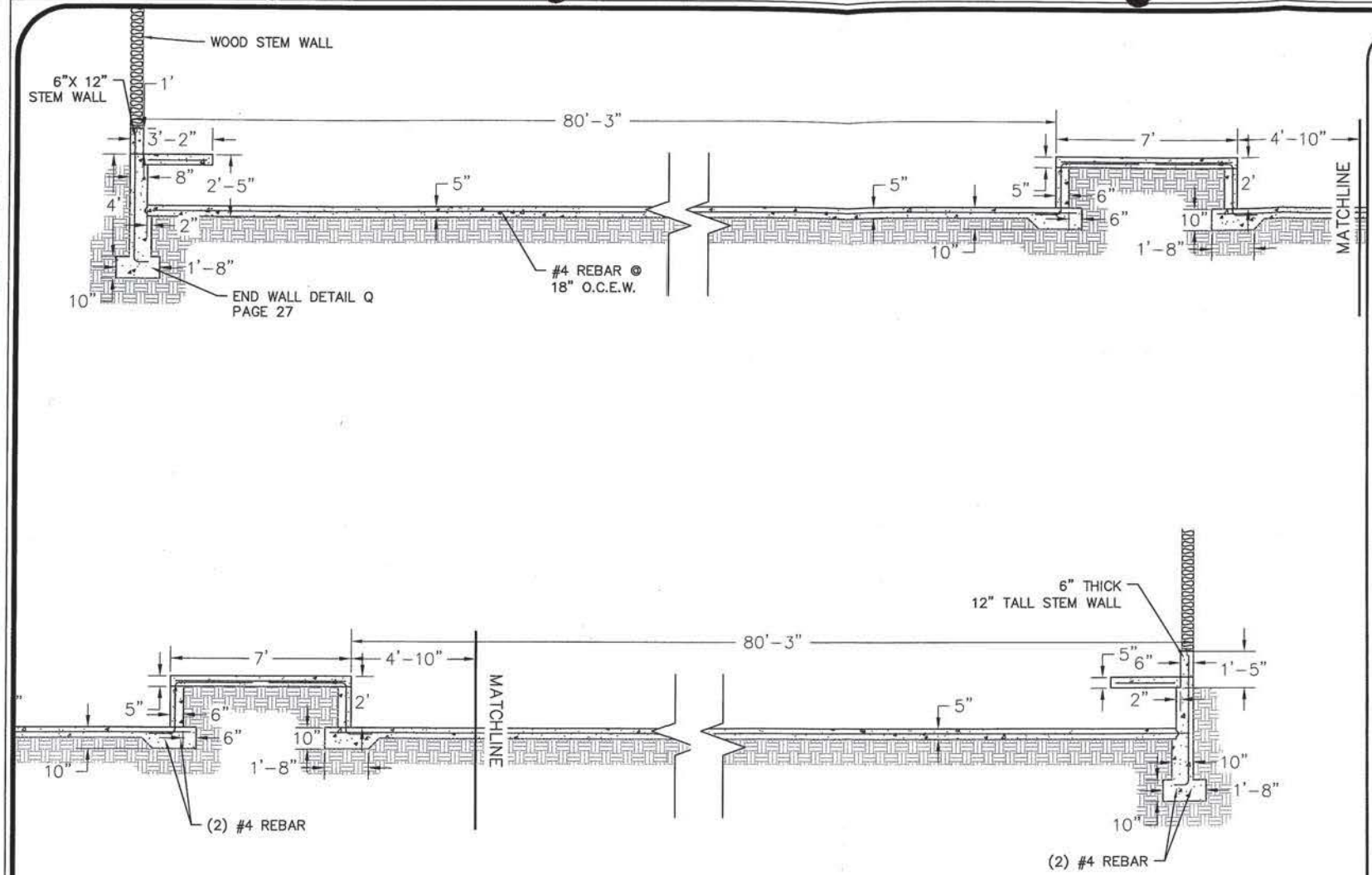
ROLLING GREEN FAMILY FARMS RE, LLP

NW 1/4, SECTION 4, T 139 N, R 54 W
CASS COUNTY, ND

FARROWING BARN PHASE I CROSS SECTION

DATE: AUG 12, 2015	SHEET: 20
SCALE: 1" = 8'	
DRAWN BY: DDR	
CHECKED BY: NAP	

FILE NAME: ND PROJECT FILES/SWINE/ROLLING GREEN/CFILES/PLAN



N-N / 19 FOUNDATION CROSS SECTION

GENERAL NOTES

SCALE, FEET
0 2 4 6 8

REGISTERED PROFESSIONAL ENGINEER
NATHAN A. PESTA
PE-6254
DATE 12/10/15
NORTH DAKOTA

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

No.	Revision/Issue	Date
1	SEWER LINE	12/03/15

DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
PO Box 522 | Mandan, ND | 58554

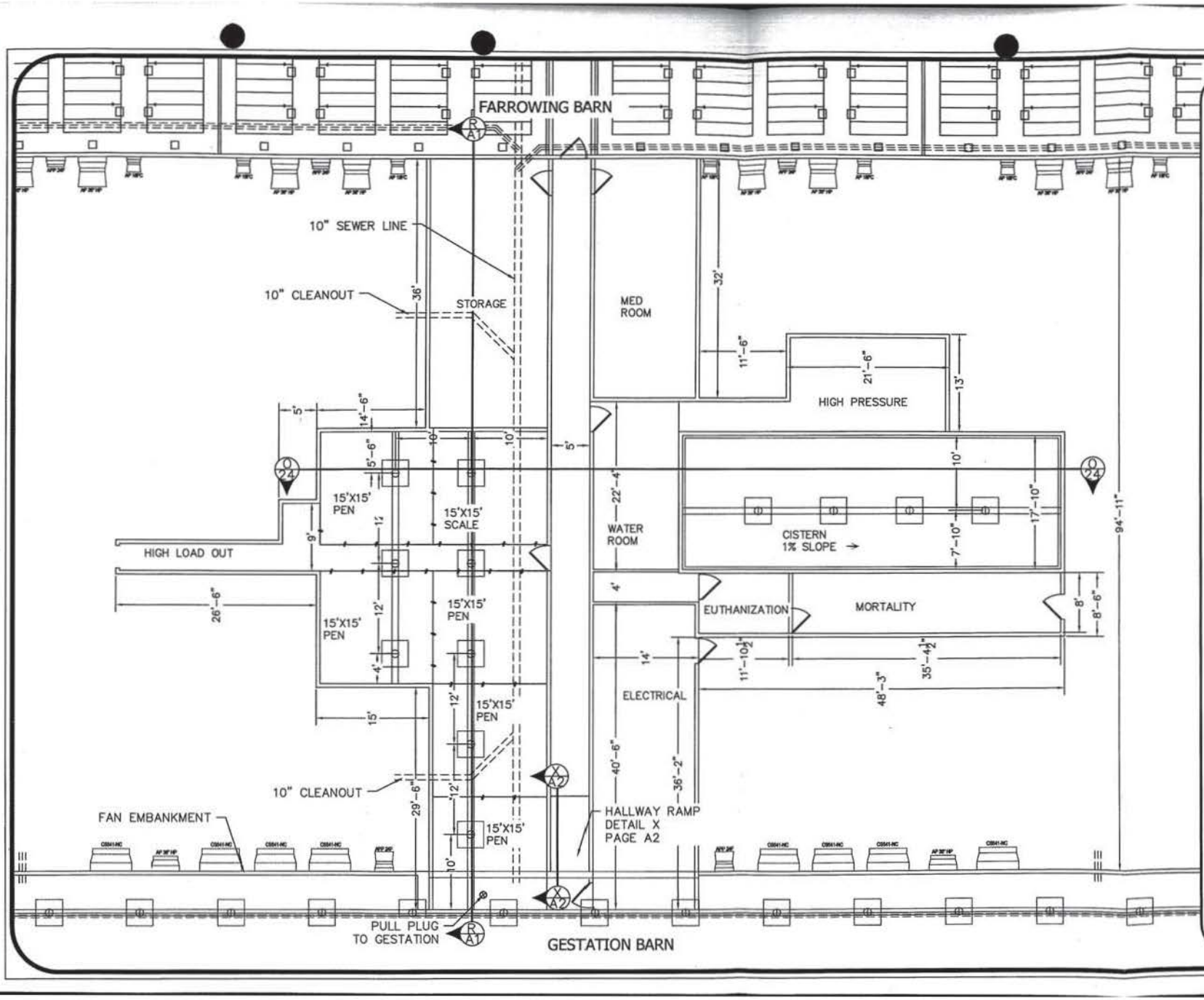
ROLLING GREEN FAMILY FARMS RE, LLP

NW 1/4, SECTION 4, T 139 N, R 54 W
CASS COUNTY, ND

FARROWING BARN
CROSS SECTION

DATE: DEC 2, 2015	SHEET: 21
SCALE: 1" = 4'	
DRAWN BY: DDR	
CHECKED BY: NAP	

FILE NAME: ND PROJECT FILES/SWINE/ROLLING GREEN/CFILES/PLAN



GENERAL NOTES

SCALE, FEET
0 6 12 18 24

REGISTERED PROFESSIONAL ENGINEER
NATHAN A. PESTA
PE-6254
DATE 12/16/15
NORTH DAKOTA

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

No.	Revision/Issue	Date
1	Hallway Details	11/30/15

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Consulting Engineers
PO Box 522 | Mandan, ND | 58554

ROLLING GREEN FAMILY FARMS RE, LLP

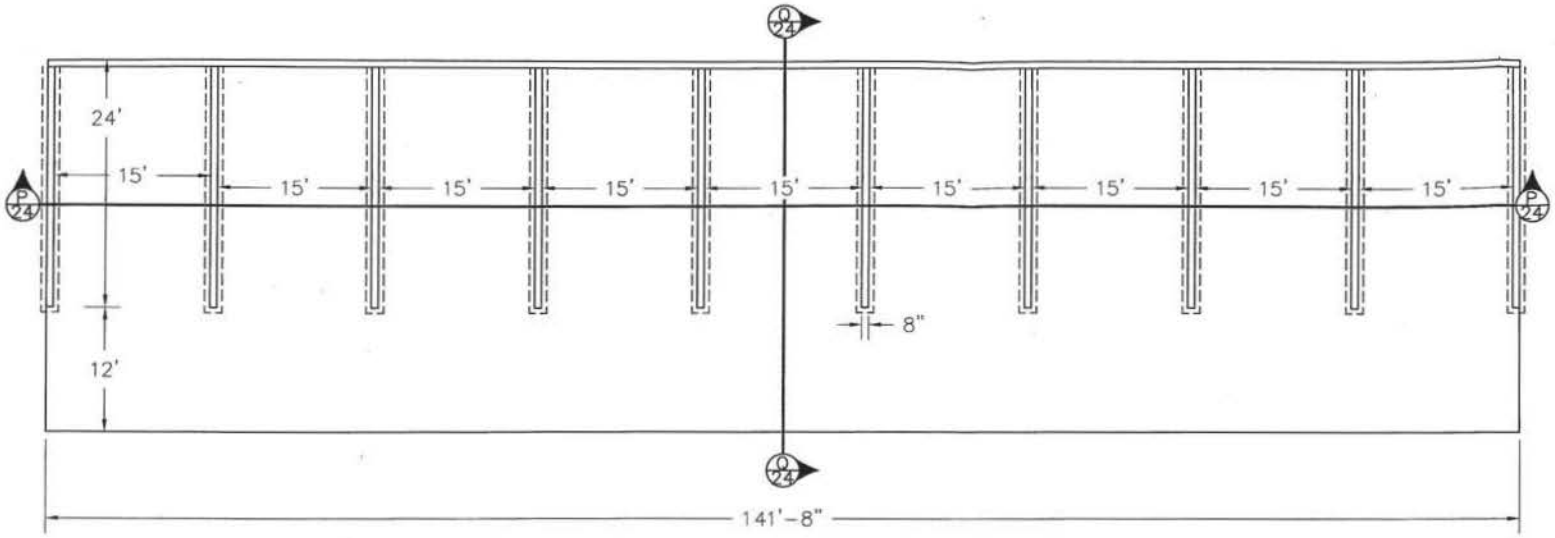
NW 1/4, SECTION 4, T 139 N, R 54 W
CASS COUNTY, ND

CONNECTOR HALLWAY FOUNDATION DETAILS

DATE: DEC 2, 2015	SHEET: 22
SCALE: 1" = 12'	
DRAWN BY: DDR	
CHECKED BY: NAP	

FILE NAME: ND PROJECT FILES/SWINE/ROLLING GREEN/CFILES/PLAN

000027



1. CONCRETE: ***(UNLESS OTHERWISE NOTED)***
   - A. CONCRETE WALLS, FLOORS: 4000 PSI MINIMUM 28 DAY STRENGTH
   - B. CONCRETE FOOTINGS: 4000 PSI MINIMUM 28 DAY STRENGTH
   - C. ALL CONCRETE TO BE AIR ENTRAINED
   - D. 3"–4" CONCRETE SLUMP ON HORIZONTAL POURS PRIOR TO ADDITIVES
   - E. 5" MAXIMUM CONCRETE SLUMP ON VERTICAL POURS PRIOR TO ADDITIVES
   - F. REFER TO ENGINEER SPECIFICATIONS FOR ADDITIONAL CONCRETE CONSTRUCTION REQUIREMENTS
2. REINFORCING STEEL: ***(UNLESS OTHERWISE NOTED)***
   - A. ALL REBAR GRADE 60
   - B. LAP ALL REINFORCING BAR SPLICES A MIN. OF 40 DIAMETERS
   - C. PROVIDE BENT BARS AT ALL CORNERS AND WALL INTERSECTIONS TO MATCH THE HORIZONTAL REINFORCING STEEL (SEE DETAILS)
   - D. EXTERIOR WALL FOOTING: #4 VERTICAL REBAR @ 7" O.C.
     #4 HORIZONTAL REBAR @ 12" O.C.
   - E. PIT FLOORS: #4 REBAR @ 18" O.C. BOTH WAYS
   - F. COMPOST WALLS: #4 VERTICAL REBAR @ 7" O.C.
     #4 HORIZONTAL REBAR @ 12" O.C.
3. COLD JOINTS (UNLESS OTHERWISE NOTED)
   - A. WALLS (SEE DETAIL)
   - B. PIT SLAB (SEE DETAIL)
4. CONTROL JOINTS (UNLESS OTHERWISE NOTED)
   - A. WALLS (NONE)
   - B. PIT SLAB (NONE)
5. MISC. (UNLESS OTHERWISE NOTED)
   - A. KEYWAY TO BE USED ON ALL PIT SLAB/PIT WALL JOINTS (SEE DETAILS)
   - B. WATERSTOP TO BE USED ON ALL EXTERIOR PIT SLAB/PIT WALL JOINTS (SEE DETAILS)
   - C. LINTEL KNOCKOUT ROUGH OPENINGS: 10" W x 10" H x 2" D
   - D. FIELD VERIFY LOCATION OF FRESH WATER PIPE KNOCKOUT: R.O. 6" DIA.

GENERAL NOTES

SCALE, FEET
0 6 12 18 24

REGISTERED PROFESSIONAL ENGINEER
NATHAN A. PESTA
PE-6254
DATE 2/16/15
NORTH DAKOTA

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

No.	Revision/Issue	Date
1	WIDTH	12/03/15

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Consulting Engineers
PO Box 522 | Mandan, ND | 58554

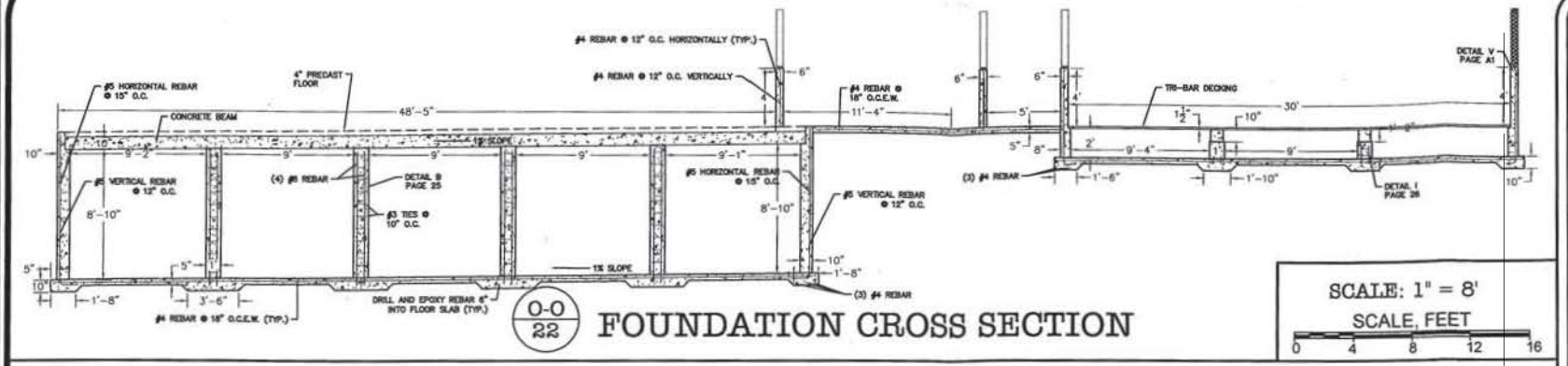
ROLLING GREEN FAMILY FARMS RE, LLP

NW 1/4, SECTION 4, T 139 N, R 54 W
CASS COUNTY, ND

COMPOST BARN FOUNDATION DETAILS

DATE: DEC 2, 2015	SHEET: 23
SCALE: 1" = 12'	
DRAWN BY: DDR	
CHECKED BY: NAP	

FILE NAME: N:\ PROJECT FILES\SWINE\ROLLING GREEN\CFILES\PLAN

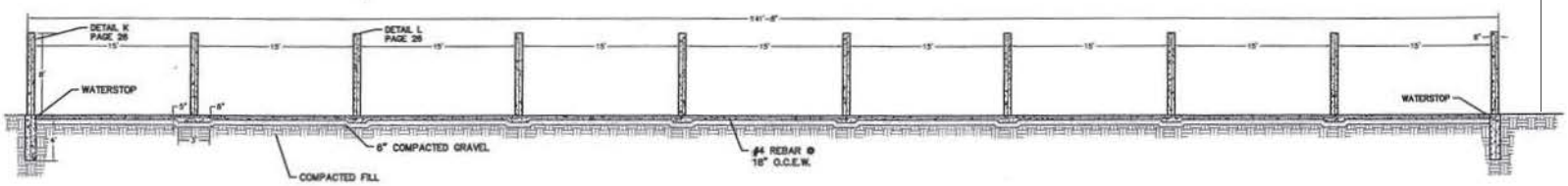


O-O / 22 FOUNDATION CROSS SECTION

SCALE: 1" = 8'

SCALE, FEET

0 4 8 12 16

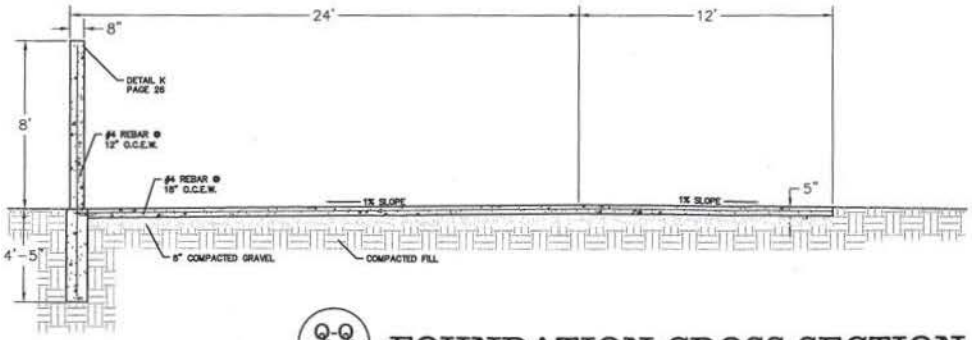


P-P / 23 FOUNDATION CROSS SECTION

SCALE: 1" = 12'

SCALE, FEET

0 6 12 18 24



Q-Q / 23 FOUNDATION CROSS SECTION

SCALE: 1" = 6'

SCALE, FEET

0 3 6 9 12

GENERAL NOTES

REGISTERED PROFESSIONAL ENGINEER
NATHAN A. PESTA
PE-6254
DATE 12/10/15
NORTH DAKOTA

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

No.	Revision/Issue	Date
1	O–O Cross Section	12/2/15

DEHAAN, GRABS & ASSOCIATES, LLC
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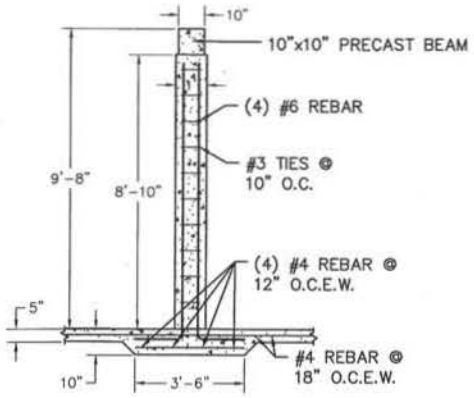
ROLLING GREEN FAMILY FARMS RE, LLP

NW 1/4, SECTION 4, T 139 N, R 54 W
CASS COUNTY, ND

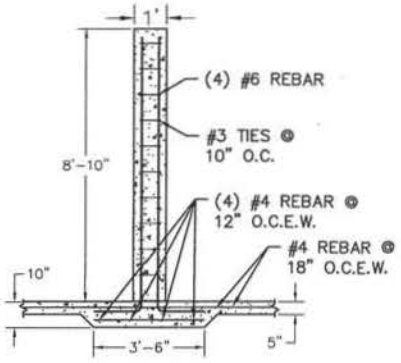
COMPOST & HALLWAY CROSS SECTIONS

DATE: AUG 17, 2015	SHEET: 24
SCALE: AS SHOWN	
DRAWN BY: DDR	
CHECKED BY: NAP	

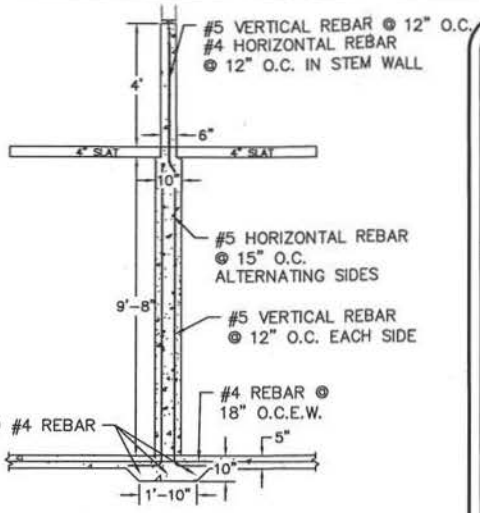
FILE NAME: ND PROJECT FILES/SWINE/ROLLING GREEN/CFILES/PLAN



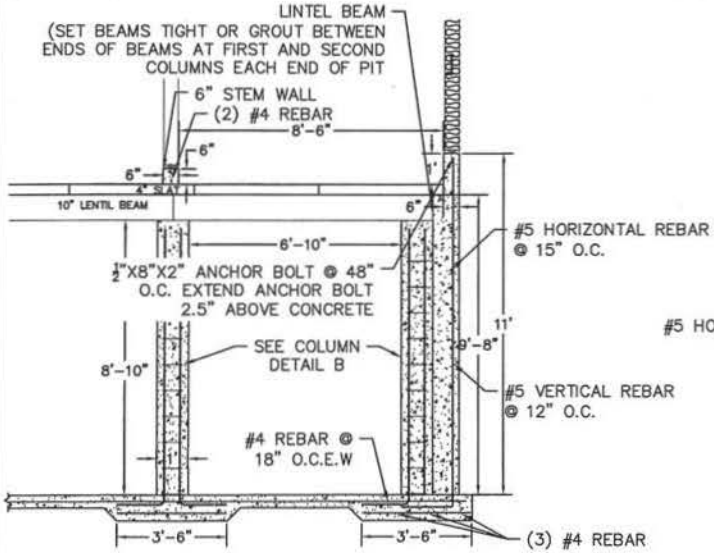
A 14,17 COLUMN DETAIL
SCALE: 1" = 4'



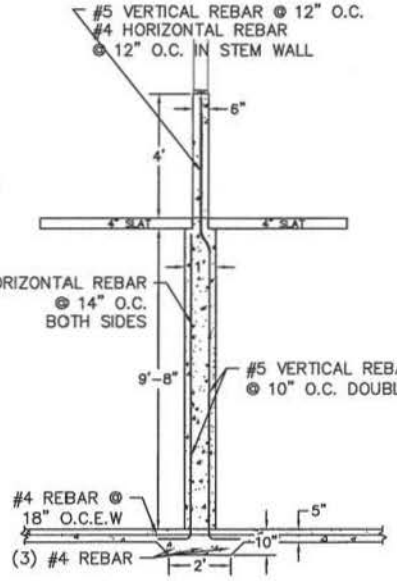
B 14,17 COLUMN DETAIL
SCALE: 1" = 4'



C 17 DIVIDER WALL DETAIL
SCALE: 1" = 4'



D 14 END WALL DETAIL
SCALE: 1" = 4'



E 14,17 DIVIDER WALL DETAIL
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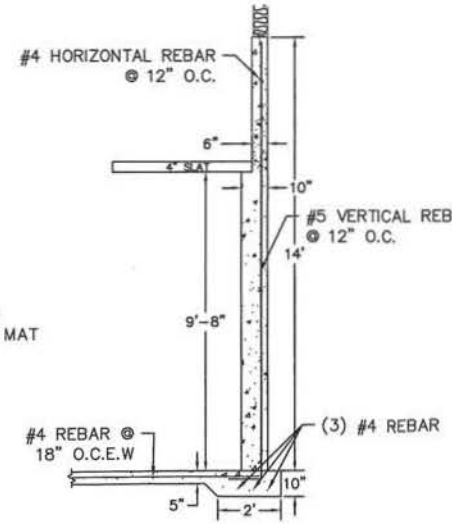

F 17 END WALL DETAIL
SCALE: 1" = 4'

GENERAL NOTES

SCALE, FEET
0 2 4 6 8

REGISTERED PROFESSIONAL ENGINEER
NATHAN A. PESTA
PE-6254
DATE 12/10/15
NORTH DAKOTA

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

No.	Revision/Issue	Date
1	Wall Detail C,E,F	12/1/15

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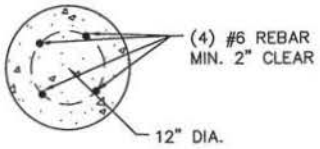
ROLLING GREEN FAMILY FARMS RE, LLP

NW 1/4, SECTION 4, T 139 N, R 84 W
CASS COUNTY, ND

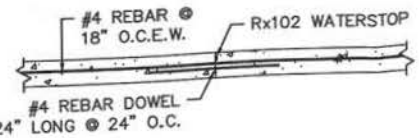
CONCRETE DETAILS

DATE: AUG 13, 2015
SCALE: 1" = 4'
DRAWN BY: DDR
CHECKED BY: NAP
SHEET: 25

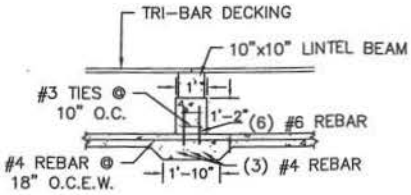
FILE NAME: ND PROJECT FILES/TWINE/ROLLING GREEN/OFILES/PLAN



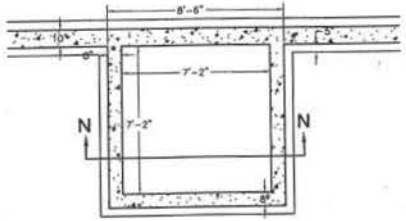
G/25 COLUMN SECTION
SCALE: 1" = 1'



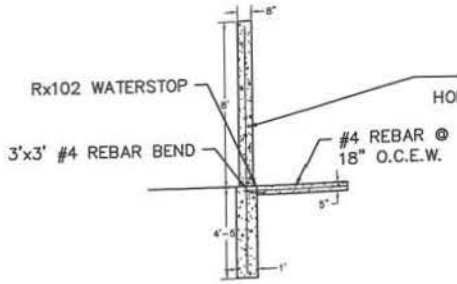
H/10 PIT FLOOR SECTION
SCALE: 1" = 2'



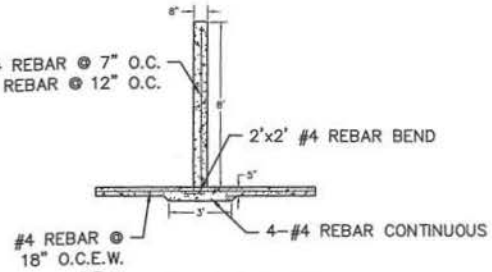
I/24 STUB WALL DETAIL
SCALE: 1" = 4'



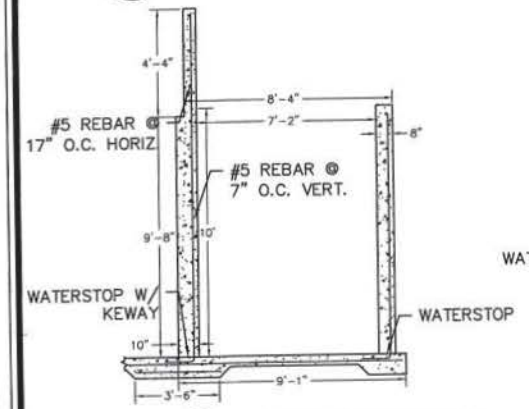
J/13 ACCESS PORT DETAIL
SCALE: 1" = 6'



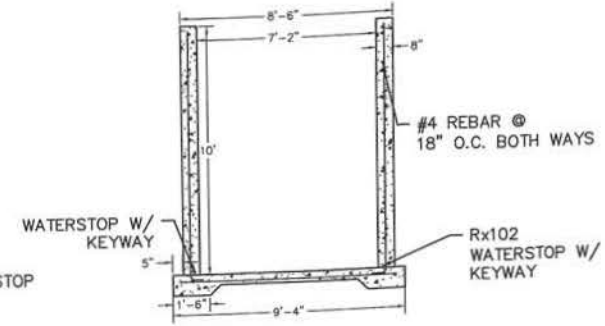
K/24 END WALL DETAIL
SCALE: 1" = 6'



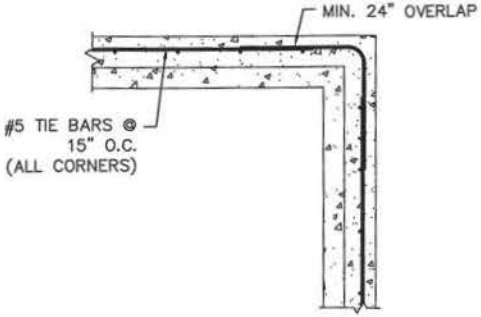
L/24 COMPOST WALL DETAIL
SCALE: 1" = 6'



M/17 ACCESS PORT SECTION
SCALE: 1" = 5'



N-N/26 ACCESS PORT SECTION
SCALE: 1" = 5'



O/10 CORNER DETAIL
SCALE: 1" = 2'

GENERAL NOTES

REGISTERED PROFESSIONAL ENGINEER
NATHAN A. PESTA
PE-6254
DATE 12/10/15
NORTH DAKOTA

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

No.	Revision/Issue	Date
1	Pump Out	11/24/15

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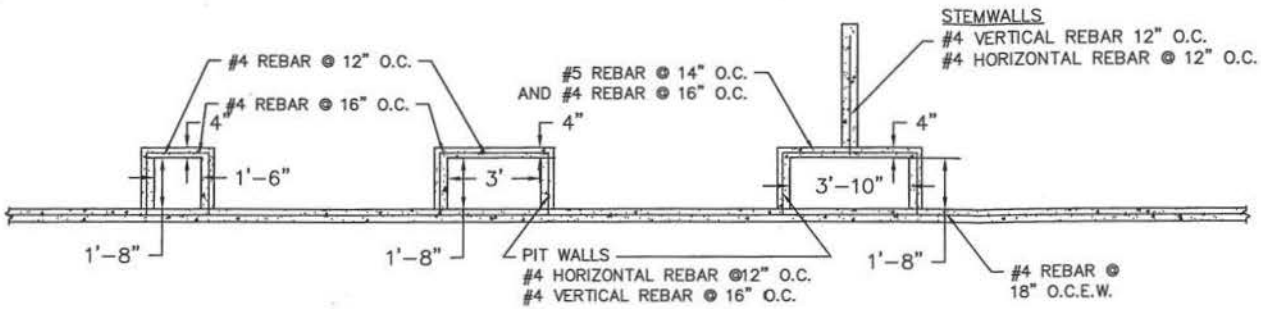
ROLLING GREEN FAMILY FARMS RE, LLP

NW 1/4, SECTION 4, T 139 N, R 84 W
CASS COUNTY, ND

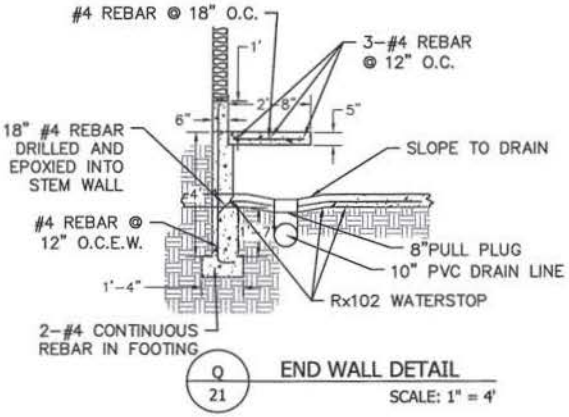
CONCRETE DETAILS

DATE: AUG 17, 2015	SHEET: 26
SCALE: AS SHOWN	
DRAWN BY: DDR	
CHECKED BY: NAP	

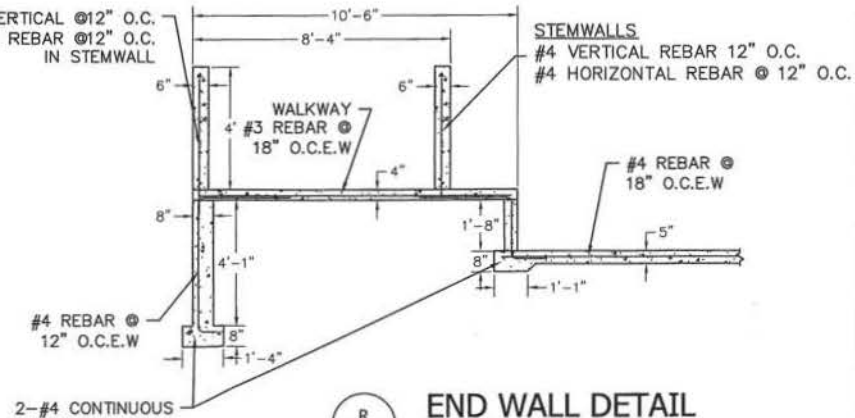
FILE NAME: ND PROJECT FILES/DIMME/ROLLING GREEN/CFILES/PLAN



P / 20 CRATE CROSS SECTION
SCALE: 1" = 4'



Q / 21 END WALL DETAIL
SCALE: 1" = 4'



R / 20 END WALL DETAIL
SCALE: 1" = 4'

GENERAL NOTES

SCALE, FEET
0 2 4 6 8

REGISTERED PROFESSIONAL ENGINEER
NATHAN A. PESTA
PE-6254
DATE 12/10/15
NORTH DAKOTA

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

No.	Revision/Issue	Date
1	Detail Q	12/7/15

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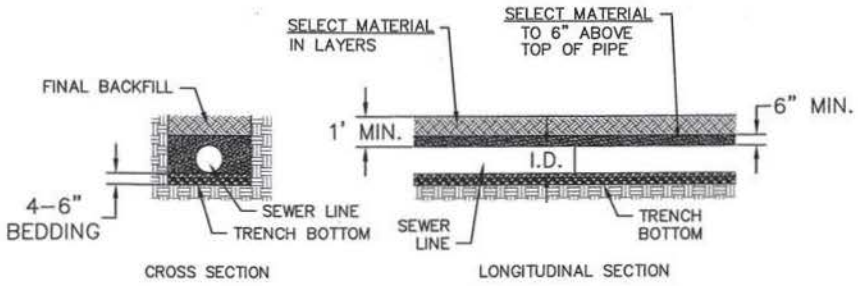
ROLLING GREEN FAMILY FARMS RE, LLP

NW 1/4, SECTION 4, T 139 N, R 84 W
CASS COUNTY, ND

CONCRETE DETAILS

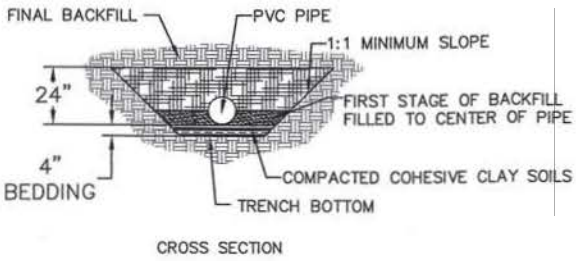
DATE: AUG 13, 2015	SHEET: 27
SCALE: 1" = 4'	
DRAWN BY: DDR	
CHECKED BY: NAP	

FILE NAME: ND PROJECT FILES/SWINE/ROLLING GREEN/DFILES/PLAN



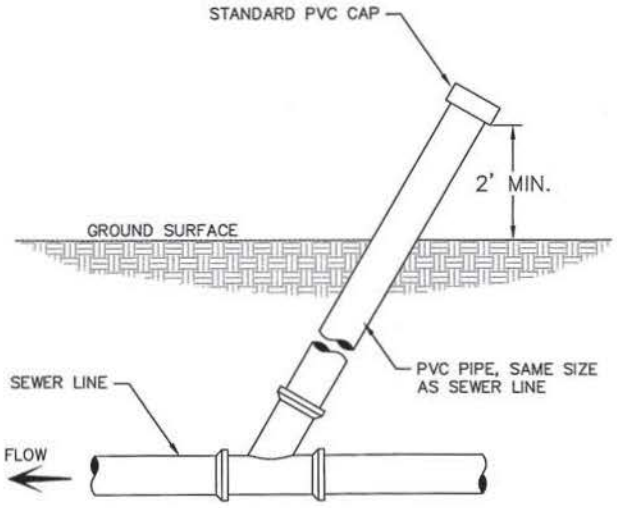
STANDARD BEDDING DETAILS FOR ADS-N12 PIPE OR EQUIVALENT

NOT TO SCALE



STANDARD BEDDING DETAILS FOR PVC PIPE OR EQUIVALENT PLACED THROUGH BERM

NOT TO SCALE



TYPICAL CLEANOUT DETAIL

ADS DUAL WALL TRENCHING & PIPELINE CONSTRUCTION NOTES

1. Select backfill shall consist of granular soil which meets the USCS soil type GM, GC, SM, or SC. Material shall have a maximum particle size of ½ inch diameter and shall be compacted in 6 inch layers (ma.) to a density not less than 85% of the Standard Proctor Density.

2. Unclassified backfill shall consist of excavated material, provided it is free from lumps of clay, stone, boulders and other debris. Material shall be wetted and compacted with available rubber tired construction equipment until approved by the Engineer.

3. In location where the trench bottom contains rocks or is unsuitable for pipe to rest on, as determined by the engineer, the pipe shall be bedded as shown.

4. In locations where the proposed pipelines cross existing utilities, the utility crossing details shall be determined in the field by the Engineer. Prior to trench excavation, existing utilities shall be located and exposed by the Contractor.

5. Select backfill shall be placed under the haunches of all pipe using the shovel slicing method or other method, approved by the Engineer.

6. All trenching excavation shall be braced and/or shored in accordance with OSHA Trench Safety Regulations.

GENERAL NOTES

LEGEND

- GRAVEL
- FILL
- CONCRETE
- STRIPPING
- EXISTING GROUND

REGISTERED PROFESSIONAL ENGINEER
NATHANIEL PESTA
PE-6254
DATE 2/10/15
NORTH DAKOTA

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

No.	Revision/Issue	Date

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Consulting Engineers
PO Box 522 | Mandan, ND | 58554

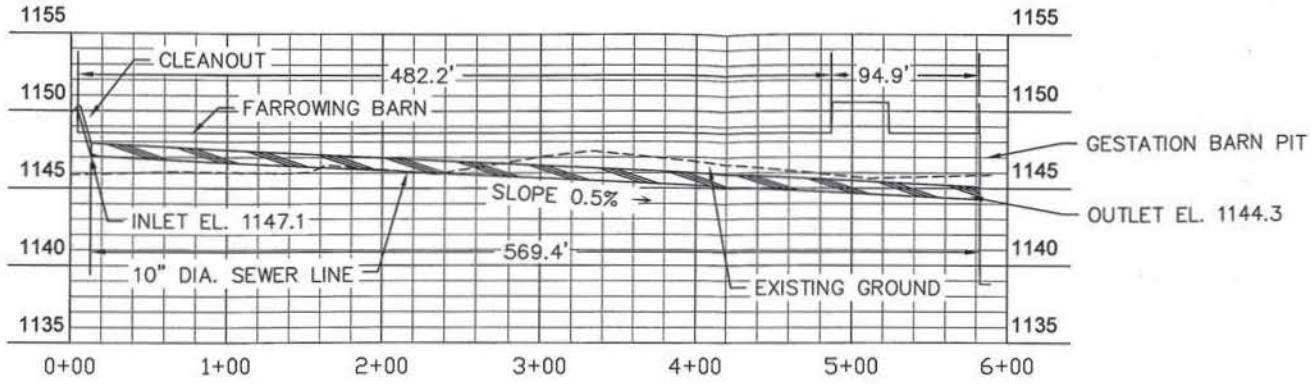
ROLLING GREEN FAMILY FARMS RE, LLP

NW 1/4, SECTION 4, T 139 N, R 54 W
CASS COUNTY, ND

CLEANOUT & STANDARD BEDDING DETAIL

DATE: AUG 19, 2015	SHEET: 28
SCALE: AS SHOWN	
DRAWN BY: DDR	
CHECKED BY: NAP	

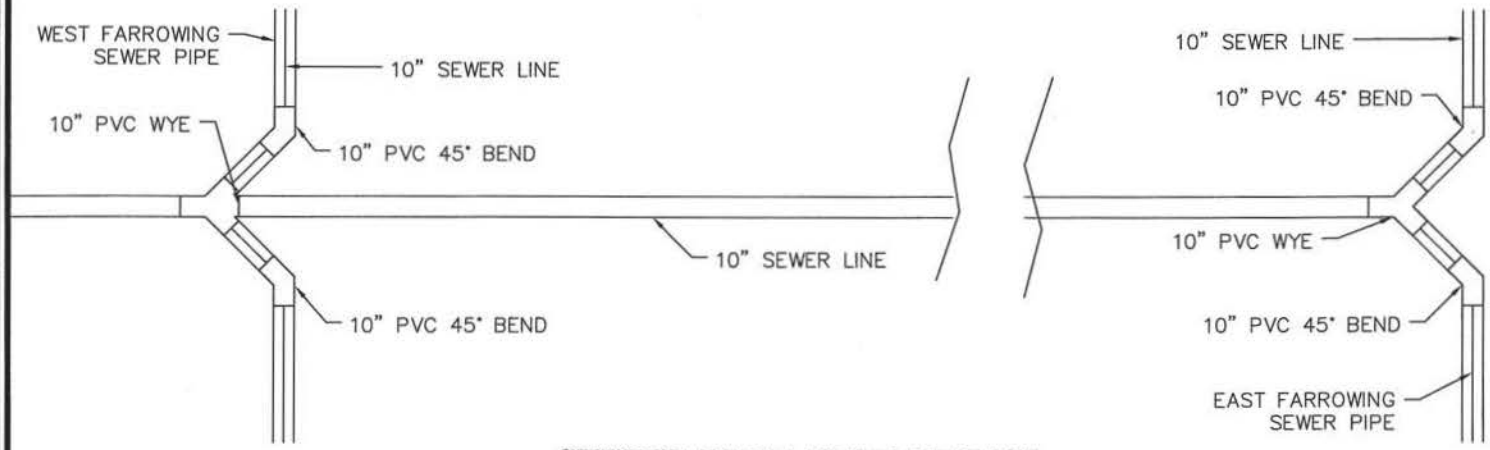
FILE NAME: ND PROJECT FILES/SWINE/ROLLING GREEN/CFILES/PLAN



SCALE:
VERTICAL: 1" = 8'
HORIZONTAL: 1" = 80'

SEWER LINE PROFILE

VERTICAL SCALE, FEET
0 4 8 12 16
HORIZONTAL SCALE, FEET
0 40 80 120 160



SEWER LINE WYE DETAIL

SCALE: 1" = 5'

GENERAL NOTES

LEGEND

---- EXISTING GROUND

SCALE, FEET
0 2.5 5 7.5 10

REGISTERED PROFESSIONAL ENGINEER
NATHAN A. PESTA
PE-6254
DATE 12/10/15
NORTH DAKOTA

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

No.	Revision/Issue	Date
1	PHASE II	12/03/15

DEHAAN, GRABS & ASSOCIATES, LLC
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ROLLING GREEN FAMILY FARMS RE, LLP

NW 1/4, SECTION 4, T 139 N, R 54 W
CASS COUNTY, ND

SEWER LINE PROFILE & WYE DETAIL

DATE: AUG 25, 2015	SHEET: 29
SCALE: AS SHOWN	
DRAWN BY: DDR	
CHECKED BY: NAP	

FILE NAME: ND PROJECT FILES/SMNE/ROLLING GREEN/CFILES/PLAN

Table of Quantities

Item	Quantity	Unit
Stripping (Includes soil removal, replacement and compaction)		
Topsoil Stripping (Does not include Borrow Area)	8,190	YD^3
Topsoil Placement (Does not Include Borrow Area)	3,390	YD^3
Excavation		
Borrow (Does Not include Stripping and Replacement)	14,500	YD^3
Building Subgrade	48,670	YD^3
Final Excavation	1,630	YD^3
Earthfill		
Building Subgrade	40,300	YD^3
Backfill	10,340	YD^3
Granular Fill Under Gestation Barn	800	YD^3
Pipe (To include all appurtenances and fittings)		
18" CPP ADS N-12	375	LFT
15" CPP ADS N-12	262	LFT
10" Sewer Line Phase I	1,744	LFT
10" Sewer Line Phase II	200	LFT
18" Dia. Nyloplast Drain Basin	2	Lump Sum
15" Dia. Nyloplast Drain Basin	2	Lump Sum
Miscellaneous		
GEOTEX 401 Nonwoven Fabric or Equivalent Under Roadways - Heavy Grade	128,895	FT^2
Gravel Class Five Medium Class, (Heavy Duty Class)	1020 (6,100)	YD^3
6" Drain Tile	300	LFT
4" Drain Tile	4,325	LFT
Drain Tile Pump Station	1	Lump Sum

GENERAL NOTES

REGISTERED PROFESSIONAL ENGINEER
NATHAN A. PESTA
PE-6254
DATE 12/14/15
NORTH DAKOTA

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

No.	Revision/Issue	Date
1	PIPES	12/03/15

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Consulting Engineers
PO Box 522 | Mandan, ND | 58554

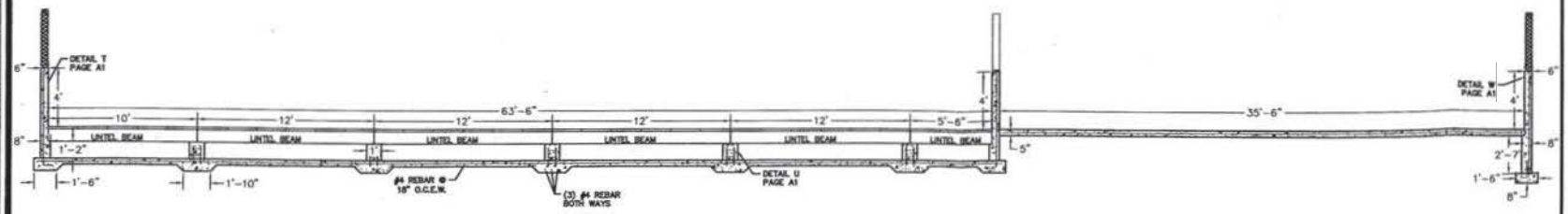
ROLLING GREEN FAMILY FARMS RE, LLP

NW 1/4, SECTION 4, T 139 N, R 84 W
CASS COUNTY, ND

TABLE OF QUANTITIES

DATE: AUG 25, 2015
SCALE: AS SHOWN
DRAWN BY: DDR
CHECKED BY: NAP
SHEET: 30

FILE NAME: ND PROJECT FILES/SWINE/ROLLING GREEN/CFILES/PLAN

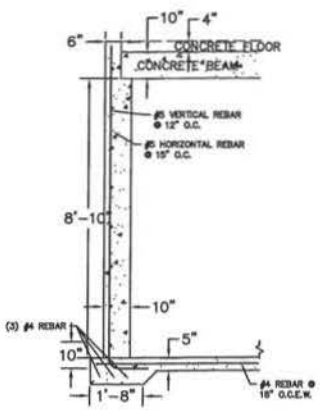


R-R / 22 FOUNDATION CROSS SECTION

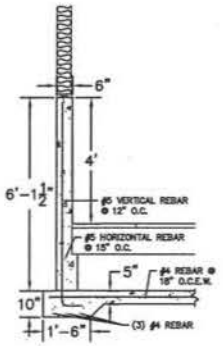
SCALE: 1" = 8'

SCALE, FEET

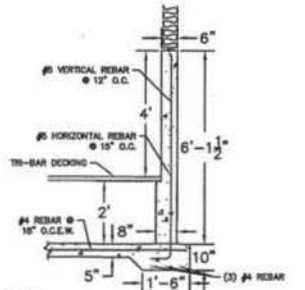
0 4 8 12 16



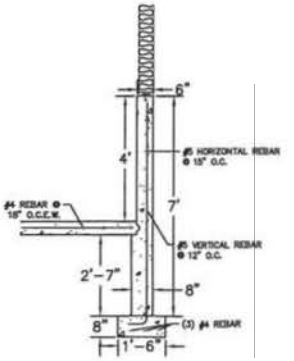
S / 24 END WALL DETAIL
SCALE: 1" = 4'



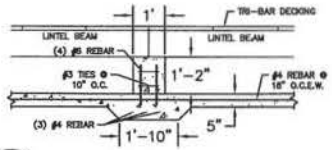
T / A1 END WALL DETAIL
SCALE: 1" = 4'



V / 24 END WALL DETAIL
SCALE: 1" = 4'



W / A1 END WALL DETAIL
SCALE: 1" = 4'



U / A1 END WALL DETAIL
SCALE: 1" = 4'

GENERAL NOTES

REGISTERED PROFESSIONAL ENGINEER
NATHAN A. PESTA
PE-6254
DATE 12/10/15
NORTH DAKOTA

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

No.	Revision/Issue	Date

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Consulting Engineers
PO Box 522 | Mandan, ND | 58554

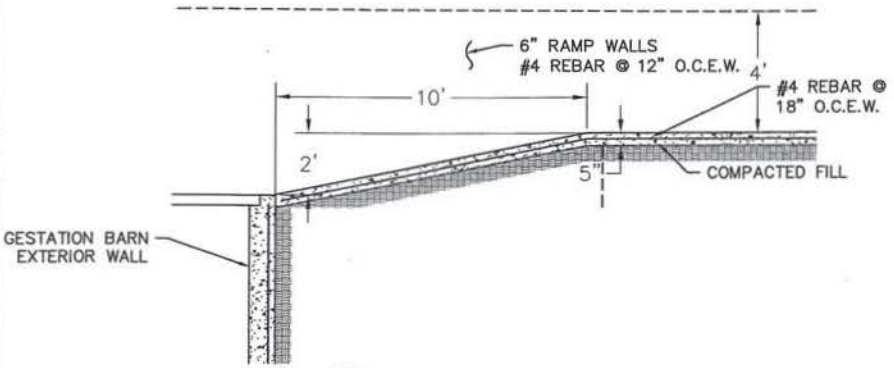
ROLLING GREEN FAMILY FARMS RE, LLP

NW 1/4, SECTION 4, T 139 N, R 84 W
CASS COUNTY, ND

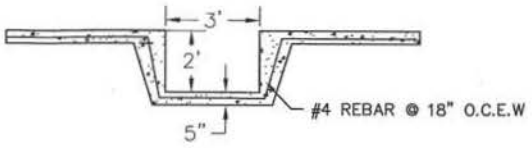
CONCRETE DETAILS

DATE: DEC 03, 2015	SHEET:
SCALE: AS SHOWN	ADDENDUM 1
DRAWN BY: DDR	
CHECKED BY: NAP	

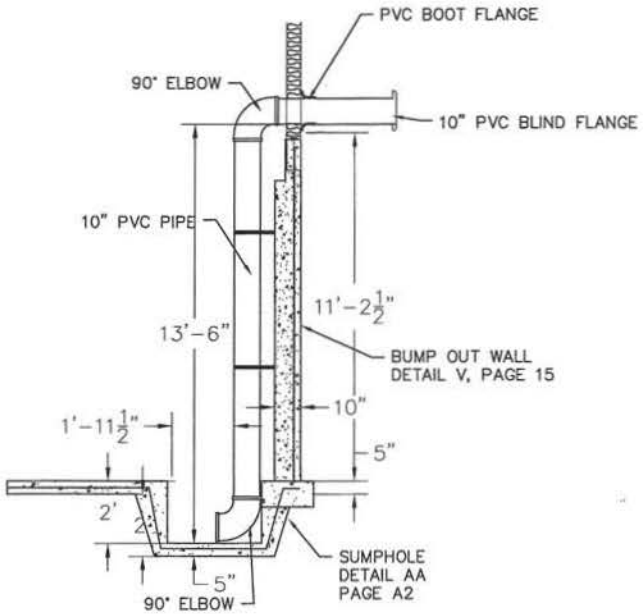
FILE NAME: ND PROJECT FILES/SWINE/ROLLING GREEN/CFILES/PLAN



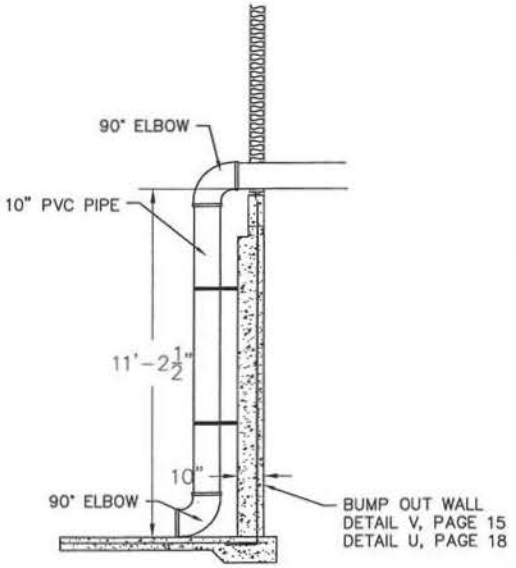
X-X / 22 HALLYWAY SECTION
SCALE: 1" = 4'



AA / 13, 15 SUMPHOLE CROSS SECTION
SCALE: 1" = 4'



Y / 13,16 PUMPOUT PIPE DETAIL
SCALE: 1" = 4'



Z / 13,16 AGITATION PIPE DETAIL
SCALE: 1" = 4'

GENERAL NOTES

SCALE, FEET
0 2 4 6 8

REGISTERED PROFESSIONAL ENGINEER
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PE-6254
DATE 2/10/15
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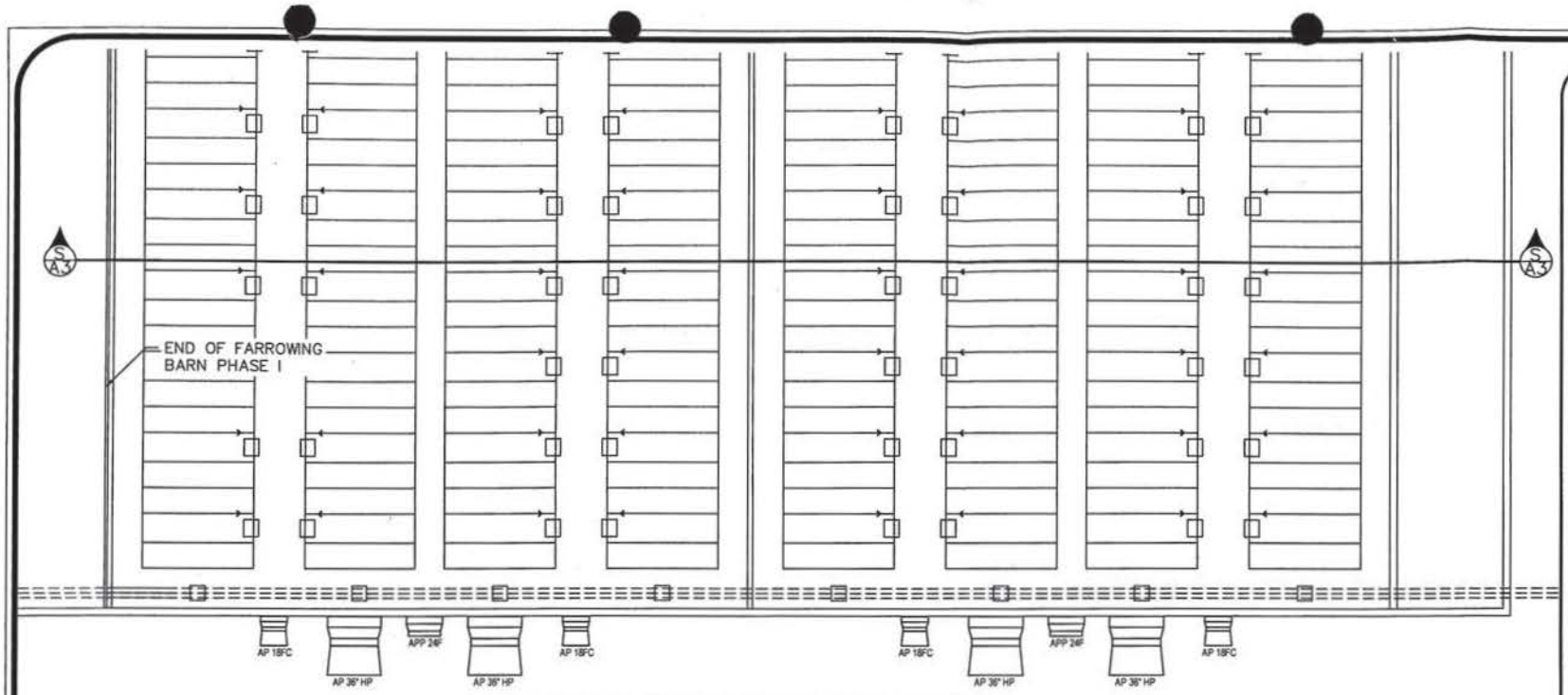
NW 1/4, SECTION 4, T 139 N, R 54 W
CASS COUNTY, ND

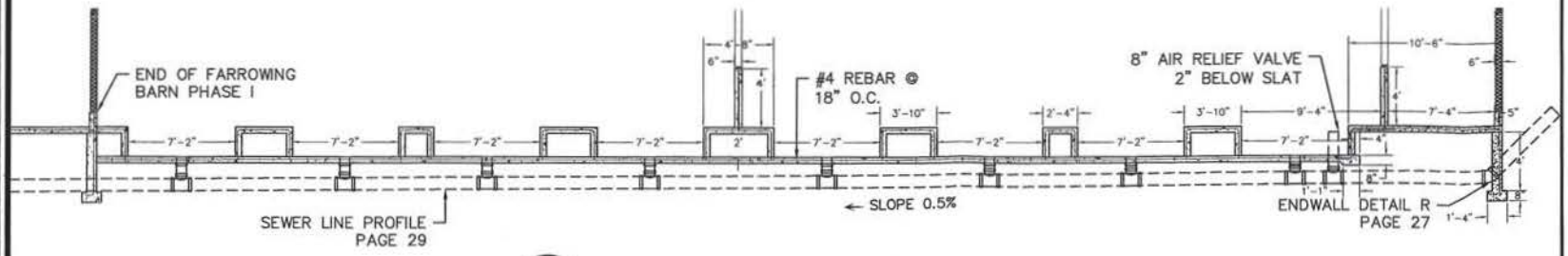
CONCRETE DETAILS

DATE: DEC 08, 2015	SHEET: ADDENDUM 2
SCALE: 1" = 4'	
DRAWN BY: DDR	
CHECKED BY: NAP	

FILE NAME: ND PROJECT FILES/SWINE/ROLLING GREEN/CFILES/PLAN



FARROWING BARN PHASE II



S-S / A3 FOUNDATION CROSS SECTION

GENERAL NOTES

SCALE, FEET
0 4 8 12 16

REGISTERED PROFESSIONAL ENGINEER
JONATHAN A. PESTA
PE-6254
DATE 2/10/15
NORTH DAKOTA

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

No.	Revision/Issue	Date

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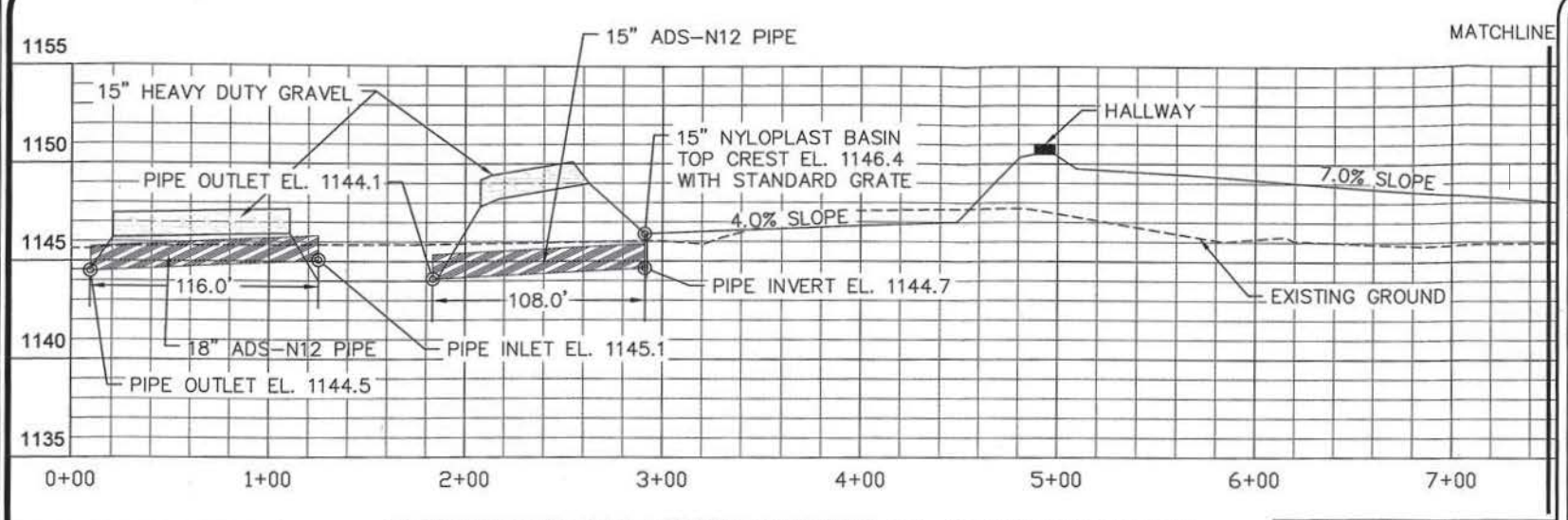
ROLLING GREEN FAMILY FARMS RE, LLP

NW 1/4, SECTION 4, T 139 N, R 54 W
CASS COUNTY, ND

FARROWING BARN PHASE II

DATE: DEC 03, 2015	SHEET: ADDENDUM 3
SCALE: 1" = 8'	
DRAWN BY: DDR	
CHECKED BY: NAP	

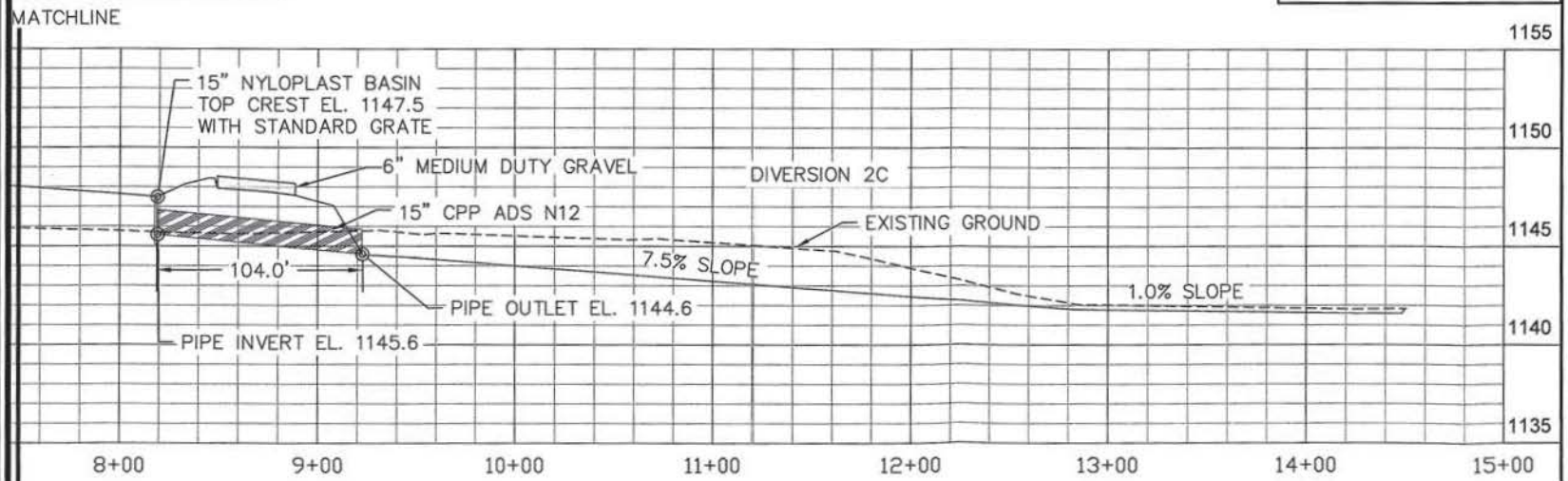
FILE NAME: ND PROJECT FILES/SWINE/ROLLING GREEN/CFILES/PLAN



CLEANWATER DIVERSIONS 1A & 2B PROFILE

SCALE:
VERTICAL: 1" = 6'
HORIZONTAL: 1" = 60'

VERTICAL SCALE, FEET
0 3 6 9 12
HORIZONTAL SCALE, FEET
0 30 60 90 120



CLEANWATER DIVERSIONS 1A & 2B PROFILE

GENERAL NOTES

LEGEND
- GRAVEL
- PIPES PROPOSED
- EXISTING GROUND
- DESIGNED GROUND

REGISTERED PROFESSIONAL ENGINEER
NATHAN A. PESTA
PE-6254
DATE 12/10/15
NORTH DAKOTA

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

No.	Revision/Issue	Date

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NW 1/4, SECTION 4, T 139 N, R 84 W
CASS COUNTY, ND

CLEANWATER DIVERSIONS 1A AND 2B, 2C DETAILS

DATE: DEC 2, 2015	SHEET: ADDENDUM 4
SCALE: AS SHOWN	
DRAWN BY: CRD	
CHECKED BY: NAP	

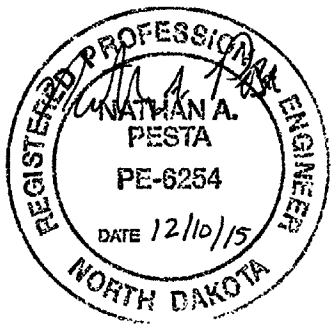
FILE NAME: ND PROJECT FILES/SWINE/ROLLING GREEN/CFILES/PLAN

DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers

ROLLING GREEN FAMILY FARMS RE, LLP

GESTATION SOW FARM

CASS COUNTY, NORTH DAKOTA



December 10, 2015

NORTH DAKOTA DEPARTMENT OF HEALTH APPLICATION

DeHaan, Grabs & Associates, LLC
PO Box 522 | Mandan, ND | 58554
www.dgaengineering.com

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Section 1: North Dakota Department of Health Application Form

Section 2: Facility Design Information

SECTION 2: FACILITY DESIGN INFORMATION

A. NARRATIVE SUMMARY OF DESIGN

This project includes provision for a 9,056 head swine sow facility to be built in two phases. The proposed facility will consist of one (1) 760.0' x 171.5' Gestation/Breeding Barn, one (1) 456.0' x 167.5 Farrowing Barn, and one (1) 166.5' x 98.0' Isolation Barn to be built in Phase I. Phase II will consist of an additional four (4) farrowing rooms 94.7' x 167.5'. The Gestation/Breeding Barn will house a total of 5,312 sows at an average weight of 400 lbs per animal and 800 nursery pigs at an average weight of 45 lbs per animal, Phase I Farrowing Barn will house 1120 sows at an average weight of 400 lbs, the Isolation Barn will house 1600 pigs at an average weight of 150 lbs per animal, and the Phase II Farrowing Barn will house a total of 224 farrowing sows at an average weight of 400 lbs. The farrowing barn has slatted farrowing crates over recharge pits which will drain into the gestation/breeding barn deep pits. The gestation/breeding barn is on slatted concrete floors over a 10' deep pit. The isolation barn is on slatted concrete floors over a 10' deep pit. Buildings are totally roofed and all extraneous drainage will be drained away from the building and diverted around the site.

The site is located 2 miles south on ND-38 from Buffalo, ND and 2 ½ miles east on 36th street. The site will be on the right (south). The legal location is the Section 4, T-139-N, R-54-W, Cass County, ND. The site was selected for adequate isolation from surrounding residential areas and for adequate agricultural land to utilize the animal manure nutrients in this complex on an intensive management approach. The site for the proposed buildings is over 1 mile from any non-owned residence, businesses, churches or schools, or public use areas.

The waste management system for the farrowing barn and farrowing rooms utilizes a pull plug recharge pit under the slats that will drain into the gestation barn deep pit. The gestation barn has a 10' deep concrete pit under the whole barn to contain the waste and the isolation barn has a 10' deep concrete pit under the whole barn to contain the waste. The waste storage pits are designed conservatively above all minimum applicable North Dakota Department of Health and Environment design standards. The size of the facility is for 365 days of storage. The minimum

Department of Health requirements is for 270 days of storage.

All animal waste generated by this complex will be disposed of primarily though land application. The waste will be recycled and utilized on the surrounding cropland. There are 3,421 (3,312 available) acres of cropland adjacent to the complex. The area will be utilized to produce corn and bean crops by consuming the nutrients in a full cycle system. Waste will applied to the land by primarily an injection applicator system. All land application areas will receive applications at rates consistent with infiltration capabilities of the native soil such that there is no runoff to surrounding areas. A buffer strip will be maintained between waste utilization areas, streams, and property boundaries within North Dakota Department of Health Guidelines (see Section 9).

Dead animals from the facility will be disposed of utilizing composting (see Section 9).

B: SITE SPECIFIC INFORMATION

1) Name of Facility

Rolling Green Family Farms RE, LLP

A. County and State

Cass County, North Dakota

B. Name and Distance to the Nearest Watercourse

Unnamed tributary to Maple River, 2 miles to the NW.

C. Type of Water Supply

Well Water

D. Soil Type in Area of Control Structure

Sandy lean clay (CL) and Silty sand (SM)

E. Depth to Water Table at Facility/Control Structure

The water table ranges from 4.5' to none at all (See Bore Test Summary). A drain tile system will be installed to maintain the water table below the

F. Separation Distance from Closest Residences, Businesses, Churches or Schools

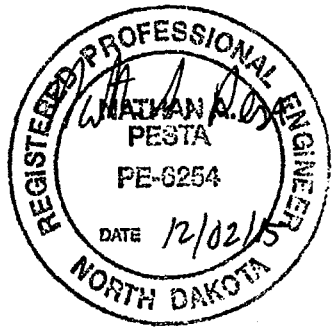
> 5,280 ft

G. Unusual Site Characteristics Presented (Rock, Gravel, Wetlands, Springs, Etc.)

None

C: DESIGN CALCULATIONS WASTE PRODUCTION CALCULATIONS

A. Facility Information



1. Type of Construction: ☐ existing, ☒ proposed-new, or ☐ expansion

2. Building(s): **Phase I Grow-Finisher Barn:** *166.0* feet by *93.0* feet
Phase I Gestation Barn: *760.0* feet by *162.2* feet
Phase I Farrowing Barn: *456.0* feet by *167.5* feet
Phase II Farrowing Barn: *94.7* feet by *167.5* feet

3. Animal Capacity (maximum head counts and average weights)

Phase I:	*800*	head of *Nursery Pigs*	@	*45*	lbs,	*36,000* lbs Total
Phase I:	*1,600*	head of *Grow-Finisher Pigs*	@	*150*	lbs,	*240,000* lbs Total
Phase I:	*5,312*	head of *Gestation Sows*	@	*400*	lbs,	*2,124,800* lbs Total
Phase I:	*1,120*	head of *Sow and Litters*	@	*400*	lbs,	*448,000* lbs Total
Phase II:	*224*	head of *Sow and Litters*	@	*400*	lbs,	*89,600* lbs Total

Total: *9,056* **head** **Total Animal Weight (TAW):** *2,938,400* **lbs**
Total Animal Units Daily Capacity (TAU): *2,938* **AU**

B. Determine Minimum Storage Requirement

The Minimum Storage Requirement is the sum of the animal waste produced (or treatment volume for an anaerobic lagoon), plus the spillage and washwater, plus the pit recharge produced in 365 days. Generally, outside or contributing drainage area runoff is to be diverted. Runoff which is not diverted must be included in the storage requirement.

The following is completed for either Liquid Manure Storage or Anaerobic Lagoon

Liquid Manure Storage

Unit Waste Production (UWP) in cubic feet per day per 1,000 pounds of animal:

Cattle	Swine	Poultry	Other
☐ Dairy = 1.3	☒ Nursery Pig = 1.4	☐ Layers = 0.9	☐ Horse = 0.8
☐ Beef = 1.0	☒ Grower/Finisher = 1.0	☐ Broiler = 1.3	☐ Sheep = 0.6
	☒ Boar/Gestating Sow = 0.5	☐ Turkey = 0.7	
	☒ Sow and Litter = 1.4		

(a) Manure produced: (TAW x (UWP x 270 days/1,000)) = *568,469* cubic feet / 1,000 lbs
(TAW x UWP for each type calculated separately and added to find total manure produced)

(b) Spillage, Washwater and Pit Recharge generated in 270 days : *285,612* cubic feet
(Based off past performance Pipestone Vet has generated approximately 0.36 ft^3/day per animal unit)

(c) Total Manure plus Spillage and Washwater and pit recharge (a)+(b): *854,081* cubic feet.

Anaerobic Lagoon

Animal Volatile Solids (VS) produced in pounds per day per 1,000 pounds of animal (check all that apply)

Cattle	Swine	Other
❒ Dairy = 8.5	❒ Nursery Pig = 8.0	❒ Horse = 9.0
❒ Beef = 7.0	❒ Grower/Finisher = 5.0	❒ Sheep = 9.0
	❒ Boar/Gestating Sow = 3.0	
	❒ Sow and Litter = 6.0	

(d) Total Volatile Solids (VS) Produced (VS) x (TAW/1,000)): _____ pounds per day

(e) Loading Rate (LR): _____pounds of VS per 1,000 cubic feet per day.
(Maximum LR is 4.0, 2.0 or less reduces odor. LR of 6.0 is allowed if solids are removed.)

(f) Lagoon Capacity Based on LR, (d) x 1,000/(e): _____ cubic feet

(g) Lagoon Requirement Based on LR + Total Manure +Spillage and Washwater, (f) + (c): ___ cubic feet

Runoff

(h) Sand Lane and Stacking Pad Area:_____feet x _____feet = _____square feet

(i) Manure Stacking Pad Area:_____feet x _____feet = _____square feet

(j) Feed Stacking Pad Area:_____feet x _____feet = _____square feet

(k) Total Runoff Area:_____square feet

(l) Minimum Runoff (Figure 1 from Appendix):_____inches

NOTE: If a covered storage is used which collects runoff, then the sum of the 25 year, 24 hour storm runoff and the expected runoff for the 180 day storage period is used as the Minimum Runoff in (m).

(m) Minimum Runoff Storage Requirement (l) x (m)/12 = _____cubic feet

Minimum Overall Storage Requirement

(n) Minimum Storage Requirement (c or g) + (m): _____*854,081*_____ cubic feet

(o) Total Manure and Wastewater/Generated per AU per day (o) ÷ 2938÷ 270: ____*1.08*____cubic feet

REGISTERED PROFESSIONAL ENGINEER
NATHAN A. PESTA
PE-6254
DATE 12/02/15
NORTH DAKOTA

D: WASTE STORAGE CALCULATIONS

A. Determine Storage Provided

Type of storage: ☐ Earthen Storage Pit ☐ Earthen Lagoon ☐ Concrete Tank
☒ Underfloor Concrete Pit ☐ Outside Concrete Pit
☐ Other (describe) _____

NOTE: A scale drawing, calculations and other supporting information will be included. Indicate the location of all diversions, diversion dimensions, and flow directions of surface runoff for the entire facility. Concrete pit or tank storage is assumed to be covered unless specified otherwise.

Rectangular Concrete Pit or Tank (capacity = length x width x depth@ Freeboard + Pumpout Pits (ft^3) - Columns (ft^3))

161.7 feet x *96.3* feet x *9.0* feet + *1,490* ft^3 - *963* ft^3 = *140,672* cubic feet (Phase I Isolation Barn)
758.3 feet x *168.8* feet x *9.0* feet + *933* ft^3 - *7348* ft^3 = *1,145,594* cubic feet (Phase I Gestation Barn)
286.7 feet x *159.2* feet x *1.5* feet (crates and divider) = *68,442* cubic feet (Phase I Farrowing Barn)
57.3 feet x *159.2* feet x *1.5* feet (crates and divider) = *13,683* cubic feet (Phase II Farrowing Pens)
= ***1,368,391*** **cubic feet TOTAL**

Cylindrical Tank Storage Capacity (capacity = diameter x diameter x height x (0.7854))

_____ feet x _____ feet x _____ feet = _____ cubic feet (see plans)
= _____ **cubic feet TOTAL**

Earthen Storage Pit or Lagoon: Volume = [(4 x sideslope^2 x depth^3) / 3] + (sideslope x bottomlength x depth^2) + (sideslope x bottomwidth x depth^2) + (bottomwidth x bottomlength x depth)

Bottom Length: _____ Bottom Width: _____

Design Full Depth: _____ feet, Overflow Depth: _____ feet

Side Slopes: _____:1 and _____, End Slopes: _____:1 and _____:1

Note: Inside slopes for earthen pits or lagoons will be at least 2:1.

Earthen Storage Pit or Lagoon Capacity: _____ cubic feet

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NATHAN A. PESTA
PE-6254
DATE 12/02/15
NORTH DAKOTA

TOTAL STORAGE PROVIDED: ***1,368,391*** **cubic feet**

NOTE: The Total Storage Provided will meet or exceed the Minimum Storage Requirement (item o) from Waste Productions Calculation

E. DESIGN STORM PEAK FLOWS

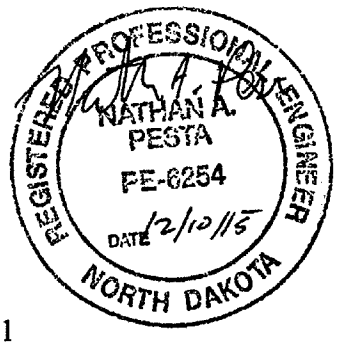
Peak flows and the subsequent Hydrographs were calculated with the aid of Hydaflow software. Some assumptions were made: The appropriate Curve Number for each Drainage area was assigned and used.

Also included in this report is a flow master calculation for the Diversions which have significant flows. The 25 year 24 hour Storm peak flow was determined by Hydaflow software for the particular diversion and by using the diversion details such as the slope, bottom width and side slope; the flow depth and velocity was found. The limiting velocity for each diversion was determined by the text: The Soil and Water Conservation Engineering Fourth Edition, pg 269.

CW Area 1

A. Inflow Hydrograph Inputs
   1. Drainage Area = 26.4 acres
   2. 25 Yr 24 Hr Rainfall Amount = 4.1 inches
   3. Average Curve Number = 80
   4. Maximum Flow Length = 2,163 feet
   5. Slope of watershed = 0.0043 feet/feet
   6. Calculated Time of Concentration = 95.7 minutes

B. Inflow Hydrograph Results
   1. Peak Flow = 23.2 cfs
   2. Time to Peak = 768 minutes
   3. Volume = 4.67 ac-ft



C. Cleanwater Diversion 1 Information
   1. Slope of Diversion = 0.0017 ft/ft
   2. Bottom width of Diversion = 20'
   2. Trapezoidal Ditch side slopes = 6:1 and 6:1
   3. Peak Flow = 23.2 cfs

D. Cleanwater Area Diversion 1 Velocity Results
   1. Velocity = 1.26 ft/s
   2. Limiting Velocity for Clean Water for ordinary firm loam = 2.49 ft/s

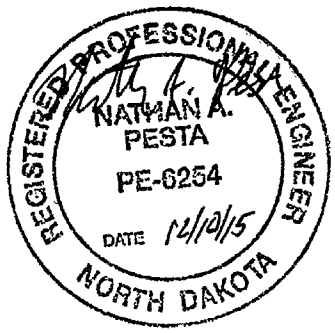
CW Area 2A

A. Inflow Hydrograph Inputs
   1. Drainage Area = 4.3 acres
   2. 25 Yr 24 Hr Rainfall Amount = 4.1 inches
   3. Average Curve Number = 85
   4. Maximum Flow Length = 1,050 feet
   5. Slope of watershed = 0.0102 feet/feet
   6. Calculated Time of Concentration = 7.94 minutes

B. Inflow Hydrograph Results
   1. Peak Flow = 10.3 cfs
   2. Time to Peak = 730 minutes
   3. Volume = 0.9 ac-ft

C. Cleanwater Diversion 2C Information
   1. Slope of Diversion = 0.0078 ft/ft
   2. Bottom width of Diversion = 12'
   2. Trapezoidal Ditch side slopes = 4:1 and 6:1
   3. Peak Flow = 10.3 cfs

D. Cleanwater Area Diversion 2C Velocity Results
   1. Velocity = 1.84 ft/s
   2. Limiting Velocity for Clean Water for ordinary firm loam = 2.49 ft/s



Hydrograph Report

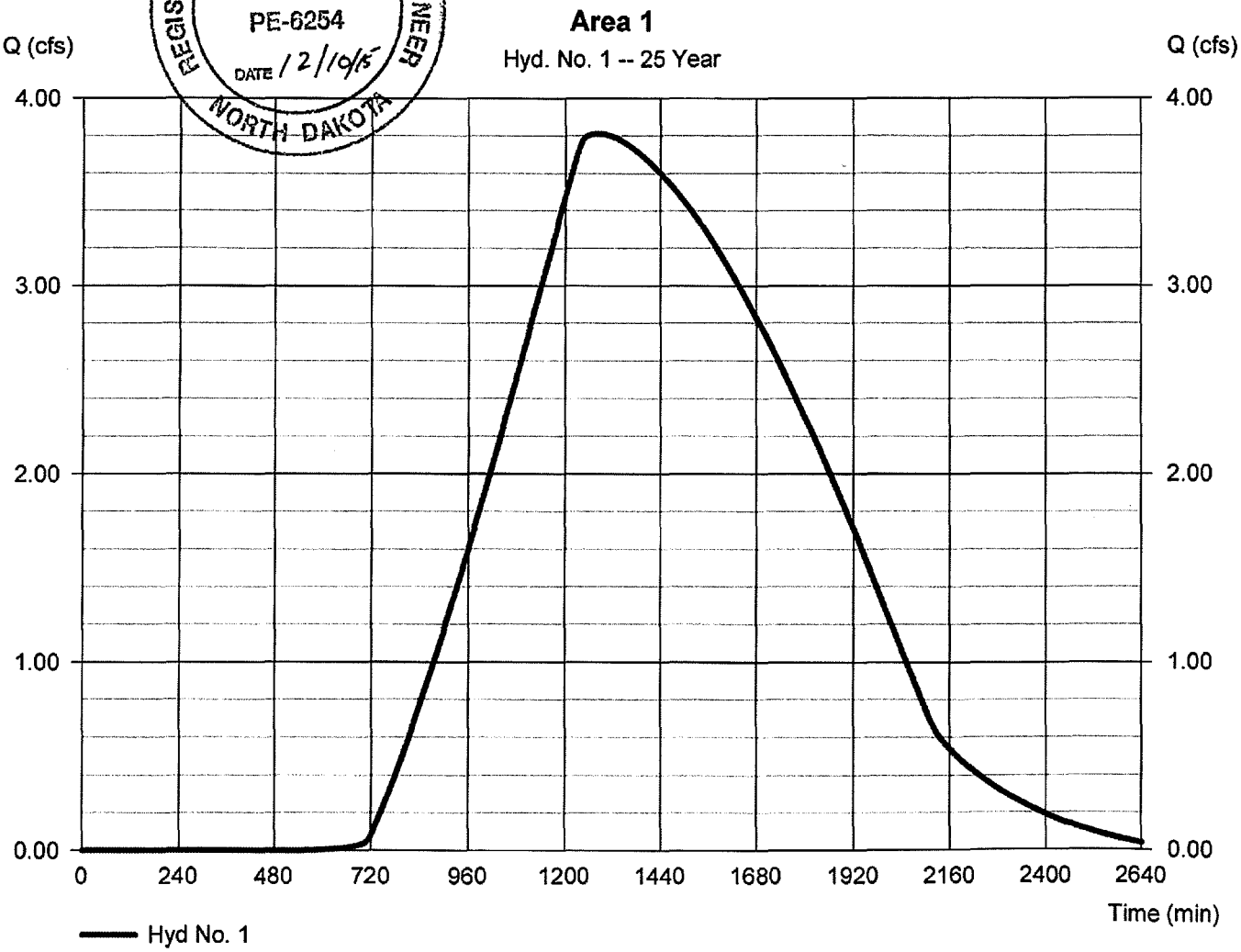
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2015 by Autodesk, Inc. v10.4 — Thursday, 12 / 10 / 2015

Hyd. No. 1

Area 1

Hydrograph type	= SCS Runoff	Peak discharge	= 3.813 cfs
Storm frequency	= 25 yrs	Time to peak	= 1280 min
Time interval	= 1 min	Hyd. volume	= 203,556 cuft
Drainage area	= 26.400 ac	Curve number	= 80
Basin Slope	= 0.0 %	Hydraulic length	= 2163 ft
Tc method	= LAG	Time of conc. (Tc)	= 900.06 min
Total precip.	= 4.10 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

REGISTERED PROFESSIONAL ENGINEER
NATHAN A. PESTA
PE-6254
DATE 12/10/15
NORTH DAKOTA



Hydrograph Report

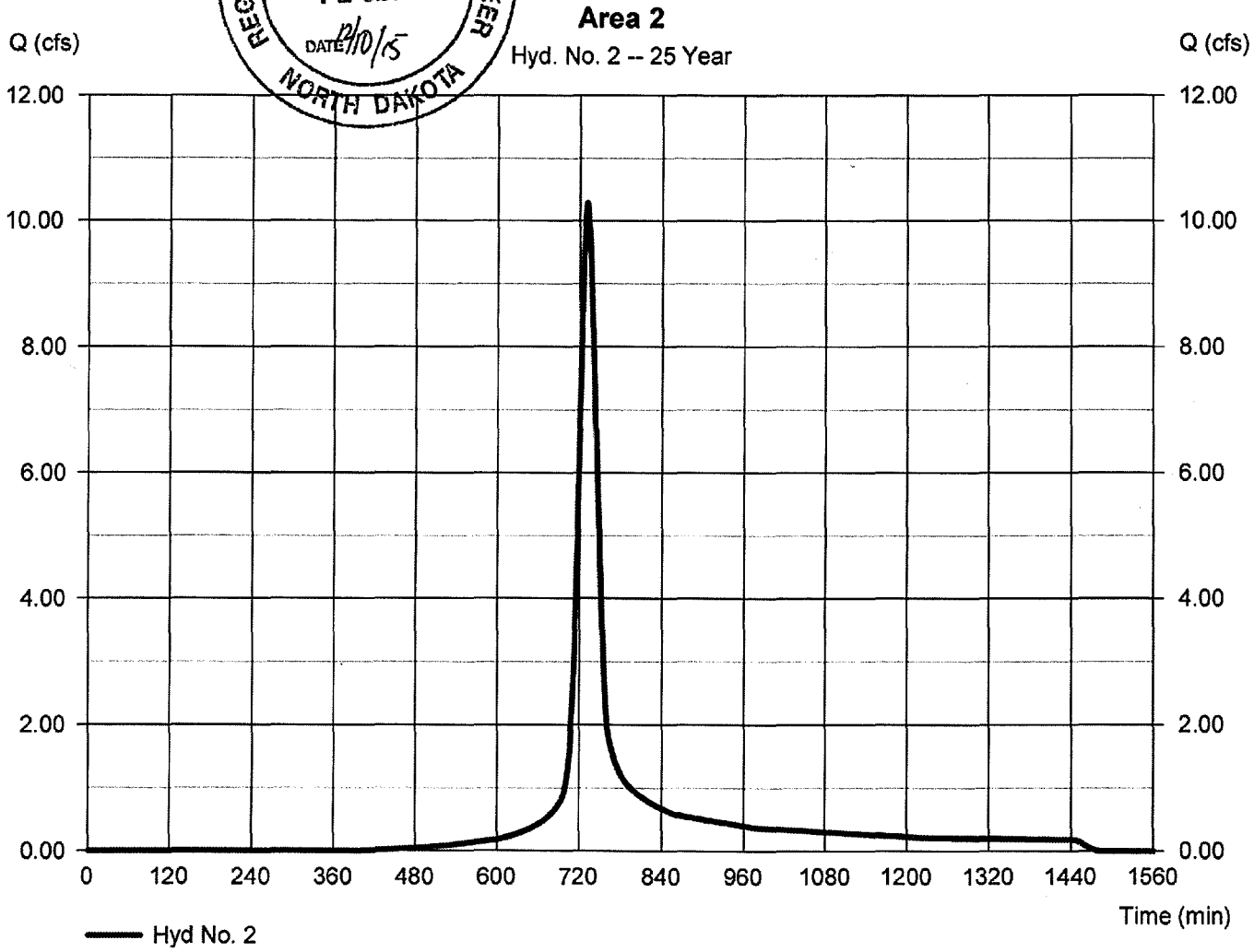
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2015 by Autodesk, Inc. v10.4 — Thursday, 12 / 10 / 2015

Hyd. No. 2

Area 2

Hydrograph type	= SCS Runoff	Peak discharge	= 10.30 cfs
Storm frequency	= 25 yrs	Time to peak	= 730 min
Time interval	= 1 min	Hyd. volume	= 39,469 cuft
Drainage area	= 4.300 ac	Curve number	= 85
Basin Slope	= 1.0 %	Hydraulic length	= 1050 ft
Tc method	= LAG	Time of conc. (Tc)	= 28.65 min
Total precip.	= 4.10 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

REGISTERED PROFESSIONAL ENGINEER
NATHAN A. PESTA
PE-6254
DATE 12/10/15
NORTH DAKOTA



Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Thursday, Dec 10 2015

Diversion 1D Details

Trapezoidal

Bottom Width (ft)	= 20.00
Side Slopes (z:1)	= 6.00, 6.00
Total Depth (ft)	= 2.00
Invert Elev (ft)	= 1144.20
Slope (%)	= 0.17
N-Value	= 0.035

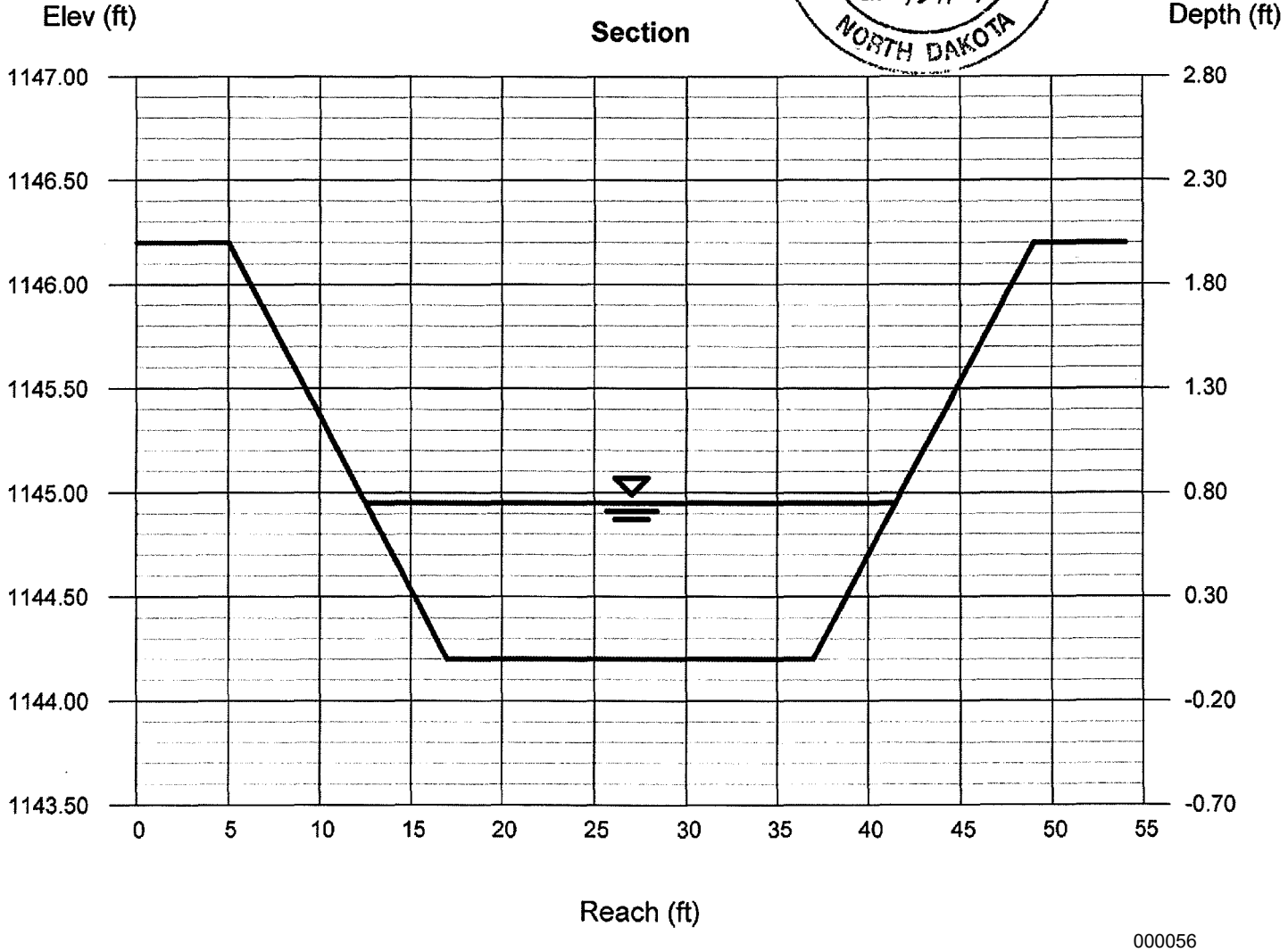
Calculations

Compute by:	Known Q
Known Q (cfs)	= 23.20

Highlighted

Depth (ft)	= 0.75
Q (cfs)	= 23.20
Area (sqft)	= 18.37
Velocity (ft/s)	= 1.26
Wetted Perim (ft)	= 29.12
Crit Depth, Yc (ft)	= 0.34
Top Width (ft)	= 29.00
EGL (ft)	= 0.77

REGISTERED PROFESSIONAL ENGINEER
NATHAN A. PESTA
PE-6254
DATE 12/10/15
NORTH DAKOTA



Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Thursday, Dec 10 2015

Diversion 2C Details

Trapezoidal

Bottom Width (ft)	= 12.00
Side Slopes (z:1)	= 6.00, 4.00
Total Depth (ft)	= 2.00
Invert Elev (ft)	= 1144.40
Slope (%)	= 0.78
N-Value	= 0.035

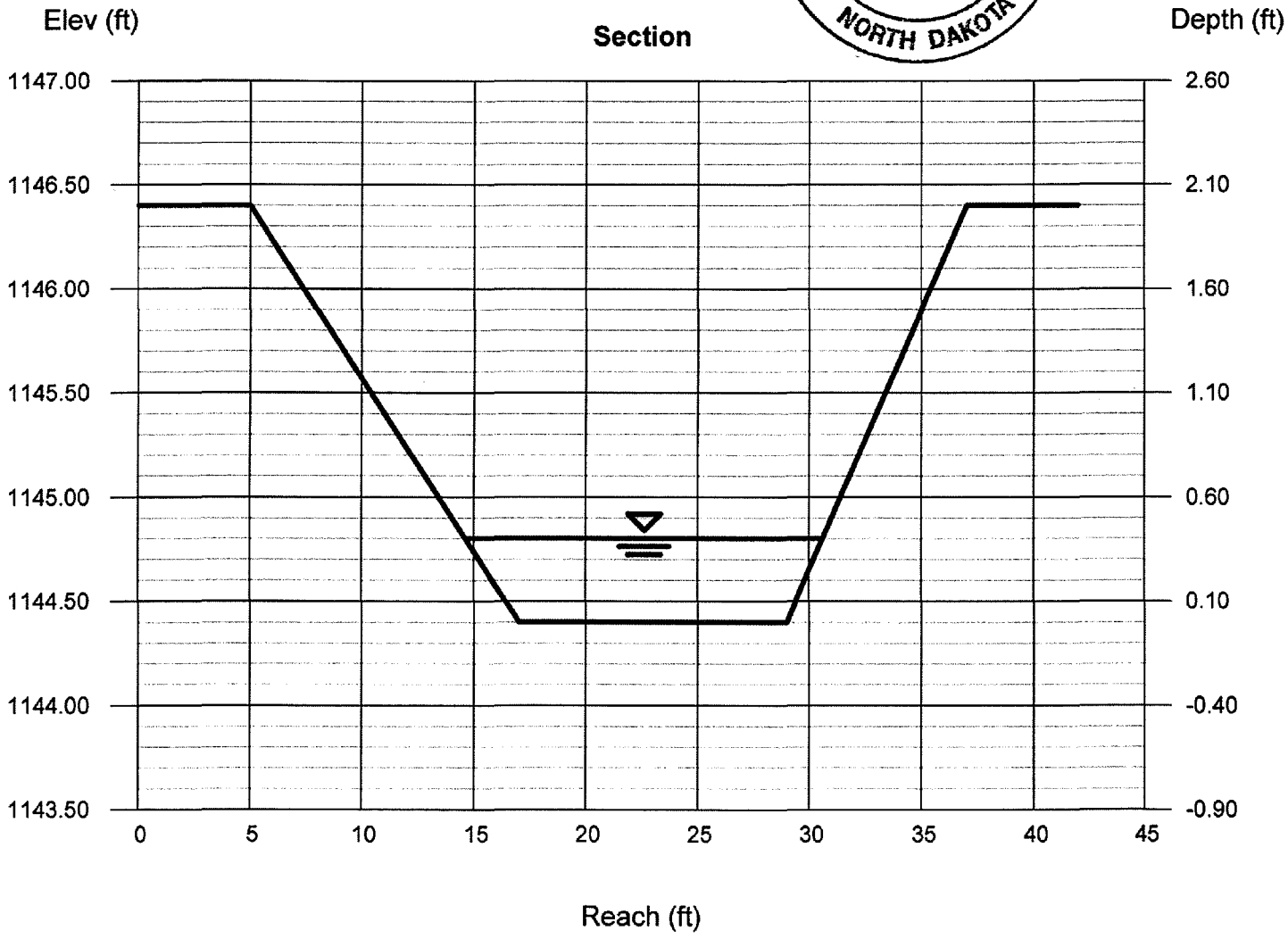
Calculations

Compute by:	Known Q
Known Q (cfs)	= 10.30

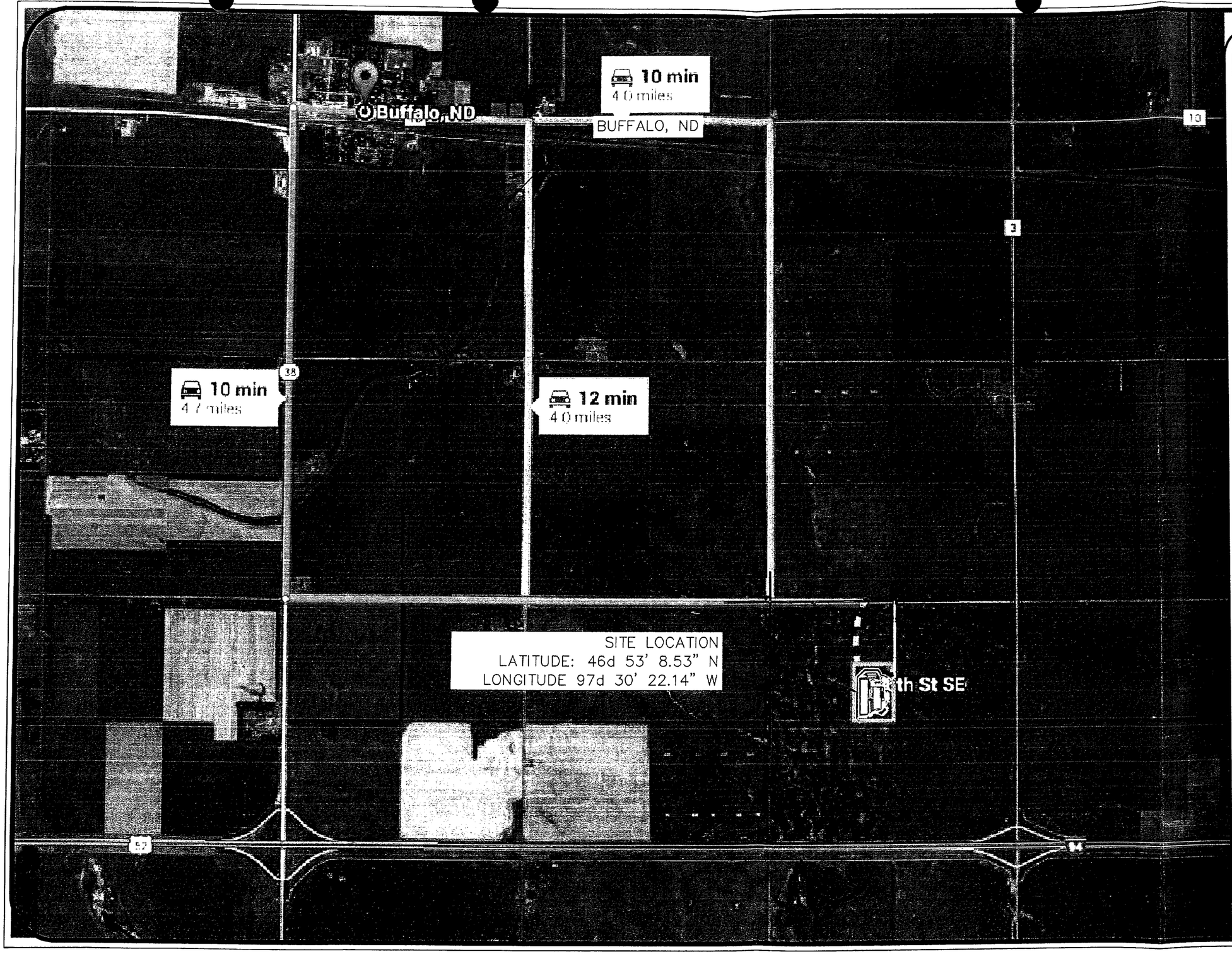
Highlighted

Depth (ft)	= 0.40
Q (cfs)	= 10.30
Area (sqft)	= 5.60
Velocity (ft/s)	= 1.84
Wetted Perim (ft)	= 16.08
Crit Depth, Yc (ft)	= 0.28
Top Width (ft)	= 16.00
EGL (ft)	= 0.45

REGISTERED PROFESSIONAL ENGINEER
NATHAN A. PESTA
PE-6254
DATE 12/10/15
NORTH DAKOTA



Section 3: General Maps



GENERAL NOTES

LEGEND

N

SCALE, FEET

0 300 600 900 1200

DeHaan, Grabs & Associates, LLC
Registration Number: C-1341

No.	Revision/Issue	Date

DeHaan, Grabs & Associates, LLC
Consulting Engineers
PO Box 522, Mandan, ND 58554
(701) 663-1116, FAX: (701) 667-1356
www.dgaengineering.com

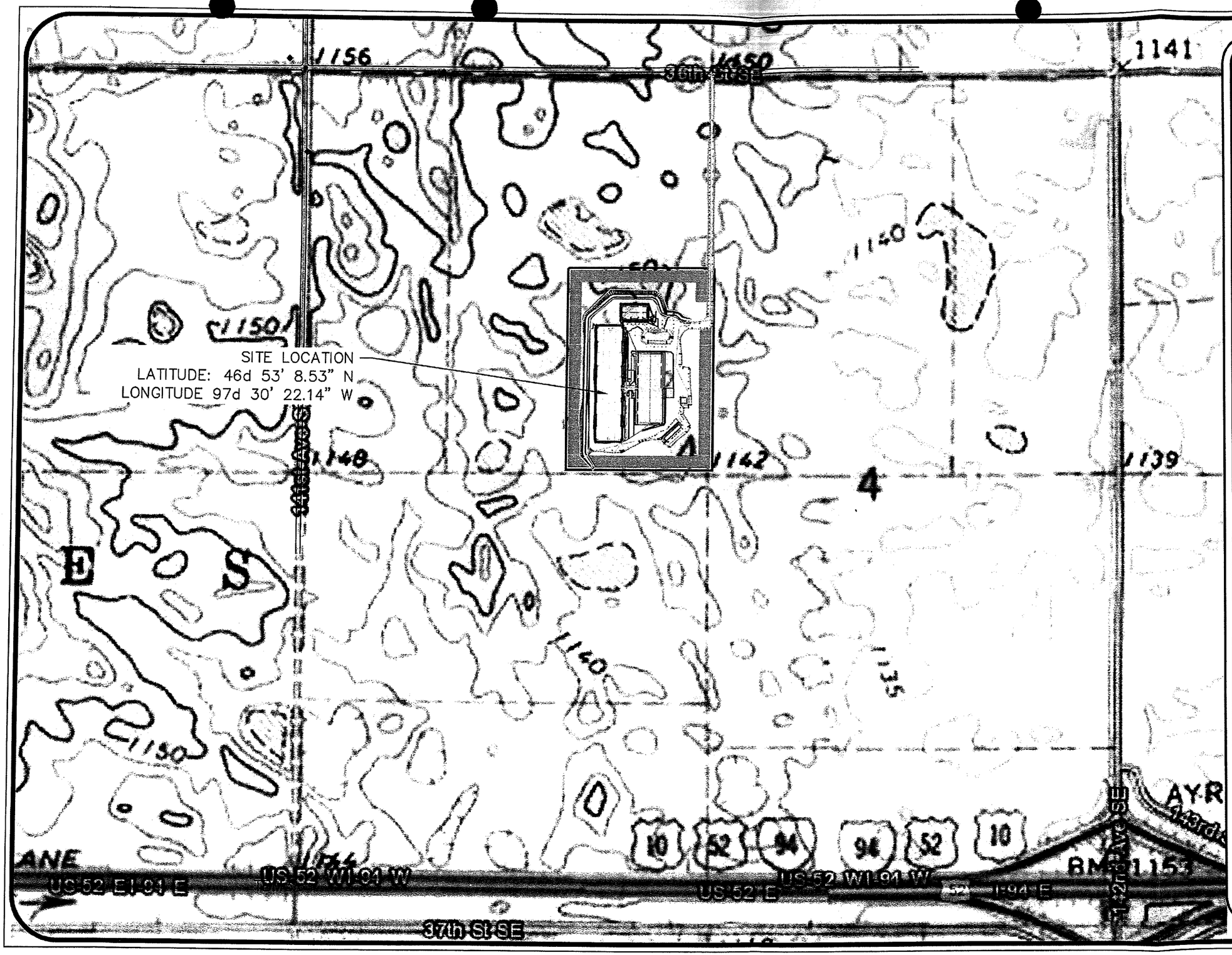
ROLLING GREEN SOW FARM
PIPESTONE VET

NW 1/4, SECTION 4, T 139 N, R 54 W
CASS COUNTY, ND

AERIAL SITE LOCATION

DATE: MAY 4, 2015	SHEET: 1
SCALE: 1" = 2,000'	
DRAWN BY: NAP	
CHECKED BY: DLD	

FILE NAME: ND PROJECT FILES/SWINE/ROLLING GREEN/CFILES/PLAN



GENERAL NOTES

LEGEND

N

SCALE, FEET

0 300 600 900 1200

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

No.	Revision/Issue	Date

DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
PO Box 522 | Mandan, ND | 58554

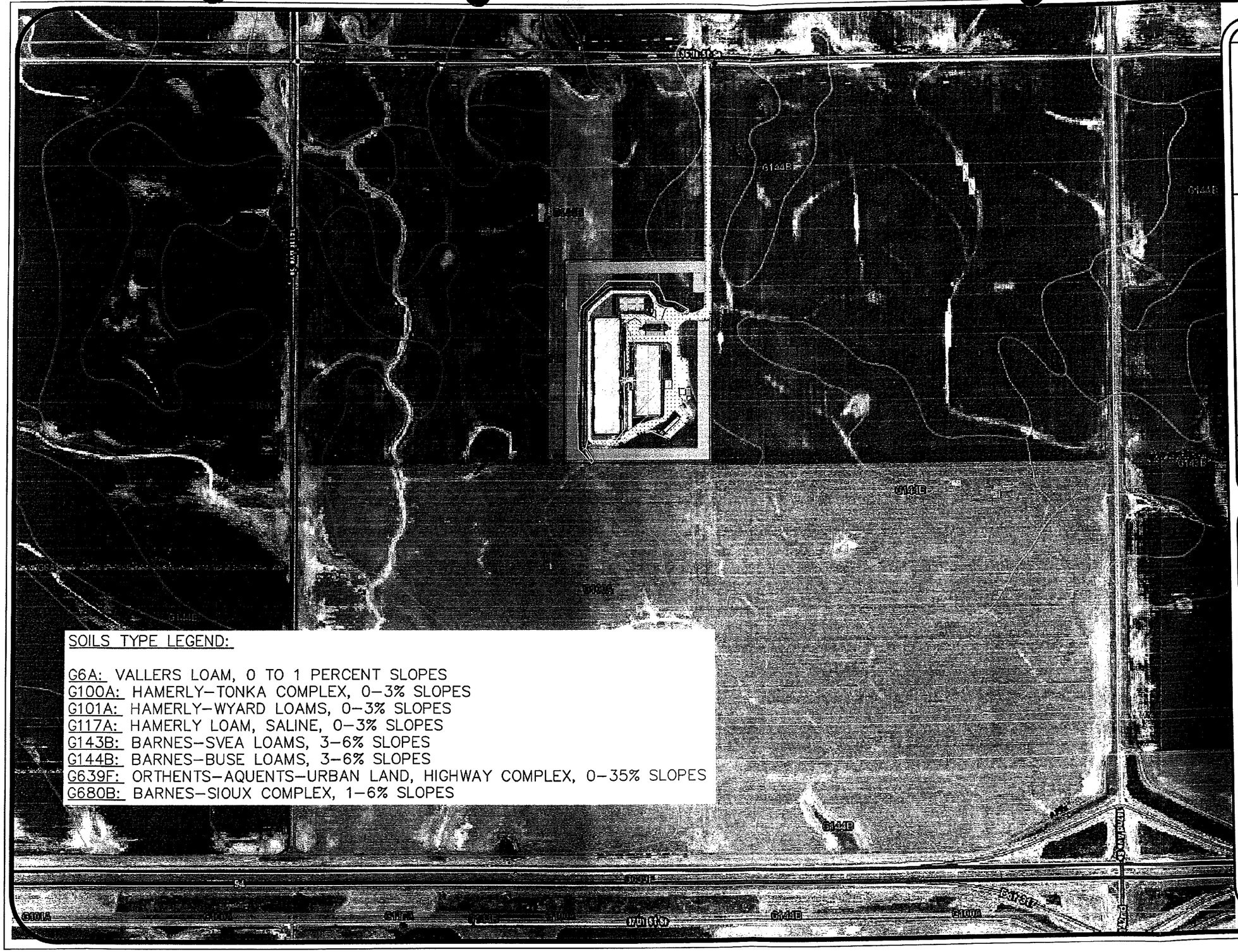
ROLLING GREEN SOW FARM
PIPESTONE VET

NW 1/4, SECTION 4, T 139 N, R 54 W
CASS COUNTY, ND

USGS SITE LOCATION

DATE: JULY 7, 2015	SHEET: 2
SCALE: 1" = 600'	
DRAWN BY: DDR	
CHECKED BY: NAP	

FILE NAME: ND PROJECT FILES/SWINE/ROLLING GREEN/CFILES/PLAN



SOILS TYPE LEGEND:

G6A: VALLERS LOAM, 0 TO 1 PERCENT SLOPES
G100A: HAMERLY–TONKA COMPLEX, 0–3% SLOPES
G101A: HAMERLY–WYARD LOAMS, 0–3% SLOPES
G117A: HAMERLY LOAM, SALINE, 0–3% SLOPES
G143B: BARNES–SVEA LOAMS, 3–6% SLOPES
G144B: BARNES–BUSE LOAMS, 3–6% SLOPES
G639F: ORTHENTS–AQUENTS–URBAN LAND, HIGHWAY COMPLEX, 0–35% SLOPES
G680B: BARNES–SIOUX COMPLEX, 1–6% SLOPES

GENERAL NOTES

LEGEND

N

SCALE, FEET

0 300 600 900 1200

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

No.	Revision/Issue	Date

DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
PO Box 522 | Mandan, ND | 58554

ROLLING GREEN SOW FARM
PIPESTONE VET

NW 1/4, SECTION 4, T 139 N, R 54 W
CASS COUNTY, ND

SOIL SURVEY MAP

DATE: AUG 24, 2015	SHEET: 3
SCALE: 1" = 600'	
DRAWN BY: DDR	
CHECKED BY: NAP	

FILE NAME: ND PROJECT FILES/SWINE/ROLLING GREEN/CFILES/PLAN

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Section 5: Technical Specifications

SECTION 5: CONSTRUCTION SPECIFICATIONS

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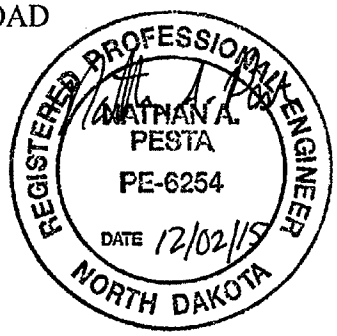

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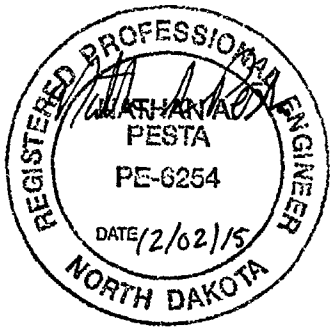

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I. EARTHEN CONTROL STRUCTURES

A. SAFETY

The contractor is solely responsible for being aware of and meeting all safety requirements for work on this site. These may include but are not limited to requirements set forth by OSHA, the State or the County. The contractor is also responsible for locating any underground power lines, pipelines, phone lines, etc. in the area of excavation. This shall include notifying the North Dakota One-Call System at least two days prior to the start of excavation activities.

If at any time, the contractor feels that due to site conditions, the construction techniques outlined in the Plans and Technical Specifications are not safe, he shall immediately stop work and contact the engineer, and an alternative method shall be determined.

B. SITE PREPARATION

The foundation and borrow area of all proposed earthwork areas shall be cleared of all old equipment, old buildings, trees, stumps, roots, brush and boulders and stripped of all sod and topsoil. All channel banks and sharp breaks shall be sloped no steeper than 1:1. All topsoil containing substantial organic matter shall be removed and stockpiled. The surface of the foundation area will be thoroughly scarified to a minimum depth of 4 inches before placement of compacted backfill. All drainage channels crossing fill areas shall be cleaned and widened to accommodate compaction equipment. Such channels shall be backfilled with suitable material as specified for compacted earthfill. All waste material shall be buried away from the fill area.

C. EXCAVATION

Unless specified by the Engineer, no borrow material shall be taken from areas outside the concrete tank area or designated borrow areas except for excavation of ditches or other structures shown on the plans. All materials undesirable for fill purposes shall be stripped from the borrow areas and either stockpiled for later use as topsoil or disposed of properly. The tank area shall be excavated to the lines and grades as shown on the plans. Any borrow areas outside the impoundment area shall be graded and left in a well-drained condition.

While excavating the tank the cut should be no steeper than 1:1 after four feet. If cut slope surfaces are unstable they shall be supported to prevent soil movement. The Contractor shall furnish, place, and subsequently remove the supports. The excavation for rigid conduit can be by Method 1, 2, or3.

The contractor shall be responsible for the removal of excess water from any portion of

the job site and all necessary equipment. In addition the contractor is responsible for ensuring that all applicable permits have been obtained prior to any dewatering. Pumping of ponded water, if necessary during construction, shall be conducted in a timely manner to prevent saturation of large areas of the borrow pit and outletted to an acceptable drainage course as determined by the Engineer.

D. BUILDING PAD/DRIVEWAY/SERVICE ROAD

Earthfill shall be placed to the lines and grades as shown on the plans on all areas for proposed building construction. Compaction shall be performed to each 8 inch loose fill lift by means of a minimum of 6 passes of a standard sheepsfoot roller so that the sheepsfoot roller walks out of each lift to ensure the area has been uniformly compacted; or the compaction shall be performed to each lift by means of controlled travel of loaded rubber-tired compaction equipment or standard sheepsfoot roller so that the fill area has been uniformly compacted to 95% Standard Proctor Density (ASTM D-698) as determined by a testing lab approved by the Engineer. Each pass of soil loading and compaction equipment should travel parallel to the length of the buildings. The moisture content at the time of compaction for cohesive soils shall be consistent with the requirements of compaction at the optimum moisture content.

E. GRAVEL

This item shall consist of performing the work necessary supply and place gravel for access road areas to the locations, dimensions and grades shown on the drawings. Final elevation tolerances are $\pm$ 0.1'. Contractor shall have the equipment and ability to transfer elevations from construction stakes and blue tops.

a) All gravel earthfills shall have a workmanlike finish (i.e. smoothed and grades with proper equipment).

b) The fill materials, noted in drawings, for construction access roads shall be:

1) Medium Class Gravel:

i) Gravel shall have a uniform range of sizes, with no more than 15% passing the No. 200 sieve and stones no larger than 2"

ii) Gravel shall be compacted in 6" lifts by 2 passes over entire surface with a vibratory roller or rubber tire type compactor.

iii) Gravel shall be leveled and graded with a road grader.

2) Heavy Class Gravel:

i) Gravel shall have a uniform range of sizes, with no more than 10% passing the No. 200 sieve and shall not have stones larger than 1 inch. (Class 5)

ii) Gravel shall be compacted in 6" lifts by 2 passes over entire surface with a vibratory roller or rubber tire type compactor.

iii) Gravel shall be leveled and graded with a road grader.

c) All organic material and topsoil shall be removed prior to areas with fill as

shown on drawings and replaced with compacted mineral earthfill. These areas shall be graded, roller compacted, and smoothed prior to geotextile and fill placement. These areas shall be brought up to top of sub-grade in low lying areas with earthfill material (mineral soils; not topsoil or organic materials).
d) Gravel material shall be underlain with a woven geotextile.
e) The access road shall be shaped as shown on drawings.

F. GEOTEXTILE

In designated areas, heavy class gravel will be underlain by a woven geotextile. The geotextile will be installed as follows:

The geotextile shall be joined by overlapping a minimum of 18 inches (unless otherwise specified) and secured against the underlying foundation material. Securing pins, approved and provided by the geotextile manufacturer, shall be placed along the edge of the panel or roll material to adequately hold it in place during installation. Pins shall be steel or fiberglass formed as a **U, L,** or **T** shape or contain "ears" to prevent total penetration through the geotextile. Steel washers shall be provided on all but the **U**-shaped pins. The upstream or upslope geotextile shall overlap the abutting downslope geotextile. At vertical laps, securing pins shall be inserted through the bottom layers along a line through approximately the mid-point of the overlap. At horizontal laps and across slope labs, securing shall be inserted through the bottom layer only. Securing pins shall be placed along a line about 2 inches in from the edge of the placed geotextile at intervals not to exceed 12 feet unless otherwise specified. Additional pins shall be installed as necessary and where appropriate to prevent any undue slippage or movement of the geotextile. The use of securing pins will be held to the minimum necessary. Pins are to remain in place unless otherwise specified.

Should the geotextile be torn or punctured, or the overlaps or sewn joint disturbed, as evidenced by visible geotextile damage, subgrade pumping, intrusion, or grade distortion, the backfill around the damaged or displaced area shall be removed and restored to the original approved condition. The repair shall consist of a patch of the same type of geotextile being used and overlaying the existing geotextile. When the geotextile seams are required to be sewn, the overlay patch shall extend a minimum of 1 foot beyond the edge of any damaged area and joined by sewing as required for the original geotextile except that the sewing shall be a minimum of 6 inches from the edge of the damaged geotextile. Geotextile panels joined by overlap shall have the patch extend a minimum of 2 feet from the edge of any damaged area.

The geotextile shall be unrolled in a direction parallel to the roadway centerline in a loose manner permitting conformation to the surface

irregularities when the roadway fill material is placed on its surface. In no case shall material be dropped on uncovered geotextile from a height of more than 5 feet. Unless otherwise specified, the minimum overlap of geotextile panels joined without sewing shall be 24 inches. The geotextile may be temporarily secured with pins recommended or provided by the manufacturer, but they shall be removed before the permanent covering material is placed. Woven geotextile shall have a minimum tensile strength of 120 lbs., conforming to ASTM Specification D 4632 (grab test method) and shall have an apparent opening size (AOS) ranging between 40 and 100 U.S. Standard sieve, conforming to ASTM Specification D 4751.

If Proctor Density tests are to be performed on-site, a minimum of 2 field density tests per 8 inch lift per building site shall be performed during construction to verify compaction quality or as determined by the Engineer based on compaction results. The compaction tests are to be paid for by the Owner. Nuclear or other standard field density test methods are acceptable for this project. Grade tolerance on building site earthwork shall be -0.10 to +0.10 ft.

G. CULVERTS

The culvert structures shall be installed to the lines and grades as shown on the plans. The culverts shall be sized as according to the plans and they shall be HDPE smooth lined corrugated high density polyethylene pipe or equivalent. Fittings and appurtenances shall be made of the same material as the pipe.

The culverts shall be bedded with a minimum of 3 inches of coarse grained material (sand, gravel or crushed rock) with a maximum diameter size of 1 inch. Initial backfill for 12 inches on both sides of the pipe and 12 inches above the top of the pipe shall consist of the same coarse grained material as the bedding. Initial backfill shall first be worked and compacted under the haunches of the pipe to provide continuous support up to the pipe centerline in layers not more than six inches thick. The remainder of the initial backfill shall then be placed in layers not more than six inches thick. Care must be taken during initial backfill to ensure that tamping or vibratory equipment does not deform or displace the culvert. Final backfill shall consist of the remaining earthfill from the top of the initial backfill to the ground surface, including mounding for settlement. Final backfill shall be free of debris, rocks or other objects with a three inch nominal diameter or larger.

H. TOPSOIL

All cut and fill areas along side roads and building areas will have the entire back slope of the embankment be covered with a minimum of 6 inches of topsoil. The topsoil shall be placed during the normal fill operation, so no additional payment will

be made for same. Topsoil shall be worked and bonded to the underlying fill and compacted to the same specifications as the underlying fill.

I. SEEDING

All cut and fill areas above the crest of the permanent impoundment pool and the entire back slope of the embankment shall be seeded to perennial grass as specified by the Natural Resource Conservation Service recommended guidelines for seeding in the area of the state the project is located.

J. CLEAN UP

During construction the Contractor shall keep the work site, areas adjacent to the work site and access roads in an orderly condition. Any spillage or debris resulting from the Contractor's operations shall be immediately removed. Upon completion, all debris, etc. shall be removed from the area. All access roads, other than public, shall be graded, smoothed over and left in a well-drained condition prior to equipment removal.

CONCRETE CONSTRUCTION SPECIFICATION

2.1 SCOPE

The work shall consist of furnishing, forming, placing, finishing, and curing portland cement concrete as required to build the structures described in Section 24 of this specification.

2.2 MATERIALS

Aggregates shall conform to the requirements of Material Specification 522 unless otherwise specified. The grading of coarse aggregates shall be as specified in Section 24.

Portland cement shall conform to the requirements of Material Specification 531 for the specified type.

Fly ash shall conform to the requirements of Material Specification 532.

Air-entraining admixtures shall conform to the requirements of Material Specification 533. If air-entraining cement is used, any additional air-entraining admixture shall be of the same type as that in cement.

Water reducing and/or retarding admixtures shall conform ot the requirements of Material Specification 533.

Curing compound shall conform to the requirements fo Material Specification 534.

Preformed expansion joint filler shall conform to the requirements of Material Specification 535.

Waterstops shall conform to the requirements of Material Specifications 537 and 538 for the specified kinds.

Water used in mixing and curing concrete shall be clean and free from injurious amounts of oil, salt, acid, alkali, organic matter or other deleterious substances.

2.3 STRENGTH OF CONCRETE

All concrete shall have the minimum compressive strength as specified on the included plans. Compressive strength shall be tested in conformance with Section 6 of this document.

2.4 AIR CONTENT AND CONSISTENCY

Unless otherwise specified in Section 24, the slump shall be 3 to 5 inches. If air entrainment is specified, the air content by volume shall be 5 to 8 percent of the volume of the concrete. When specified, directed or approved by the Engineer or his designated representative, a water-reducing, set-retarding or other admixture shall be used. High Range Water Reducing Agents (Superplasticizers) may be used to increase workability reduce water content and control concrete temperature in hot weather. The maximum slump after adding high range water reducing agents shall be 7-1/2 inches.

2.5 DESIGN OF THE CONCRETE MIX

The proportions of the aggregates shall be such as to produce a concrete mixture that will work readily into the corners and angles of the forms and around reinforcement when consolidated, but will not segregate or exude free water during consolidation.

Fly ash may be used as a partial substitution for Portland cement in an amount not greater than 25 percent (by weight) of the cement in the concrete mix, unless otherwise specified.

2.6 INSPECTION AND TESTING

The Engineer or his designated representative shall have free entry to the plant and equipment furnishing concrete under the contract. Proper facilities shall be provided for the Engineer or his designated representative to inspect materials, equipment and processes and to obtain samples of the concrete. All tests and inspections will be conducted so as not to interfere unnecessarily with manufacture and delivery of the concrete.

Slump and a minimum of 3 cylinders shall be taken at an interval of at least every 100 CY of concrete or once per pour, whichever is greater. One cylinder of each set shall be tested at 7 days and one at 28 days. The third shall be kept for re-testing if necessary. If any of the 28-day tests fail to meet the minimum compressive strength specified on the construction plans, the extra cylinder shall be tested. If the both the 28-day and the extra cylinder fail to meet the minimum required compressive strength, a minimum of 3 concrete cores shall be taken of the area in question and tested for compressive strength at the contractor's expense. In the event that the compressive strength of the core samples fails to meet the specified minimum, the area in question shall be removed and replaced

per Section 20 of this document and retested. As an alternative to removal and replacement, retrofitting options may be submitted to the engineer for approval on a case by case basis.

2.7 HANDLING AND MEASUREMENT OF MATERIALS

Materials shall be stockpiled and batched by methods that will prevent segregation or contamination of aggregates and insure accurate proportioning of the ingredients of the mix.

Except as otherwise provided in Section 8, cement and aggregates shall be measured as follows:

Cement shall be measured by weight or in bags of 94 pounds each. When cement is measured in bags, no fraction of a bag shall be used unless weighed.

Aggregates shall be measured by weight. Mix proportions shall be based on saturated, surface-dry weights. The batch weight of each aggregate shall be the required saturated, surface-dry weight plus the weight of surface moisture it contains.

Water shall be measured, by volume or by weight, to an accuracy within one percent of the total quantity of water required for the batch.

Admixtures shall be measured within a limit of accuracy of three percent.

2.8 MIXERS AND MIXING

Concrete shall be uniform and thoroughly mixed when delivered to the work site. Variations in slump of more than one (l) inch within a batch will be considered evidence of inadequate mixing and shall be corrected by increasing mixing time or other acceptable alternative.

For stationary mixers, the mixing time after all cement and aggregates are in the mixer drum shall be not less than 1-1/2 minutes. When concrete is mixed in a truck mixer, the number of revolutions of the drum or blades at mixing speed shall be not less than 70 nor more than 100.

No mixing water in excess of the amount called for by the job mix shall be added to the concrete during mixing or hauling or after arrival at the delivery point.

2.9 FORMS

Forms shall be of wood, plywood, steel or other approved material and shall be mortar tight. The forms and associated falsework shall be substantial and unyielding and shall be

constructed so that the finished concrete will conform to the specified dimensions and contours. Form surfaces shall be smooth and free from holes, dents, sags or other irregularities. Forms shall be coated with a non-staining form release agent before being set into place.

Metal ties or anchorages within the forms shall be equipped with cones, she-bolts or other devices that permit their removal to a depth of at least one inch without injury to the concrete. Ties designed to break off below the surface of the concrete shall not be used without cones.

All edges that will be exposed to view when the structure is completed shall be chamfered, unless finished with molding tools as specified in Section 18.

2.10 PREPARATION OF FORMS AND SUBGRADE

Prior to placement of concrete, the forms and subgrade shall be free of chips, sawdust, debris, water, ice, snow, extraneous oil, mortar, or other harmful substances or coatings and the temperature of all surfaces to be in contact with the new concrete shall be not be less than 40°F. Any oil on the reinforcing steel or other surfaces required to be bonded to the concrete shall be removed. Rock surfaces shall be cleaned by air-water cutting, wet sandblasting or wire brush scrubbing, as necessary, and shall be wetted immediately prior to placement of concrete. Placement of concrete on mud, dried earth or un-compacted fill or frozen subgrade will not be permitted. Earth surfaces shall be firm and damp. Granular subgrade material, if required, shall be graded and compacted as described in Section 24 of this specification.

Items to be embedded in the concrete shall be positioned accurately and anchored firmly.

Weepholes in walls or slabs shall be formed with nonferrous materials.

2.11 CONVEYING

Concrete shall be delivered to the site and discharged into the forms within 1-1/2 hours after the introduction of the cement to the aggregates. In hot weather or under conditions contributing to quick stiffening of the concrete, the time between the introduction of the cement to the aggregates and discharge shall not exceed 45 minutes.

The Engineer or his designated representative may allow a longer time, provided the setting time of the concrete is increased a corresponding amount by the addition of an approved set-retarding admixture. In any case, concrete shall be conveyed from the mixer to the forms as rapidly as practicable by methods that will prevent segregation of the aggregates and no loss of mortar occurs.

2.12 PLACING

The Contractor shall give reasonable notice to the Engineer or his designated representative each time he intends to place concrete. Such notice shall provide sufficient time for the Engineer or his designated representative to inspect the subgrade, forms, steel reinforcement and other preparations for compliance with the specifications. "Other preparations" include but are not limited to the concrete mixing plant, delivery equipment system, placing, finishing, and curing equipment and system, schedule of work, workforce, heating or cooling facilities if applicable. Deficiencies are to be corrected before concrete is delivered for placing.

When placing the concrete, it shall be conveyed to the forms in such a manner to prevent segregation of aggregates. The concrete shall be deposited as closely as possible to its final position in the forms and shall be worked into the corners and angles of the forms and around all reinforcement and embedded items in a manner to prevent segregation of aggregates or excessive laitance. Formed concrete shall be placed in horizontal layers not more than 20 inches thick. Concrete shall not be dropped more than 10 feet vertically unless suitable equipment is used to prevent segregation. When high range water reducing agents are used, the concrete shall not be allowed to drop more than 15 feet. Hoppers and chutes, pipes or "elephant trunks" shall be used as necessary to prevent segregation and the splashing of mortar on the forms and reinforcing steel above the layer being placed.

Immediately after the concrete is placed in the forms, it shall be consolidated by spading, hand tamping or vibration as necessary to insure smooth surfaces and dense concrete. Each layer shall be consolidated to insure monolithic bond with the preceding layer. If the surface of a layer of concrete in-place sets to the degree that it will not flow and merge with the succeeding layer when spaded or vibrated, the Contractor shall discontinue placing concrete and shall make a construction joint according to the procedure specified in Section 13.

If placing is discontinued when an incomplete horizontal layer is in place, the unfinished end of the layer shall be formed by a vertical bulkhead.

2.13 CONSTRUCTION JOINTS

Construction joints shall be made at the locations shown on the drawings. If construction joints are needed which are not shown on the drawings, they shall be placed in locations approved by the Engineer or his designated representative.

Where a feather edge would be produced at a construction joint, as in the top surface of a sloping wall, an insert form shall be used so that the resulting edge thickness on either side of the joint is not less than 6-inches.

In walls and columns, as each lift is completed, the top surfaces shall be immediately and

carefully protected from any condition that might adversely affect the hardening of the concrete.

Steel tying and form construction adjacent to concrete in-place shall not be started until the concrete has cured at least 12-hours. Before new concrete is deposited on or against concrete that has hardened, the forms shall be re-tightened. New concrete shall not be placed until the hardened concrete has cured at least 12-hours.

Surfaces of construction joints shall be cleaned of all unsatisfactory concrete, laitance, coatings or debris by washing and scrubbing with a wire brush or wire broom or by other means approved by the Engineer or his designated representative. The surfaces shall be kept moist for at least one hour prior to placement of the new concrete.

2.14 EXPANSION AND CONTRACTION JOINTS

Expansion and contraction joints shall be made only at locations shown on the drawings.

Exposed concrete edges at expansion and contraction joints shall be carefully tooled or chamfered, and the joints shall be free of mortar and concrete. Joint filler shall be left exposed for its full length with clean and true edges.

Preformed expansion joint filler shall be held firmly in the correct position as the concrete is placed.

When open joints are specified, they shall be constructed by the insertion and subsequent removal of a wooden strip, metal plate or other suitable template in such a manner that the corners of the concrete will not be chipped or broken. The edges of open joints shall be finished with an edging tool prior to removal of the joint strips.

2.15 WATERSTOPS

Waterstops shall be held firmly in the correct position as the concrete is placed. Joints in metal waterstops shall be soldered, brazed or welded. Joints in rubber or plastic waterstops shall be cemented, welded or vulcanized as recommended by the manufacturer. Joints shall be watertight and of a strength equivalent to that specified in Material Specification 537. Intersecting waterstop joints shall be prefabricated and supplied by the same manufacturer providing the waterstop.

2.16 REMOVAL OF FORMS

Forms shall be removed in such a way as to prevent damage to the concrete. Supports shall be removed in a manner that will permit the concrete to take the stresses due to its own weight uniformly and gradually.

2.17 FINISHING FORMED SURFACES

Immediately after the removal of the forms:

a. All fins and irregular projections shall be removed from exposed surfaces.

b. Unless otherwise specified in Section 24, the holes produced on all surfaces by the removal of form ties, cone-bolts, and she-bolts shall be cleaned, wetted and filled with a dry-pack mortar consisting of one part portland cement, three parts sand that will pass a No. 16 sieve, and just sufficient water to produce a consistency such that the filling is at the point of becoming rubbery when the material is solidly packed.

2.18 FINISHING UNFORMED SURFACES

All exposed surfaces of the concrete shall be accurately screeded to grade and then float finished, unless specified otherwise.

Excessive floating or troweling of surfaces while the concrete is soft will not be permitted.

The addition of dry cement or water to the surface of the screeded concrete to expedite finishing will not be allowed.

Joints and edges on unformed surfaces that will be exposed to view shall be chamfered or finished with molding tools.

2.19 CURING

Concrete shall be prevented from drying for a curing period of at least 7 days after it is placed. Exposed surfaces shall be kept continuously moist for the entire period, or until curing compound is applied as specified below. Moisture shall be maintained by sprinkling, flooding or fog spraying or by covering with continuously moistened canvas, cloth mats, straw, sand or other approved material. Wood forms left in-place during the curing period shall be kept continuously wet. Formed surfaces shall be thoroughly wetted immediately after forms are removed and shall be kept wet until patching and repairs are completed. Water or covering shall be applied in such a way that the concrete surface is not eroded or otherwise damaged.

Concrete, except at construction joints, may be coated with the approved curing compound in lieu of continued application of moisture, except as otherwise specified in Section 24. The compound shall be sprayed on the moist concrete surfaces as soon as free water has disappeared, but shall not be applied to any surface until patching, repairs and finishing of that surface are completed. The compound shall be applied at a uniform

rate of not less than one gallon per 175 square feet of surface and shall form a continuous adherent membrane over the entire surface. Curing compound shall be thoroughly mixed before applying and continuously agitated during application. Curing compound shall not be applied to surfaces requiring bond to subsequently placed concrete, such as construction joints, shear plates, reinforcing steel and other embedded items. If the membrane is damaged during the curing period, the damaged area shall be re-sprayed at the rate of application specified above. Surfaces covered by the membrane shall not be trafficked unless protected from wear.

2.20 REMOVAL AND REPLACEMENT OR REPAIR

When concrete is honeycombed, damaged or otherwise defective, the Contractor shall remove and replace the structure or structural member containing the defective concrete or, where feasible, correct or repair the defective parts. The Engineer or his designated representative will determine the required extent of removal, replacement or repair. Prior to starting repair work the Contractor shall obtain the Engineer's or his designated representative's approval of his plan for effecting the repair. The Contractor shall perform all repair work in the presence of the Engineer or his designated representative.

2.21 CONCRETING IN COLD WEATHER

Concrete shall not be mixed nor placed when the daily minimum atmospheric temperature is less than 40°F unless facilities are provided to prevent the concrete from freezing or appropriate non-chloride based accelerators are used. If accelerators or antifreeze compounds are planned to be used, the Engineer shall be notified at least 2 days prior to their use for review.

2.22 CONCRETING IN HOT WEATHER

The Contractor shall apply effective means to maintain the temperature of the concrete below 90°F during mixing, conveying and placing.

2.23 MEASUREMENT AND PAYMENT

For items of work for which specific unit prices are established in the contract, concrete will be measured to the neat lines shown on the drawings and the volume of concrete will be computed to the nearest 0.1 cubic yard. Measurement of concrete placed against the sides of an excavation without the use of intervening forms will be made only to the neat lines or pay limits shown on the drawings. No deduction in volume will be made for chamfers, rounded or beveled edges or for any void or embedded item that is less than five (5) cubic feet in volume.

Payment for each item of structure concrete will be made at the contract unit price or the

contract lump sum, whichever is applicable, for that item. Such payment will constitute full compensation for all labor, materials, equipment, transportation, tools, forms, falsework, bracing and all other items necessary and incidental to the completion of the work, except items listed for payment elsewhere in the contract.

Compensation for any item of work described in the contract but not listed in the bid schedule will be included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in Section 24 of this specification.

2.24 ITEMS OF WORK AND CONSTRUCTION DETAILS

Items of work to be performed in conformance with this specification and the construction details therefor are:

2.24.1 Reinforced Concrete

2.24.1.1 This item shall consist of furnishing and placing concrete as shown in the plans.

2.24.1.2 Cement shall be Type I, IA (air-entrained), II or IIA (air-entrained).

2.24.1.3 Concrete shall be air-entrained. The air content (by volume) of the concrete at time of placement shall be 5 to 8 percent.

2.24.1.4 The gradation of the coarse aggregate shall be Size No. 57 as defined in ASTM C-33.

2.24.1.5 At least 30% of the total weight of aggregate shall be coarse aggregate crushed limestone.

2.24.1.6 Slump shall be 3" plus or minus 1" for concrete without admixtures. If water reducing agents the maximum slump may be increased to 7.5".

2.24.1.6 The temperature of the concrete at the time of placement shall not be less than 40oF nor greater than 90oF.

2.24.1.7 Non-shrink grout shall be used everywhere that grouting is required.

2.24.1.8 The contractor shall be required to have, as a minimum,

two mechanical vibrators in working condition for consolidation of concrete on the site during concrete placement operations.

2.24.1.9 The granular subgrade shall meet the Nebraska Department of Roads gradation 47B (fine aggregate for concrete), and shall be compacted as follows:

2.24.1.9.1 The subgrade material shall be thoroughly wet prior to compaction.

2.24.1.9.2 Compaction shall be accomplished while the material is wet from the above step.

2.24.1.9.3 The subgrade shall be compacted by 2 (minimum) passes of a hand-directed, vibratory compactor over the entire surface.

2.24.1.7 Payment for concrete will be made as per agreement between the Contractor and Cooperator, which may or may not be a contract lump sum price.

2.24.2 Subsidiary Item, Waterstops

This item shall consist of furnishing and installing the waterstops as shown on the drawings. Separate payment will not be made for waterstops, as compensation will be considered in the payment for concrete.

2.24.3 Subsidiary Item, Grouting between gang slat panels

This item shall consist of furnishing and placing grout between the gang slat panels as described on the drawings. Separate payment will not be made for grouting, as compensation will be considered in the payment for concrete.

2.24.4 Subsidiary Item, Grouting between slat support girders

This item shall consist of furnishing and placing grout between the slat support girders as described on the drawings. Separate payment will not be made for grouting, as compensation will be considered in the payment for concrete.

3. STEEL REINFORCEMENT FOR CONCRETE CONSTRUCTION SPECIFICATION

3.1 SCOPE

The work shall consist of furnishing and placing steel reinforcement for reinforced concrete or pneumatically applied mortar.

3.2 MATERIALS

Steel reinforcement shall conform to the requirements of Material Specification 539. Before reinforcement is placed, the surfaces of the bars and fabric and any metal supports shall be cleaned to remove any loose, flaky rust, mill scale, oil, grease or other undesirable coatings or foreign substances. Epoxy-coated steel reinforcement shall be free of surface damage. After placement, the reinforcement shall be maintained in a clean and serviceable condition until it is completely embedded within the concrete.

3.3 BAR SCHEDULE, LISTS AND DIAGRAMS

Any supplemental bar schedules, bar lists or bar-bending diagrams required in Section 10 of this specification to accomplish the fabrication and placement of steel reinforcement shall be provided by the Contractor. Prior to placement of reinforcement, the Contractor shall furnish four copies of any such lists or diagrams to the Engineer or his designated representative for approval. Acceptance of the reinforcement will not be based on approval of these lists or diagrams, but will be based on inspection of the steel reinforcement after it has been placed, tied, supported and ready to receive concrete.

3.4 BENDING

Reinforcement shall be cut and bent in compliance with the requirements of the American Concrete Institute Standard 315. Bars shall not be bent or straightened in a manner that will injure or weaken the material. Bars with kinks, cracks or improper bends will be rejected.

3.5 SPLICING BAR REINFORCEMENT

Locations for splices of reinforcement shall be left to the judgement of the Contractor. Splice lengths shall meet the requirements of ACI Standard 318 "Building Code Requirements for Reinforced Concrete" and are given in Section 10 of this specification. Locations where splices of reinforcement are not allowed are described in Section 10 of this specification.

3.6 SPLICING WELDED WIRE FABRIC

Unless otherwise specified, welded wire fabric shall be spliced in the following manner:

a. Adjacent sections shall be spliced end to end (longitudinal lap) by overlapping a minimum of one full mesh plus two (2) inches plus the length of the two end overhangs. The splice length is measured from the end of the longitudinal wires in one piece of fabric to the end Of the longitudinal wire in the lapped piece of fabric.

b. Adjacent sections shall be spliced side to side (transverse lap) a minimum of one full mesh plus two (2) inches. The splice length shall be measured from the centerline of the first longitudinal wire in one piece of fabric to the centerline of the first longitudinal wire in the lapped piece of fabric.

3.7 PLACING

Reinforcement shall be accurately placed and secured in position in a manner that will prevent its displacement during the placement of concrete. Tack welding of bars will not be permitted. Metal chairs, metal hangers, metal spacers and concrete chairs may be used to support the reinforcement. Metal hangers, spacers and ties shall be placed in such a manner that they will not be exposed in the finished concrete surface. The legs of metal chairs or side form spacers that may be exposed on any face of slabs, walls, beams or other concrete surfaces shall have a protective coating or finish by means of hot dip galvanizing, epoxy coating, plastic coating, or be stainless steel. Metal chairs and spacers not fully covered by a protective coating or finish shall have a minimum cover of 3/4 inch of concrete over the unprotected metal portion except for those with plastic coatings may have a minimum cover of 1/2 inch of concrete over the unprotected metal portion. Pre-cast concrete chairs shall be manufactured of the same class of concrete as specified for the structure and shall have the tie wires securely anchored in the chair or a V-shaped groove at least 3/4 inch in depth molded into the upper surface to receive the steel bar at the point of support. Pre-cast concrete chairs shall be clean and moist at the time concrete is placed.

High density or structural plastic rebar accessories, designed to insure maximum concrete bond, may be substituted for metal or concrete accessories in spacer applications as approved by the Engineer or his designated representative. Exposure of plastic rebar accessories at the finished concrete surface shall be kept to a minimum. Plastic rebar accessories, when used, shall be staggered along adjacent parallel bars and shall be placed at intervals no closer than twelve (12) inches. Plastic rebar accessories shall not be used in concrete section six (6) inches or less in thickness.

3.8 STORAGE

Steel reinforcement stored at the work site shall be placed on platforms, skids or other

supports and in a manner that contact with the ground is avoided and be protected from mechanical damage and/or corrosion.

3.9 MEASUREMENT AND PAYMENT

For items of work for which specific unit prices are established in the contract, the weight of steel reinforcement placed in the concrete in accordance with the drawings will be determined to the nearest pound by computation from the placing drawings. Measurement of hooks and bends will be based on the requirements of ACI Standard 315. Computation of weights of reinforcement will be based on the unit weights established in Tables 34-1 and 34-2 of this specification. Computation of weights for welded wire fabric not shown in Table 34-2 shall be based on ACI Standard 315. The area of welded wire fabric reinforcement placed in the concrete in accordance with the drawings will be determined to the nearest square foot by computation from the placing drawings with no allowance for required laps. The weight of steel reinforcing in extra splices or extra-length splices approved for the convenience of the Contractor or the weight of supports and ties will not be included in the measurement for payment.

Payment for furnishing and placing reinforcing steel will be made at the contract unit price. Such payment will constitute full compensation for all labor, materials, equipment and all other items necessary and incidental to the completion of the work including preparing and furnishing bar schedules, lists or diagrams; furnishing and attaching ties and supports; and furnishing, transporting, storing, cutting, bending, cleaning and securing all reinforcements.

Compensation for any item of work described in the contract, but not listed in the bid schedule, will be included in the payment for the item of work to which it is made subsidiary. Such items to which they are made subsidiary are identified in Section 10 of this specification.

TABLE 34-1. STANDARD REINFORCING BARS

Bar Size No.	Weight (lb./ft.)
3	0.376
4	0.668
5	1.043
6	1.502
7	2.044
8	2.670
9	3.400
10	4.303
11	5.313

14	7.650
18	13.600

TABLE 34-2. RECTANGULAR WELDED WIRE FABRIC *Style Designation*		
By Steel Wire Gauge	**By W-Number**	**(lb./100 Sq. Ft.)**
6 x 6 - 10 x 10	6 x 6 - W1.4 x W1.4	21
6 x 6 - 8 x 8	6 x 6 - W2.1 x W2.1	30
6 x 6 - 6 x 6	6 x 6 - W2.9 x W2.9	42
6 x 6 - 4 x 4	6 x 6 - W4.0 x W4.0	58
4 x 4 - 10 x 10	4 x 4 - W1.4 x W1.4	31
4 x 4 - 8 x 8	4 x 4 - W2.1 x W2.1	44
4 x 4 - 6 x 6	4 x 4 - W2.9 x W2.9	62
4 x 4 - 4 x 4	4 x 4 - W4.0 x W4.0	85
4 x 12 - 8 x 12	4 x 12 - W2.1 x W0.9*	25
4 x 12 - 7 x 11	4 x 12 - W2.5 x W1.1*	31

NOTE: Style Designation is defined in ACI Standard 315 of the American Concrete Institute.
*Welded smooth wire fabric with wires smaller than Size W1.4 is manufactured from galvanized wire.

3.10 ITEMS OF WORK AND CONSTRUCTION DETAILS

Items of work to be performed in conformance with this specification and the construction details therefore are:

3.10.1 Reinforcing Steel

3.10.1.1 This item shall consist of furnishing and placing reinforcing steel as shown on the plans.

3.10.1.2 All reinforcing steel (bars and wire mesh) shall be Grade 60.

3.10.1.3 Splice lengths shall be 25", 33", and 41" for #3, #4, and #5 bars respectively.

3.10.1.4 There shall be no splicing of the bars in the endwall beam (the heavily reinforced section of the endwall near the top) unless the splice occurs directly behind the center of the girder/endwall connection.

3.10.1.5 If any shop drawings are developed, copies will be given to the Engineer for review prior to construction.

3.10.1.6 Payment for reinforcing steel will be made as per agreement between the Contractor and Cooperator, which

4. PLASTIC SEWER PIPE AND FITTINGS

A. SCOPE.

The work specified under this section includes the manufacture, construction, and installation of polyvinyl chloride (PVC) pipe and fittings for gravity and pressure animal waste collection and transfer pipeline systems.

B. WASTE STORAGE TANK INLET STRUCTURES.

The inlet structures shall be defined as beginning at the final clean out and continuing through the inlet support in the waste storage TANK as shown on the plans. The inlet structures shall be installed to the lines and grades as shown on the plans. The inlets shall be constructed of PVC pipe. Pipe shall be hand back-filled and compacted a minimum of 3 feet from the waste storage tank interior finish line to preclude any seepage path along the pipe.

C. PIPELINE.

1. MATERIALS. Pipe used in all mains and services shall be rigid extruded Polyvinyl Chloride (PVC) pipe. All pipe used shall conform to Commercial Standard 256-63 for Polyvinyl Chloride (PVC) Pressure pipe, and ASAE Standard S376, Design, Installation and Performance of Underground Thermoplastic Irrigation Pipelines. All pipe shall have the following minimum strengths: SDR35 for gravity drains and SDR26 for pressure lines.
2. INSTALLATION. All pipe shall be clean on the inside and free of any foreign material. If the Engineer deems it necessary, the pipe shall be cleaned by passing a swab of the proper size through the pipe before joining. Once cleaned, the pipe shall be kept clean during and after installation. A tight cap shall be placed over the open end of the installed pipeline after each workday.
3. TRENCHING AND BACKFILL. Where possible the pipe trench shall be excavated to a depth sufficient to provide a minimum cover of 84 inches above the top of the pipe for pressure lines and 48 inches for gravity lines.

Backfill immediately adjoining the pipe to 12 inches above the pipe shall be loose soils or sand free from stone. Where possible this shall be obtained from the site, but if suitable material is not available on site, an acceptable borrow area, as determined by the Engineer, shall be supplied by the Owner. In areas where any rock is encountered, backfill pipe to avoid damage to the pipe and eliminate the presence of potentially damaging rock.

The remainder of the backfill may be placed by hand or machine. This material shall contain no rock larger than 6 inches in it's longest dimension except in areas where rip rap is needed in the top 6 inches of fill. Any rock incorporated as backfill must first be approved by the Engineer. In areas where no rock is encountered, all backfill may be machine placed. All waste rock and brush caused by the installation of the waterline shall be disposed of. Backfill shall be mounded over the trench to allow for future settlement. Vegetative reseeding shall be required only on large disturbed areas such as around the manhole site.

If the cover material is not available, then the pipe will need to be insulated from freezing conditions.

4. PIPE LAYING. Pipe routes shall be as shown on the plans. Pipe may be strung along in advance of trenching but only as may be reasonably installed in one work day.

   Trenches shall be allowed to nearly reach the temperature of the surrounding earth before attachment to fixed structures or back filling operations commence as outlined in ASAE Standard S376 for placement in extremely hot or cold weather.

5. SEWER LINES. All sewer lines shall be installed to the lines and grades as shown on the plans. Tolerance for sewer grades shall to +0.5% in any 100 foot section. No slope reversals shall be tolerated. All sewer pipe shall be SDR 35 PVC plastic with bell and gasket joints for gravity lines and SDR 26 PVC plastic with bell and gasket joints for pressure lines. All pipe shall be installed according to the ASTM Recommended Practice for the Installation of PVC Sewer Pipe ASTM 2341. Proper safety precautions for installations in deep trenches shall be followed at all times. Cleanouts shall be installed every 200 feet as shown on the plans. Earthfill over the sewer lines shall be compacted to the same density as is required in adjacent fill.

6. SEWER LINE ROUTES. Placement of fill over sewer lines shall follow procedures outlined in the waste retention pond embankment section of these specifications. Minimum 84 inch cover depths shall be obtained over all pressure sewer lines and 48 inches over gravity lines by placement of additional fill in areas needed. Compaction of

this fill where not located under proposed buildings shall be to the same levels as specified for earthfill placed in the waste storage pond embankment. Where the sewer line is to be buried on the pond dike, adequate excess fill above design height shall be place to maintain 4 feet of cover there also. The fill required to do this shall be placed on the top of the berm and blended in with the design slopes of the berm. Adequate measures shall be taken to insure drainage paths are not obstructed by earthfill placed to insure adequate sewer line cover. Grade on fill placed over sewer line routes shall be adequate to maintain proper surface drainage.

7. THRUST BLOCKING. Thrust blocking prevents line movement and is required primarily with rubber gasket joints. Thrust blocks are required at the following locations:
   a. Where the pipe changes the direction of the water (tees, elbows, crosses, etc.)
   b. Where the pipe size changes (reduces)
   c. At the end of the pipeline (clean outs, plugs, etc.)
   d. Where there is an in line valve.

   Thrust blocks shall be placed against a solid wall, usually hand excavated. Sizing and placement shall be determined as shown in the plans and ASAE S376 or a minimum of 2000 psi compressive strength at 28 days. Thrust blocking shall be provided similarly wherever needed in all suspended piping in the unit. Blocking shall provide neat, secure, and serviceable installation using suspension strapping, joint ties and other appropriate means as reviewed and approved by the Engineer.

8. INSPECTION. Each phase of construction of the lines shall be inspected and approved by the Engineer or a qualified representative of the Engineer.

   The inspector shall examine and determine the adequacy of the following construction steps:
   h. Trenching - minimum depth and condition of the bottom of trench.
   i. Placement of bedding material (if required).
   j. Installation of pipe (cleaning, joint testing, snaking, thrust blocks).
   k. Supervised backfill to 12 inches over pipe.
   l. Mechanical placed backfill in areas without rocks and above 12 inches over pipe.
   m. Testing - (pressure check, leak repair).

   In areas where rock is encountered, the bedding together with the first 12 inches of carefully placed fill shall be done only with the inspector

present.

9. ORDER OF WORK. Work shall commence at the point of connection to the source and commence in an orderly manner so that each section of line is tied together and tested in sequence. More than one section of line may be constructed at the same time, but work shall commence toward joining together all sections to be tested in sequence. Priority of construction shall be determined by the Engineer.

10. SYSTEM TESTING. All pressure lines shall be hydrostatically tested at the pressure rating of the pipe or 160 psi, whichever is less. The system shall be tested in segments that can be isolated by valving or dead ends in the finished system. Sufficient backfilling shall be carried out prior to testing to prevent damage to fittings caused by excessive pipe movement. Testing shall be conducted in the following manner:

    a. Slowly fill the pipe with water until all air is exhausted from the system. Bleed each meter site until all air is removed.

    b. Raise pressure to working strength of the pipe or 160 psi, whichever is less, based upon the lowest elevation of the pipe adjusted to the elevation of the pressure gauge. This should be done by controlled pumping from a container of known volume.

    c. Pressure must be maintained for 2 hours without additional pumping. A chart should be kept for each test performed showing pressure changes as a function of time. This can be manually recorded or recorded by appropriate instrumentation under the supervision of the inspector.

    If constant pressure cannot be maintained for 2 hours without additional pumping, a leak may be indicated in the segment. The leak shall be located and repaired and the segment retested. Entrapped air can cause pressure drops of up to 10 psi without a leak being present under certain conditions so a longer test period may be needed if air is believed to be in the system.

    If all means of finding a leak have been exhausted without success, the Engineer may use the following method to determine leakage:

    n. Fill containers of known volume and maintain pressure in segment for 2 hours by pumping from these containers.

    o. Measure water required to refill containers after 2 hour test period.

    p. Leakage shall not exceed 10 gallon per inch of pipe diameter per mile of pipe over 24 hours.

The inspector shall be present at times of testing and record results. The inspector shall make results of the tests available to the Owner. All defective materials found during testing shall be removed and replaced at the Contractor's expense. No segment of the line shall be approved by the Engineer until it has been successfully tested. The contractor shall furnish all the necessary equipment for testing and make the test at his own expense.

D. VALVE AND CLEANOUTS.

1. GATE VALVES. All valves shall be gate valves of equivalent size. All gate valves shall be iron body, bronze mounted, double disc, parallel seat type valves, designed and guaranteed for a working pressure of not less than 200 psi. Valves shall be "Kennedy AWWA" or equivalent with end connections for PVC pipe. Valve stems for key operated valves shall have a 2 inch square opening nut, secured with a lock nut.
2. CHECK VALVES. Where the check flow meters are shown on the final plans, the check valve shall be a 6" check valve or equivalent.
3. VALVE BOXES. Valve boxes shall either a PVC pipe sized and cut to the appropriate length for the valve installed or a typical valve box as shown on the plans. Boxes shall be of a length compatible with the depth of trench required. Boxes for all gate valves and cleanouts shall use 8 or 10 inch SDR 26 PVC pipe. Lids shall be either a standard PVC caps or a typical valve box as shown on the plans.
4. SETTING VALVES. Valves shall be located according to the instructions of the Engineer. The valve boxes shall be set directly over the valve, plumbed and top brought level with the ground and backfilled. The backfill shall be thoroughly tamped around the box.

E. CONCRETE.

All cement, water, aggregates and metal reinforcements shall conform to the requirements of the American Concrete Institute 318 "Building Code Requirements of Reinforced Concrete".
Strengths of concrete used in foundations for structures associated with the storage and distribution system shall be a minimum of 3000 psi at 28 days. Concrete work shall conform to all the requirements of ACI "Specifications for Structural Concrete for Building" except where specifically modified by written agreement between the Owner and the Contractor.

5. QUALITY ASSURANCE PROGRAM

A. LINES OF AUTHORITY

1. The ENGINEER will act in the capacity of the OWNER and will ensure the project is completed according to the DRAWINGS and SPECIFICATIONS.

2. The CONTRACTOR shall keep on the work site a copy of current DRAWINGS and SPECIFICATIONS.

3. In case of conflict between the DRAWINGS and SPECIFICATIONS, the SPECIFICATIONS shall govern. Figured dimensions on DRAWINGS shall govern over general DRAWINGS.

4. Any discrepancies found between the DRAWINGS and SPECIFICATIONS and site conditions or any inconsistencies or ambiguities in the DRAWINGS or SPECIFICATIONS shall be immediately reported to the ENGINEER, who shall promptly correct such inconsistencies or ambiguities.

B. SPECIALIZED SKILLS OR WORK QUALIFICATIONS

1. Any testing or inspection conducted will be under the approval of the ENGINEER.

2. All sampling and testing will be conducted by an authorized representative of the ENGINEER or by a testing company approved to conduct tests as specified in the SPECIFICATIONS.

C. OBSERVATION AND OVERSIGHT DUTIES

1. The ENGINEER or his representative will stake out the construction of the facility.

2. The construction will be inspected by the ENGINEER or his assigned representative.

3. During the construction of the following components the ENGINEER will have a representative on site.

a. Concrete Forming & Placement of Rebar
b. Concrete Pouring of Floor and Walls
c. Sewer Line Installation

4. After finished construction, the site will be measured by the ENGINEER to ensure it was constructed as planned.

D. TEST PROCEDURES, FREQUENCIES AND REPORTING

1. The Construction of the Site will meet the SPECIFICATIONS identified in this section.

2. The Engineer or his designated representative shall have free entry to the plant and equipment furnishing concrete under the contract. Proper facilities shall be provided for the Engineer or his designated representative to inspect materials, equipment and processes and to obtain samples of the concrete. All tests and inspections will be conducted so as not to interfere unnecessarily with manufacture and delivery of the concrete.

   Slump and a minimum of 3 cylinders shall be taken at an interval of no more than once each 100 CY of concrete or once per pour, whichever is greater. One cylinder of each set shall be tested at 7 days and one at 28 days. The third shall be kept for re testing if necessary. If any of the 28 day tests fail to meet the minimum compressive strength specified on the construction plans, the extra cylinder shall be tested. If the both the 28 day and the extra cylinder fail to meet the minimum required compressive strength, a minimum of 3 concrete cores shall be taken of the area in question and tested for compressive strength at the contractor's expense. In the event that the compressive strength of the core samples fails to meet the specified minimum, the area in question shall be removed and replaced as per the ENGINEER'S requirements and retested. As an alternative to removal and replacement, retrofitting options may be submitted to the engineer for approval on a case by case basis.

3. A final certification and report will be conducted by the ENGINEER to ensure that the facility is within $\pm$ 5 % in dimensions and that the liner as well as all critical components were constructed according to the DRAWINGS and SPECIFICATIONS.

Section 6: Zoning Requirements

SECTION 6: ZONING REQUIREMENTS

Zoning Requirement

Cass County does not require a conditional use permit. The site is located in Howes Township, there are no regulations that are shown on the ND Department of Health website.

Section 7: Water Quality Information

SECTION 7: WATER QUALITY INFORMATION

A. Well Water Quality Analysis

There is currently no active well on the proposed site. The primary source of water will be well water, which will require a well to be drilled on site. When a well is completed, the well logs will be supplied to the Department of Health along with the proper permitting conducted with the Water Commission.

B. Surface Water Analysis

There is no surface water on site and there is no glacial till aquifer under the facility. The closest documented aquifer is located approximately 7 miles to the west and is called the Tower City aquifer. The facility is located 4 miles from the Maple River and over 2 miles from an unnamed tributary to the Maple River.

C. Analysis of livestock waste or runoff

This is a total confinement new facility, therefore, no analysis of the livestock waste or runoff has been conducted.

Section 8: Geologic/Hydraulic or Soil Information

SECTION 8: Geologic/Hydraulic or Soils Information

A. Well logs for wells at the facility

There is currently no active well on the proposed site. The primary source of water will be well water, which will require a well to be drilled on site. When a well is completed, the well logs will be supplied to the Department of Health along with the proper permitting conducted with the Water Commission.

B. Geologic, ground or surface water studies

The geology was documented in a Geology report conducted by Robert Klausing of the U.S. Geological Survey, US Department of the Interior. The study states that Cass County is located in the Drift Prairie physiographic province, the rest is in the Red River Valley (Lake Agassiz basin. The major stratigraphic units are, in ascending order: crystalline rocks of Precambrian age, Winnipeg Formation of Ordovician age, and Dakota Sand stone, Graneros Shale, and Greenhorn Formation of Cretaceous age. No Indurated rocks younger than the Green horn are known to be present in the county.
Pleistocene glacial drift covers the entire county. The known thickness of the drift, including the Lake Agassiz deposits, ranges from 132 to 447 feet. All the surficial features of the county are late Pleistocene in age. Drift, probably deposited by more than one ice sheet, is present in the subsurface, but older drift can be differentiated in only a few places. Local zones of oxidized till, extensive bodies of buried outwash, and buried lake clays are valid indications of older drift in the subsurface. The major surficial features in the county are the ice-marginal drainage channels and the channel of the proglacial Maple River. Minor features include kames, eskers, terraces in the proglacial Maple River channel, ground moraine, and local recessional features referred to as washboard moraines. The trends of the wash - board moraines show, at least in part, the configuration of the ice margin at the time they were formed.

A ground water study was conducted by Robert Klasing of the U.S. Geological Survey in 1979. Ground water in Cass County is obtainable from sand and gravel deposits associated with the glacial drift and from sand and (or) sandstone beds in the Dakota Sandstone. Six major drift aquifers are identified and described. These are, the Fargo, West Fargo, Page, Tower City, Bantel, and Sheyenne Delta aquifers. The West Fargo aquifer is the most permeable and productive and will yield as much as 1,300 gallons per minute to individual wells. Heavy pumping from the West Fargo aquifer has caused the water levels to decline a s much as 85 feet since 1938. During 1965, water levels declined more than 2.5 feet at West Fargo and more than 0.5 foot in areas 20 miles away. The declines will continue as long as withdrawals exceed recharge. The closest aquifer is the Tower City aquifer. The facility is approximately 7 miles to the east of the Tower City aquifer.

C. Personal Observation

The facility location is a fairly well drained area with no wells on site. The land is used as crop land and it appears that the soil types on the top are a sandy lean clay. However, since this is a deep pit, it should work well for construction.

D. Geologic Investigation

The USDA Soil Survey predicts that the soil in the location of the storage structures is a Hamerly-Tonka Complex (G100A), 0-3% slopes, Hamerly-Wyard loams (G101A), 0-3% slopes, Barnes-Svea loams (G143B), 3-6% slopes, and Barnes-Buse loams, 3-6% loams. The Hamerly soils consist of loam from 0-79 inches. The Tonka soils consist of silt loam from 0 - 13 inches, loam from 13-19 inches, silty clay loam from 19-34 inches, clay loam from 34-50 inches and loam from 50-79 inches. The Wyard soils consist of loam from 0-79 inches. The Barnes soils consist of loam from 0-79 inches. The Svea soils consist of loam from 0-79 inches. The Buse soils also consist of loam but from 0-60 inches. The

map indicates that the Hamerly-Tonka Complex to have the largest coverage of the site.

A geologic investigation was conducted by Material Testing Services on June 4, 2015. Seven (7) total borings were drilled, five (5) to 23.5' and two (2) to 18.5'. Bore hole #1 is located in the NW part of the site beside finish (isolation) barn location. Bore hole #2, bore hole #3, and bore hole #4 are located at the gestation barn location. Bore Hole #5 is located on an open space on the site. Bore Hole #6 is located at the farrowing barn location and bore hole # 7 is located on the south side of the site where the road is located.

The soil logs for the bore holes are summarized in the following table:

Boring Number	Surface Elevation	Bore Depth	Soil Type 0-0.5 ft	Soil Type 0.5-9 ft	Soil Type 9-12 ft	Soil Type 12-23.5 ft
1	1148.4'	23.5'	Organic Lean Clay (OL)	Sandy Lean Clay (CL)	Silty Sand (SM)	Sandy Silt (ML)

Boring Number	Surface Elevation	Bore Depth	Soil Type 0-1 ft	Soil Type 1-2 ft	Soil Type 2-3 ft	Soil Type 3-12 ft	Soil Type 12-14 ft	Soil Type 14-15 ft	Soil Type 15-23.5 ft
2	1145.8'	23.5'	Organic Lean Clay (OL)	Sandy Lean Clay (CL)	Silt (ML)	Sandy Lean Clay (CL)	Sandy Lean Clay (CL)	Sand with Gravel (SP)	Silt (ML)

Boring Number	Surface Elevation	Bore Depth	Soil Type 0-0.7 ft	Soil Type 0.7-9 ft	Soil Type 9-12 ft	Soil Type 12-18 ft	Soil Type 18-23.5 ft
3	1145.5'	23.5'	Organic Lean Clay (OL)	Sandy Lean Clay (CL)	Clayey Sand (SC)	Sandy Lean Clay (CL)	Sandy Silt (ML)

Boring Number	Surface Elevation	Bore Depth	Soil Type 0-0.5 ft	Soil Type 0.5-12 ft	Soil Type 12-18.5 ft
4	1143.8'	18.5'	Organic Lean Clay (OL)	Sandy Lean Clay (CL)	Silty Sand (SM)

Boring Number	Surface Elevation	Bore Depth	Soil Type 0-0.7 ft	Soil Type 0.7-2.0 ft	Soil Type 2-4 ft	Soil Type 4-9 ft	Soil Type 9-12 ft	Soil Type 12-18 ft	Soil Type 18-23.5 ft
5	1146.0'	23.5'	Organic Lean Clay (OL)	Sandy Lean Clay (CL)	Clayey Sand (SC)	Sandy Silt (ML)	Sandy Lean Clay (CL)	Silty Sand (SM)	Silty Sand (SM)

Boring Number	Surface Elevation	Bore Depth	Soil Type 0-0.5 ft	Soil Type 0.5-7 ft	Soil Type 7-23.5 ft
6	1146.2'	23.5'	Organic Lean Clay (OL)	Sandy Lean Clay (CL)	Sandy Lean Clay (CL)

Boring Number	Surface Elevation	Bore Depth	Soil Type 0-0.5 ft	Soil Type 0.5-11 ft	Soil Type 11-14 ft	Soil Type 14-16 ft	Soil Type 16-18.5 ft
7	1145.0'	18.5'	Organic Lean Clay (OL)	Sandy Lean Clay (CL)	Sandy Lean Clay (CL)	Silty Sand (SM)	Silt (ML)

Each boring location was investigated for depth of water. The following chart defines the water elevations in relation to the topographical elevations.

Boring Number	Surface Elevation	Bore Depth	Water Depth	Water Elevation	Static Water Depth	Static Water Elevation
1	1148.4'	23.5'	9.3'	1139.1'	5.5'	1142.9'
2	1145.8'	23.5'	10.5'	1135.3'	4.7'	1141.1'
3	1145.5'	23.5'	NM	NM	NM	NM
4	1143.8'	18.5'	9.3'	1134.5'	N/A	N/A
5	1146.0'	23.5'	9.0'	1137.0'	4.5'	1141.5'
6	1146.2'	23.5'	9.8'	1136.4'	7.6'	1138.6'
7	1145.0'	18.5'	9.4'	1135.6'	6'	1139.0'

The planned subgrade elevation for the deep pits in the gestation and isolation barns are 1,138.8 ft. The planned subgrade elevation for the farrowing barn is 1,148.6 ft. Based off the separation distance to potential water, drain tile is planned underneath both the gestation and isolation barns.

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State Water Commission

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139-054-03 D

Data Source	ND State Water Commission	Well Index	34117
County	Cass	Date Drilled	04/04/1977
Aquifer	Undefined	Purpose	Test Hole
Basin	Maple River	Casing Type	
MP Elevation (ft)	0.00	Diameter (in.)	0.0
Surface Elev. (ft)	1,125.00	Screened Interval (ft)	0 - 0
Elevation Source (Datum)	Topographic Map (NVGD29)	Coord (Long,Lat)	-97.47707, 46.87946
Total Depth (ft)	0.00	USGS ID	
Bedrock Depth (ft)	0.00		

Lithologic Log

Interval (ft)	Unit	Description
0 - 2	TOPSOIL	Black
2 - 12	CLAY	Sandy, brown
12 - 22	CLAY	Sandy, blue
22 - 31	CLAY	Sandy with small lens of fine sand
31 - 32	SAND	Fine, colored
32 - 55	CLAY	Sandy, blue
55 - 57	SAND	Very dirty, gray
57 - 95	CLAY	Soft sandy
95 - 142	CLAY	Sandy, very soft, blue

[NO Water Levels Available] [NO Water Chemistry Available]
[Return to Site Selection]
* Recorder Data will not be plotted in the Hydrograph because of the volume of data involved!

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139-054-03 C

Data Source	ND State Water Commission	Well Index	34118
County	Cass	Date Drilled	04/05/1977
Aquifer	Undefined	Purpose	Test Hole
Basin	Maple River	Casing Type	
MP Elevation (ft)	0.00	Diameter (in.)	0.0
Surface Elev. (ft)	1,130.00	Screened Interval (ft)	0 - 0
Elevation Source (Datum)	Topographic Map (NVGD29)	Coord (Long,Lat)	-97.48766, 46.87943
Total Depth (ft)	157.00	USGS ID	
Bedrock Depth (ft)	0.00		

Lithologic Log

Interval (ft)	Unit	Description
0 - 2	TOPSOIL	Black
2 - 4	SAND	Brown
4 - 20	CLAY	Sandy, with small lenses sand and gravel, brown
20 - 22	CLAY	Sandy, blue
22 - 22	SAND	Gray
22 - 27	CLAY	Sandy, blue
27 - 29	SAND	Gray
29 - 76	CLAY	Sandy, blue
76 - 84	SAND	Drilled poor, fine dirty, gray
84 - 94	CLAY	With lenses small fine sand
94 - 157	CLAY	Sandy, soft, blue

[NO Water Levels Available] [NO Water Chemistry Available]

[Return to Site Selection]

* Recorder Data will not be plotted in the Hydrograph because of the volume of data involved!

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Material Testing Services, LLC

July 21, 2015

Attn: Mr. Nathan Pesta
DeHaan Grabs & Associates
PO Box 522
Mandan, ND 58554

ref: Soil Boring Logs
Rolling Green Sow Farm
Near Buffalo, North Dakota
Laboratory Number G15-052

Dear Mr. Pesta:

Enclosed are the logs of the soil borings that we recently conducted for the referenced project. The work was conducted in general accordance with our proposal. Please contact us if you would like laboratory tests conducted on the samples obtained from the borings.

The soil samples will be stored at the laboratory for a period of fourteen days from the date of this report. The samples will then be discarded unless we are requested to store them for a longer period of time.

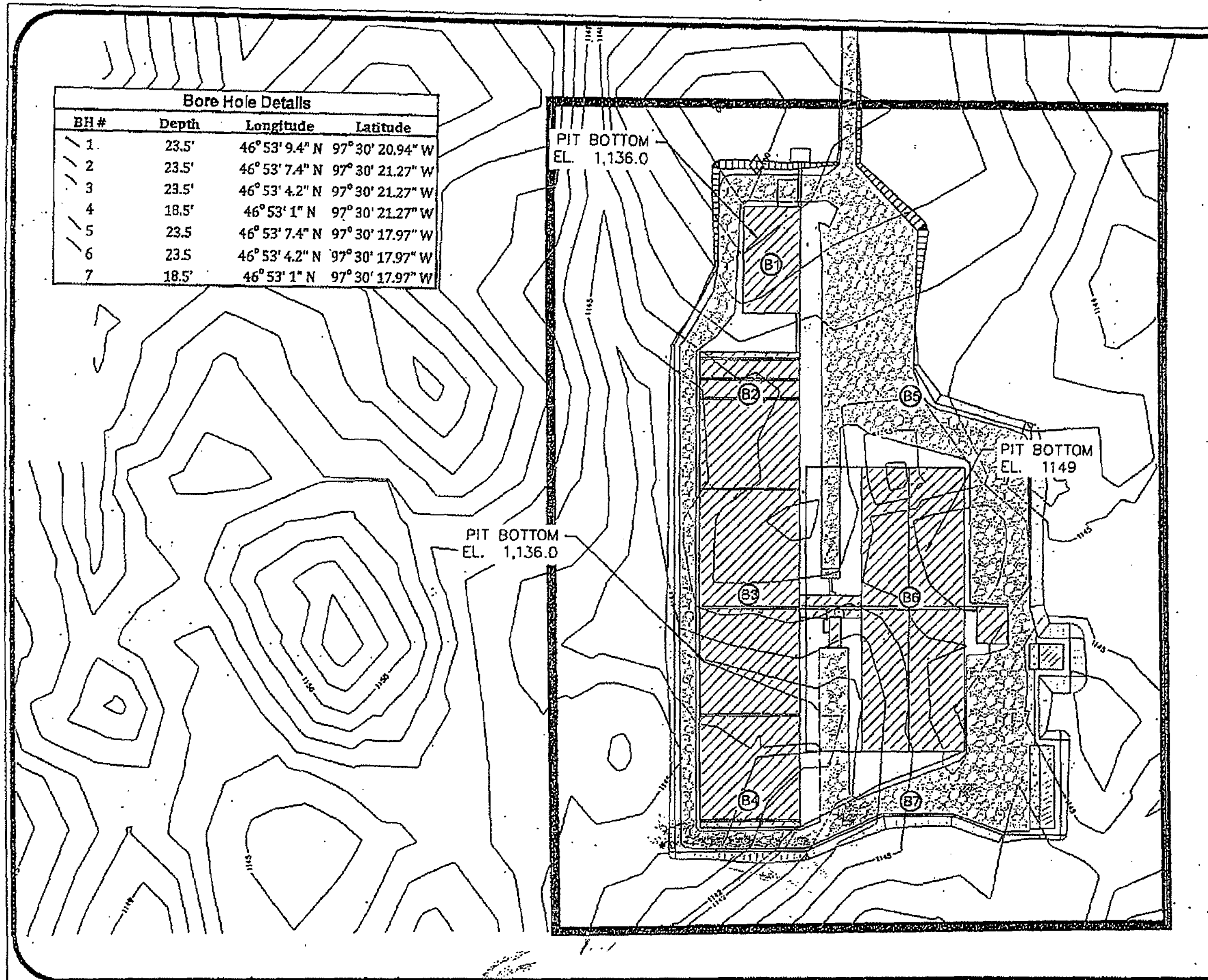
Please call if you have any questions or comments concerning this report.

Sincerely,
MATERIAL TESTING SERVICES, LLC

Rusten R.L. Roteliuk
Geotechnical Engineer

P.O. Box 634
Minot, North Dakota 58702
701-852-5553

P.O. Box 1093
Williston, North Dakota 58802
701-572-4226



Bore Hole Details

BH #	Depth	Longitude	Latitude
1	23.5'	46° 53' 9.4" N	97° 30' 20.94" W
2	23.5'	46° 53' 7.4" N	97° 30' 21.27" W
3	23.5'	46° 53' 4.2" N	97° 30' 21.27" W
4	18.5'	46° 53' 1" N	97° 30' 21.27" W
5	23.5	46° 53' 7.4" N	97° 30' 17.97" W
6	23.5	46° 53' 4.2" N	97° 30' 17.97" W
7	18.5'	46° 53' 1" N	97° 30' 17.97" W

GENERAL NOTES

LEGEND
- BENCHMARK
- BUILDINGS
- GRAVEL PROPOSED
- CULVERT/PIPE
- DRAINAGE ARROW

SCALE, FEET
0 75 150 225 300

DRAFT

DeHaan, Grabs & Associates, LLC
Registration Number: C-1341

No.	Revision/Issue	Date

DeHaan, Grabs & Associates, LLC
Consulting Engineers
PO Box 522, Mandan, ND 58554
(701) 663-1116, FAX (701) 667-1356
www.dgaengineering.com

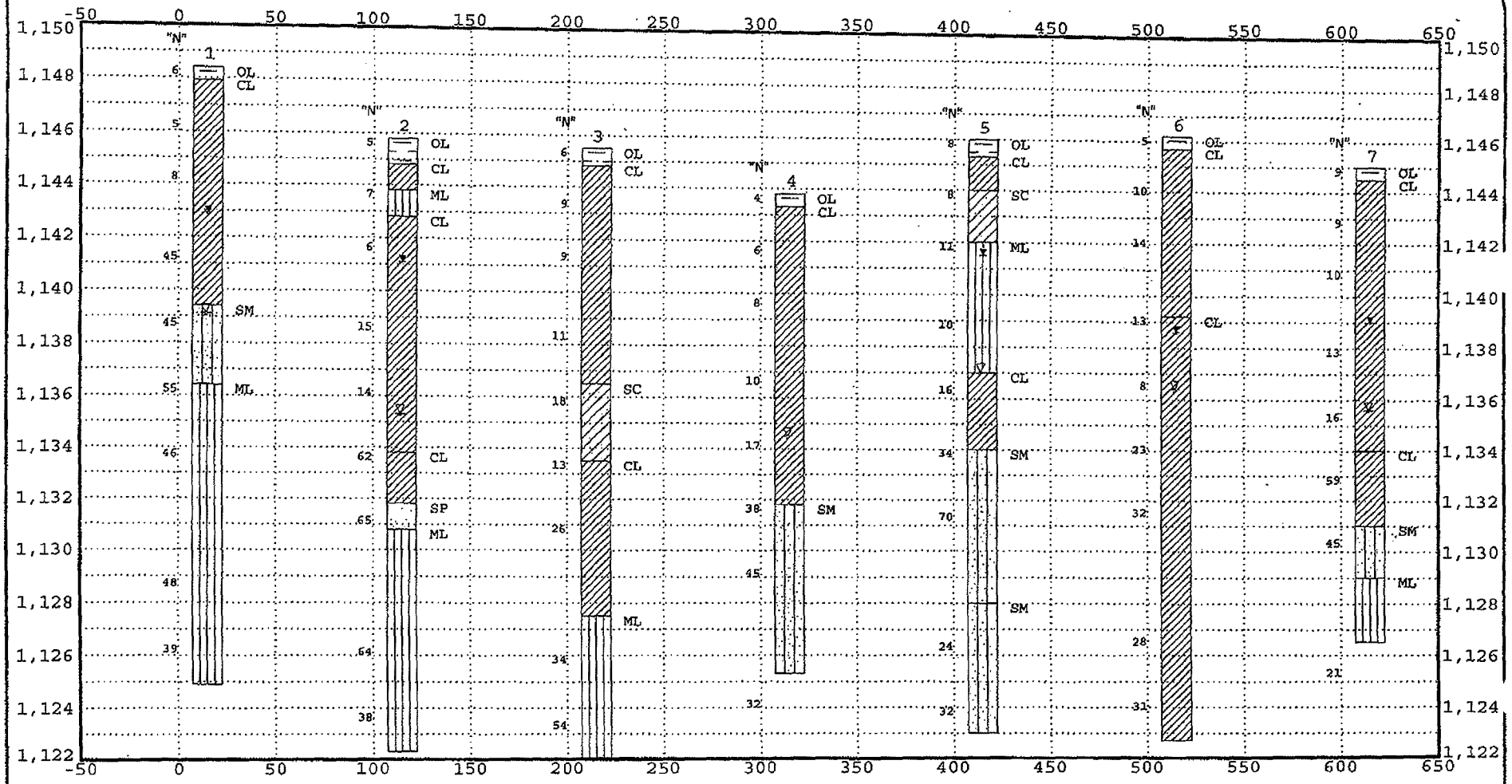
ROLLING GREEN SOW FARM
PIPESTONE VET

NW 1/4, SECTION 4, T 139 N, R 54 W
CASS COUNTY, ND

BORE HOLE
LOCATION MAP

DATE: MAY 4, 2015
SCALE: 1" = 150'
DRAWN BY: NAP
CHECKED BY: DLD
SHEET: B2

FILE NAME: NO PROJECT-FILES/SWINE/ROLLING GREEN/CIVILES/PLAN



Boring	North	East	Elev.	Depth
1	0	100	1148.4	23.5
2	0	200	1145.8	23.5
3	0	300	1145.5	23.5
4	0	400	1143.8	18.5
5	0	500	1146.0	23.5
6	0	600	1146.2	23.5
7	0	700	1145.0	18.5

SOIL PROFILE DIAGRAM

Material Testing Services, LLC

Rolling Green Sow Farm

Buffalow, North Dakota

PROJECT #	DATE	PLATE
G15-052	Jul 15	1

MATERIAL TESTING SERVICES, LLC
Box 634
Minot, North Dakota 58702
(701) 852-5553

SOIL BORING RECORD

BORING NUMBER 1 SHEET 1 OF 1
PROJECT Rolling Green Sow Farm
PROJECT LOCATION Buffalow, North Dakota
PROJECT NUMBER G15-052
START DATE 6/4/15 FINISH DATE 6/4/15

LAYER DEPTH/ ELEVATION (FT)	SOIL DESCRIPTION	SYMBOLIC LOG	ELEVATION/ DEPTH (FT)	GEOLOGY	SAMPLE TYPE	SAMPLE LEGEND	SAMPLE D (pcf)	SAMPLE N VALUES BLOWS/FT	SAMPLE WATER LEVEL	TEST RESULTS MOISTURE CONTENT (%)	TEST RESULTS LIQUID LIMIT (%)	TEST RESULTS PLASTIC LIMIT (%)	TEST RESULTS Qu (psf)
0.5 / 1147.9	Topsoil, Organic Lean Clay, dark brown to black, moist, (OL)		0 / 1148.4	Topsoil	SB			6					
	Sandy Lean Clay, grayish brown, a trace of gravel, light gray and rust colored mottles, wet, soft, (CL)			Glacial Till	SB			5					
					SB			8					
			5 / 1143.4						▼				
					SB			45					
9.0 / 1139.4	Silty Sand, reddish brown, fine grained, waterbearing, dense, (SM0			Carlile Formation					▽				
			10 / 1138.4		SB			45					
12.0 / 1136.4	Sandy Silt, gray, reddish brown laminations, lenses of fine sand, wet, very hard, (ML)				SB			55					
			15 / 1133.4		SB			46					
			20 / 1128.4		SB			48					
23.5 / 1124.9	End of Boring				SB			39					

NM = None Measurable

DRILLER	CW
METHOD	4" FA
LOGGER	MT
REVIEWER	RR
DRILL RIG	CME 45

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING MUD LEVEL	WATER LEVEL
6/4/15	1515	23.5		17.0		9.3
6/4/15	1730	23.5		15.5		5.5

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SOIL BORING RECORD

BORING NUMBER 2 SHEET 1 OF 1
PROJECT Rolling Green Sow Farm
PROJECT LOCATION Buffalow, North Dakota
PROJECT NUMBER G15-052
START DATE 6/4/15 FINISH DATE 6/4/15

LAYER DEPTH/ ELEVATION (FT)	SOIL DESCRIPTION	SYMBOLIC LOG	ELEVATION/ DEPTH (FT)	GEOLOGY	SAMPLE TYPE	SAMPLE LEGEND	SAMPLE D (pcf)	N VALUES BLOWS/FT	WATER LEVEL	TEST RESULTS MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	Qu (psf)
1.0 1144.8	Topsoil, Organic Lean Clay, dark brown to black, moist, (OL)		0 1145.8	Topsoil	SB			5					
2.0 1143.8	Sandy Lean Clay, grayish brown, a trace of gravel, light gray and rust colored mottles, wet, soft, (CL)			Glacial Till	SB			7					
3.0 1142.8	Silt, grayish brown, wet, soft, (ML)												
	Sandy Lean Clay, grayish brown, a trace of gravel, light gray and rust colored mottles, wet, soft to firm, (CL)		5 1140.8		SB			6	▼				
					SB			15					
			10 1135.8		SB			14	▽				
12.0 1133.8	Sandy Lean Clay, gray, a trace of gravel, wet, very hard, (CL)				SB			62					
14.0 1131.8	Sand with Gravel, brown, fine to coarse grained, waterbearing, (SP)			Coarse Alluvium	SB			65					
15.0 1130.8	Silt, gray, wet, very hard, (ML)		15 1130.8	Carlile Formation									
			20 1125.8		SB			64					
					SB			38					
23.5 1122.3	End of Boring												
	NM = None Measurable												

DRILLER	CW
METHOD	4" FA
LOGGER	MT
REVIEWER	RR
DRILL RIG	CME 45

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING MUD LEVEL	WATER LEVEL
6/4/15	1605	23.5		15.5		10.5
6/4/15	1730	23.5		13.7		4.7

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SOIL BORING RECORD

BORING NUMBER 3 SHEET 1 OF 1
PROJECT Rolling Green Sow Farm
PROJECT LOCATION Buffalow, North Dakota
PROJECT NUMBER G15-052
START DATE 6/4/15 FINISH DATE 6/4/15

LAYER DEPTH/ ELEVATION (FT)	SOIL DESCRIPTION	SYMBOLIC LOG	ELEVATION/ DEPTH (FT)	GEOLOGY	SAMPLE TYPE	SAMPLE LEGEND	SAMPLE D (pcf)	SAMPLE N VALUES BLOWS/FT	SAMPLE WATER LEVEL	TEST RESULTS MOISTURE CONTENT (%)	TEST RESULTS LIQUID LIMIT (%)	TEST RESULTS PLASTIC LIMIT (%)	TEST RESULTS Qu (psf)
0.7 1144.8	Topsoil, Organic Lean Clay, dark brown to black, moist, (OL)		0 1145.5	Topsoil	SB			6					
	Sandy Lean Clay, grayish brown, a trace of gravel, light gray and rust colored mottles, wet, soft to firm, (CL)			Glacial Till	SB			9					
					SB			9					
			5 1140.5										
					SB			11					
9.0 1136.5	Clayey Sand, brown, a trace of gravel, wet, hard, (SC)		10 1135.5		SB			18					
12.0 1133.5	Sandy Lean Clay, gray, a trace of gravel, wet, firm to hard, (CL)				SB			13					
			15 1130.5		SB			26					
18.0 1127.5	Sandy Silt, gray, reddish brown laminations, lenses of fine sand, wet, very hard, (ML)			Carlile Formation									
			20 1125.5		SB			34					
					SB			54					
23.5 1122.0	End of Boring												
	NM = None Measurable												

DRILLER	CW
METHOD	4" FA
LOGGER	MT
REVIEWER	RR
DRILL RIG	CME 45

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING MUD LEVEL	WATER LEVEL
6/4/15	1650	23.5		21.8		NM

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SOIL BORING RECORD

BORING NUMBER 4 SHEET 1 OF 1
PROJECT Rolling Green Sow Farm
PROJECT LOCATION Buffalow, North Dakota
PROJECT NUMBER G15-052
START DATE 6/4/15 FINISH DATE 6/4/15

LAYER DEPTH/ ELEVATION (FT)	SOIL DESCRIPTION	SYMBOLIC LOG	ELEVATION/ DEPTH (FT)	GEOLOGY	SAMPLE TYPE	SAMPLE LEGEND	SAMPLE D (pcf)	SAMPLE N VALUES BLOWS/FT	SAMPLE WATER LEVEL	TEST RESULTS MOISTURE CONTENT (%)	TEST RESULTS LIQUID LIMIT (%)	TEST RESULTS PLASTIC LIMIT (%)	TEST RESULTS Qu (psf)
0.5 1143.3	Topsoil, Organic Lean Clay, dark brown to black, moist, (OL)		0 1143.8	Topsoil	SB			4					
	Sandy Lean Clay, grayish brown, a trace of gravel, light gray and rust colored mottles, mois to wet, soft to hard, (CL)			Glacial Till	SB			6					
					SB			8					
			5 1138.8										
					SB			10					
									▽				
			10 1133.8		SB			17					
12.0 1131.8	Silty Sand, grayish brown, fine to medium grained, waterbearing, dense, (SM)			Carlile Formation	SB			38					
					SB			45					
			15 1128.8										
18.5 1125.3	End of Boring												
	NM = None Measurable				SB			32					

DRILLER	CW
METHOD	4" FA
LOGGER	MT
REVIEWER	RR
DRILL RIG	CME 45

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING MUD LEVEL	WATER LEVEL
6/4/15	1725	18.5		13.0		9.3

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SOIL BORING RECORD

BORING NUMBER 5 SHEET 1 OF 1
PROJECT Rolling Green Sow Farm
PROJECT LOCATION Buffalow, North Dakota
PROJECT NUMBER G15-052
START DATE 6/4/15 FINISH DATE 6/4/15

LAYER DEPTH/ ELEVATION (FT)	SOIL DESCRIPTION	SYMBOLIC LOG	ELEVATION/ DEPTH (FT)	GEOLOGY	SAMPLE TYPE	SAMPLE LEGEND	SAMPLE D (pcf)	SAMPLE N VALUES BLOWS/FT	SAMPLE WATER LEVEL	TEST RESULTS MOISTURE CONTENT (%)	TEST RESULTS LIQUID LIMIT (%)	TEST RESULTS PLASTIC LIMIT (%)	TEST RESULTS Qu (psf)
0.7 1145.3	Topsoil, Organic Lean Clay, dark brown to black, moist, (OL)		0 1146.0	Topsoil	SB			8					
2.0 1144.0	Sandy Lean Clay, grayish brown, a trace of gravel, light gray and rust colored mottles, moist, soft, (CL)			Fine Alluvium	SB			8					
4.0 1142.0	Clayey Sand, grayish brown, a trace of gravel, wet, soft, (SC)				SB			11	▼				
	Sandy Silt, grayish brown, laminations of sand and lean clay, wet, firm, (ML)		5 1141.0		SB			10					
9.0 1137.0	Sandy Lean Clay, grayish brown, a trace of gravel, wet, hard, (CL)			Glacial Till	SB			16	▽				
12.0 1134.0	Silty Sand, grayish brown, fine grained, waterbearing, dense, (SM)		10 1136.0	Carlile Formation	SB			34					
			15 1131.0		SB			70					
18.0 1128.0	Silty Sand, gray, fine grained, waterbearing, medium dense to dense, (SM) End of Boring NM = None Measurable												
			20 1126.0		SB			24					
23.0 1123.0					SB			32					

DRILLER	CW
METHOD	4" FA
LOGGER	MT
REVIEWER	RR
DRILL RIG	CME 45

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING MUD LEVEL	WATER LEVEL
6/4/15	1415	23.5		16.5		9.0
6/4/15	1730	23.5		9.0		4.5

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SOIL BORING RECORD

BORING NUMBER 6 SHEET 1 OF 1
PROJECT Rolling Green Sow Farm
PROJECT LOCATION Buffalow, North Dakota
PROJECT NUMBER G15-052
START DATE 6/4/15 FINISH DATE 6/4/15

LAYER DEPTH/ ELEVATION (FT)	SOIL DESCRIPTION	SYMBOLIC LOG	ELEVATION/ DEPTH (FT)	GEOLOGY	SAMPLE TYPE	SAMPLE LEGEND	SAMPLE D (pcf)	SAMPLE N VALUES BLOWS/FT	SAMPLE WATER LEVEL	TEST RESULTS MOISTURE CONTENT (%)	TEST RESULTS LIQUID LIMIT (%)	TEST RESULTS PLASTIC LIMIT (%)	TEST RESULTS Qu (psf)
0.5 1145.7	**Topsoil, Organic Lean Clay**, dark brown to black, moist, (OL)		0 1146.2	Topsoil	SB			5					
	Sandy Lean Clay, brown to grayish brown, a trace of gravel, light gray and rust colored mottles, wet, soft to firm, (CL)			Glacial Till	SB			10					
					SB			14					
			5 1141.2										
7.0 1139.2	**Sandy Lean Clay**, gray, a trace of gravel, wet, soft to very hard, (CL)				SB			13	▼				
			10 1136.2		SB			8	▽				
					SB			23					
			15 1131.2		SB			32					
					SB			28					
			20 1126.2		SB			31					
23.5 1122.7	End of Boring												
	NM = None Measurable												

DRILLER	CW
METHOD	4" FA
LOGGER	MT
REVIEWER	RR
DRILL RIG	CME 45

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING MUD LEVEL	WATER LEVEL
6/4/15	1330	23.5		16.0		9.8
6/4/15	1730	23.5		13.8		7.6

MATERIAL TESTING SERVICES, LLC
Box 634
Minot, North Dakota 58702
(701) 852-5553

SOIL BORING RECORD

BORING NUMBER 7 SHEET 1 OF 1
PROJECT Rolling Green Sow Farm
PROJECT LOCATION Buffalow, North Dakota
PROJECT NUMBER G15-052
START DATE 6/4/15 FINISH DATE 6/4/15

LAYER DEPTH/ ELEVATION (FT)	SOIL DESCRIPTION	SYMBOLIC LOG	ELEVATION/ DEPTH (FT)	GEOLOGY	SAMPLE TYPE	SAMPLE LEGEND	SAMPLE D (pcf)	SAMPLE N VALUES BLOWS/FT	SAMPLE WATER LEVEL	TEST RESULTS MOISTURE CONTENT(%)	TEST RESULTS LIQUID LIMIT (%)	TEST RESULTS PLASTIC LIMIT (%)	TEST RESULTS Qu (psf)
0.5 / 1144.5	Topsoil, Organic Lean Clay, dark brown to black, moist, (OL)		1145.0 / 0	Topsoil	SB			9					
	Sandy Lean Clay, brown to grayish brown, a trace of gravel, light gray and rust colored mottles, moist to wet, firm to hard, (CL)			Glacial Till	SB			9					
					SB			10	▼				
			1140.0 / 5										
					SB			13					
					SB			16	▽				
11.0 / 1134.0	Sandy Lean Clay, gray, a trace of gravel, wet, very hard, (CL)		1135.0 / 10		SB			59					
14.0 / 1131.0	Silty Sand, brown, fine to medium grained, waterbearing, (SM)		1130.0 / 15	Carlile Formation	SB			45					
16.0 / 1129.0	Silt, gray, wet, hard, (ML)												
18.5 / 1126.5	End of Boring NM = None Measurable				SB			21					

DRILLER	CW
METHOD	4" FA
LOGGER	MT
REVIEWER	RR
DRILL RIG	CME 45

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING MUD LEVEL	WATER LEVEL
6/4/15	1240	18.5		13.8		9.4
6/4/15	1730	18.5		12		6.0

SECTION 9A: OPERATION & MAINTENANCE GUIDELINE

The owner acknowledges responsibility for the proper operation and maintenance of the animal waste management system. Although the design is based on the best available technical knowledge, it must be recognized that any system creates some risks, and therefore needs to be properly operated and maintained, including periodic inspection. In addition, maximum efficiency cannot be obtained unless the system is properly operated and maintained so that it will function safely in its intended manner.

Recognizing this, this Manual has been prepared as a general guideline for operating and maintaining the system. This Manual is not inclusive of all of the provisions of the North Dakota Livestock Program Design Manual (NDLPDM), or Approval to Operate, therefore the owner should review the permit in its entirety.

It is recommended that the following list be reviewed and be used as a checklist to ensure major elements of operation and maintenance are consistently being observed.

I. General Considerations

A. Any discharge from the waste management system or land application sites must be reported as soon as possible, but no later than twenty-four hours after the discharge was discovered. The discharge must be reported to the State of North Dakota at (701) 328-5210, or (800) 472-2121 after normal business hours.

B. All inspections should be documented on the forms included with this manual or other suitable forms. Documentation must be maintained on site and be made available to the Department of Health when requested.

C. Travel of vehicles and livestock should be confined to designated areas to prevent erosion and enhance vegetation.

D. Maintain grades around containment structures to assure positive surface drainage away from the structures in all directions. Fill any settled areas which may collect water.

E. Any discovered damage to any facility component must be repaired as soon as possible to original specifications.

F. Do not allow trees to grow adjacent to concrete storage tanks, to avoid root damage to the structures.

G. Manage vegetation growth on and near facility components so that adequate

component inspection is possible.

H. Maintain the overall system (i.e. diversions, concrete tanks) to ensure that all contaminated runoff enters the containment structures.

II. Waste Application Considerations

A. Land application must be planned and carried out of concrete storage tank levels from rising above the maximum operating elevation. In the event that this level is exceeded, the producer has 14 days to restore the tank to a level at or below the maximum operating elevation as required by the NDLPDM.

B. Whenever possible, apply downwind from any residences. Avoid applying on calm, humid days, since these conditions restrict the dispersion and dilution of odors. Application on weekends or holidays, when people in the area are more likely to be outdoors, should also be avoided.

C. Do not apply waste on snow or frozen ground unless unavoidable. Consult the NDLPDM for conditions that must be followed in these circumstances

D. Do not apply waste material immediately after rain or within twelve hours of forecasted rain unless it can be immediately incorporated into the soil.

E. The above ground piping shall be double lined by way of a protective sleeve when the piping passes through culverts that are for intermittent streams or larger water crossings.

F. Where the above ground piping crosses under roads or railroad tracks the hose couplers shall remain visible at all times during pumping (no couplers in culverts).

G. The above ground piping shall be monitored for leaks during pumping events.

H. During land application on fields with surface tile inlets, the inlets shall be covered during the land application event.

III. Inspection and Documentation

Records shall be maintained for at least 5 years to document plan implementation.

A. Items to be Performed Daily

1. Year Round
    a. Record any measurable precipitation
    b. Inspection of water lines, including drinking water or cooling water lines.
2. During Periods of Land Application
    a. Record the days each field is applied to, as well as weather

conditions including; temperature and wind speed and direction.

b. Inspect and record the condition of the land application fields being used.

c. Inspect and record the condition of all land application equipment being used.

d. Inspect and record the condition of the concrete tank pumpout ports near the pump intake if pumping is taking place.

e. Inspect and record the tile outlet for discharge of manure for field 5 in the Nutrient Management Plan.

f. Record the Field Setbacks that are observed such as manure shall not be applied any closer than a 100 feet to any down-gradient surface waters, open tile line intake structures, sinkholes, agricultural well heads or other conduits to surface waters.

B. Items to be Performed Weekly

The entire Waste Management System should be inspected weekly. This includes but is not limited to the following.

1. Record the depth of water in all concrete storage tanks.
2. Inspect pipes to ensure they are not plugged or damaged. Clean any significant sediment build up as soon as possible.
3. Inspect concrete storage tank for signs of leaking or seepage, excessive settling, excessive vegetation growth or damage due to vehicles or equipment, rodents or erosion. Report any leakage as detailed above and make plans to rectify any problems as soon as possible.
4. Inspect fences and safety signs around facility, if applicable, to ensure they are present and in good condition. If necessary repair immediately.
5. Record any livestock mortalities and how the carcasses were properly disposed of (i.e. rendering service receipt, location of burial, etc.)

C. Items to be Performed Annually

1. Conduct soil and manure nutrient testing as required by the Nutrient Management Plan.
2. Prepare an annual Nutrient Management Plan based on current data.
3. Prepare and submit a report to the Department of Health as referenced in NDSU Ext Pub NM-1306.

IV. Items pertaining to the control of odors, flies and other nuisances

A. As much as is reasonable, standing water and wet pen conditions shall be

prevented or eliminated by routine pen maintenance.

B. Mortalities shall be promptly disposed of using composting.

C. Feed storage areas will be managed to as much as possible prevent spoilage of feed. When spoilage does occur, is shall promptly cleaned up and disposed of properly (i.e. field applied, dried and stockpiled, buried, etc.).

D. If insects become problematic, a pesticide program will be undertaken for control.

V. Record Keeping

A. The following items should be kept on site at all times.

1. Copy of the approved North Dakota Department of Health Approval to Operate.
2. Copy of current nutrient management plan.

B. The following items should be kept on site for a period of 5 years from the date they are created.

1. Inspection reports from all inspections listed above.
2. Soil and manure nutrient test results.
3. Calculations of allowable manure application rates and actual rates applied.
4. Documentation of any action taken to correct deficiencies required.
5. Documentation of any discharge, steps taken to minimize it and the estimated volume discharged.

I have reviewed the above Operation and Maintenance Manual for my Waste Management System and agree to provide the necessary resources to properly implement its provisions.

Barry R. Kuhl 10-30-15

Operator Date

SECTION 9B: CAFO INSPECTION SHEETS

Rolling Green Family Farms RE. LLP
Cass County, ND

CAFO Inspection Records and Weather Conditions for: Month: Year:

Day	Daily Water Line Checks	Weekly Checks				Weekly Reading *(ft from Bottom)*	Corrective Action *(action taken, date repaired, and initials.)*	Weather Conditions	Discharge Status	Rainfall Amount (in)
	N - no problems Y - is a problem	Diversions	Culverts	Pen Drainage	Ponds/Basins (Solids, Water level)	Gestation, Isolation				
1										
2										
3										
4										
5										
6										
7										
8										
9										
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31										

SECTION 9C: ODOR CONTROL PLAN

A. Site Selection and Evaluation

1. Rolling Green Family Farms RE, LLP selected the facility based on its compliance with regulatory setback requirements.

2. The nearest neighbor to the facility is over a mile to the buildings and the waste storage facility.

3. When determining the exact location of the facility, topography and predominant wind direction data were reviewed.

B. Animal Confinement Areas

- Schedule of Activities

  - Surfaces in the barn where dust and manure can collect and cause a potential for higher odor emissions.

    1) Personnel at the facility wash down the pens as needed.
    2) The manure on the slats that is not pushed down into the pits will be cleaned as needed.
    3) Pit plugs are pulled approximately one time every one-two weeks to reduce odors emanating from the barns.

C. Carcass Disposal

1. The removal of carcasses from the barns is done promptly at the time of discovery.

   a) The carcasses are disposed of in a timely manner.
   b) The carcasses will be disposed of as identified in the Waste Management Plan.

2. The temporary carcass disposal area will be disinfected once per week and thoroughly cleaned twice annually.

D. Concrete Storage Pits

1. The concrete storage pits are covered and contained minimizing the potential for odor spreading from the waste storage area.

2. The manure in the farrowing barn pits will be removed one to two weeks and additional water will be added to help clean and maintain odors.

E. Land Application of Liquid Manure

1. Careful scheduling of the land application activities will reduce the threat of odor emissions to residents near the facility.

2. Days with low humidity are best for land application.

   b) Applications on holidays and weekends when people are most likely to be outdoors will be avoided when possible.

3. The use of surface injection for land application as identified in the Waste Management Plan will assist in reducing the odors.

F. Maintenance Procedures

Maintenance on odor control equipment, such as ventilation fans, will be performed on an as needed basis. In addition, odor control equipment will be serviced per manufacturer's recommendations.

G. Best Management Practices

1. Regular flushing of manure storage pits, controlling feed loss to the manure pits and reducing the spillage of feed from inefficient or malfunctioning feeders will help reduce odor emissions.

2. The ventilation systems were adopted on an individual farm basis to take the environmental conditions of the facility location into account.

3. Rolling Green Family Farms RE will work in cooperation with the animal nutrition specialist to develop feed formulations that will maximize swine feed conversion and reduce the overall manure treatment system loading rate.

4. Vegetative barriers is proposed as part of the plan to reduce odor.

H. On-Farm Odor Abatement Plan Amendments

- This plan may be amended as appropriate.

SECTION 9D: EMERGENCY RESPONSE PLAN

A. General

A copy of this emergency response plan and any associated records and data will be maintained at the facility headquarters and will be readily accessible to the North Dakota Department of Health personnel. Any other versions of the plan and associated records and data from the previous five years will also be retained at this location. A copy of the current plan will be posted in a location where it is readily accessible to facility operators and emergency response personnel.

B. Potential Pollutant Source:

- Discharge of solid waste or polluted runoff from confinement resulting from storm events in excess of the 25 year, 24 hour rainfall.

- Discharge of waste from spreading vehicles during loading and transfer operations

C. Contingency Plan:

- **Power Failure**
  Response: Provide back-up power for stock water well pumps to ensure death to animals is minimal. For waste application, this is not required as portable pumps will be utilized.

- **Excessive rainfall due to large storms or chronic wet periods.**
  Response: Divert excessive runoff flows away from swine facility. Repair any breaks in the gradient diversion as soon as possible. Remove debris from storm water drainage ditches.

- **Accidents.**
  Response: Collect accidental material and apply according to the nutrient utilization plan.

- **Water System leaks or pipeline breaks.**
  Response: Shut off system immediately. Collect discharge material and apply according to the nutrient utilization plan.

- **Failure of Components of the Livestock Waste Control Facility:**
  Response: Repair any breaks or failures as soon as possible. Apply the waste

material according to the nutrient utilization plan to reduce load on waste control facility as soon as possible.

Important: Any discharges of manure or related wastes not covered by the nutrient utilization plan will be reported within two hours the discharge is first noticed to:

Barry Kerkaert
Phone: (507) 215-0471

And within twenty-four hours to:

Department of Health
Division of Environmental Quality
918 East Divide Avenue, 4th Floor
Bismarck, ND 58501-1947

8:00 a.m. to 5:00 p.m. weekdays call (701) 328-5210, or evening, weekends, or holidays call (800) 472-2121.

The operator will report any emergency, spill, accident discharge, overflow, or unplanned release associated with feedlot or other process waste to the Department within twenty four hours of discovery by telephone. A written report of the incident using the attached notification form will be submitted within seven days of the initial contact.

D. Mitigation Measures

A soil test will be taken in the area impacted by the spill or discharge. The test report will indicate the concentrations of nitrogen, phosphorus, pH, and total soluble salts. The area will be tilled and planed to a cover crop if constituent levels are such that vegetation can be established to stabilize the area. Otherwise, the impacts volume of soil will be excavated, spread over agricultural land, incorporated by tillage and planted to a suitable vegetation. The rate of spreading will be determined according to guidelines contained in the nutrient utilization plan.

E. Plan Review

The facility operators are responsible for implementation of the emergency response plan. The plan will be reviewed annually and amended as required. Amended plans will be submitted to Department of Health and Environment for approval.

Emergency Response Report Form

Facility Name: _____

Date of Spill : _____ **Time Spill was Discovered:** _____

Name of Individual(s) Who Discovered the Spill: _____

Who was Contacted and When? _____

_____

Give a description of the cause and source of the spill. Include what time the clean up process started and ended. Describe the flow and location of the spill. Give the estimated amount or volume that was associated with the spill.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Give a description of what corrective actions have been taken to contain, utilize or properly dispose of the manure, as well as the steps taken to prevent a future release.

DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers

Nutrient Management Plan For

ROLLING GREEN FAMILY FARMS RE, LLP

Cass County, ND

Prepared by DeHaan, Grabs & Associates, LLC,
Mandan, ND

December 2015

DeHaan, Grabs & Associates, LLC
PO Box 522 | Mandan, ND | 58554
www.dgaengineering.com

10. A. NUTRIENT UTILIZATION PLAN

1. Introduction
2. Record Keeping
3. Soil Sampling
4. Manure Sampling
5. Nutrient Budget for Land Application
6. Timing, Rate, and Frequency of Liquid and Solid Manure Applications
7. Land Application of Liquid Manure
8. Amounts of Nitrogen Applied
9. Management Considerations for Nitrogen
10. Phosphorus Risk Assessment
11. Management Considerations for Phosphorus
12. Solid Accumulation in the Settling Basin
13. Setback Requirements
14. Typical Crops Grown and Crop Yields for the Land Application Areas
15. Nutrient Utilization Amendments

1. Introduction

This Nutrient Management Plan was developed for Rolling Green Family Farms RE, LLP. This facility is by Buffalo, ND (2 miles south on ND-38 from Buffalo, ND and 2 ½ miles east on 36th street). The site will located on the south side of 36th Street. The facility is a confinement barn where they plan to have 800 nursery pigs, 1600 finish pigs, 5312 gestating sows, and 1344 sows and litters. Animals are confined the whole year. This Nutrient Management Plan was developed as a joint effort between Pipestone Vet and DeHaan, Grabs & Associates, LLC.

The total nutrients available for crop application of N (153,761lbs), available P_2O_5 (141,346), and total K_2O (172,661) produced annually by the livestock was determined by DeHaan, Grabs & Associates, LLC using AWMFH from Tables 4.5 to 4.9 and ASAE D384.2 Table 19. The manure will be collected through slotted floors in the confinement barn which will be applied to the fields via knife or sweep injection. The CNMP includes 3,280.4 acres of agricultural land which is available for manure application. Rolling Green Family Farms RE, LLP plans to rotate between corn and beans with conventional tillage. All of the manure application sites are dryland. Plant uptake from the fields in an average corn/bean rotation is calculated at 449,300 lbs of N and 128,526 P_2O_5 respectively. Commercial fertilizer will need to be applied to meet the N requirements of the crops. It is important to remember that the rotation will be adjusted based off of market forces, weather, feed requirements, economic influences, etc. When calculating projected land base requirements and RUSLE 2 calculations, Cass County average yields x 110% was used unless the approved yield for the field was higher. When calculating annual nutrient application needs, actual yields on a per field basis will be used.

2. Record Keeping.

It is recommended that records be maintained for at least 5 years to document plan implementation and maintenance. As applicable, records include:

1) Soil, plant tissue, water, manure, and organic by-products analyses resulting in recommendations for nutrient application.
2) Quantities analyses and sources of nutrients applied on the forms in Section 10.F.
3) Dates, methods of nutrient applications, source of nutrients, and rates of application.
4) Weather conditions and soil moisture at the time of application; lapsed time to manure incorporation; rainfall or irrigation event,
5) Crops planted, planting and harvest dates, yields, nutrient analyses of harvested biomass and crop residues removed.
6) All enhanced efficiency fertilizer products used.
7) Maps identifying the variable rate application source, timing, amount, and placement of all plant nutrients applied and

8) GPS-based yield maps for crops where yields can be digitally collected.
9) Prepare an annual Nutrient Management Plan based on current data.

3. **Soil Sampling.**
Nutrient planning recommendations should be based on current soil, manure, and tissue test results developed in accordance with NDSU recommendations. Current soil tests are those that are no older than 3 years. The soil and tissue tests must include analyses of pertinent to monitoring or amending the annual nutrient budget, e.g., pH, electrical conductivity (EC) and sodicity where salts are a concern, soil organic matter, phosphorus, potassium, or other nutrients and test for nitrogen where applicable. The sampling procedure shall be followed as shown in Section K.

4. **Manure Sampling.**
a. Manure samples in conjunction with soil samples, will be taken prior to land application to determine land application rate.

b. Liquid and solid manure samples will be analyzed by a certified laboratory for, potassium, total nitrogen, ammonium-nitrogen and phosphorus and total solids.

5. **Nutrient Budget for Land Application.**
a. Nutrient loss due to volitization, evaporation, and crop uptake will be accounted for each time liquid manure is applied to the land application area.
b. Planned nutrient application rates for nitrogen, phosphorus and potassium must not exceed the land-grant university guidelines or industry practice.

6. **Timing, Rate, and Frequency of Liquid and Solid Manure Applications.**
a. Timing and placement of all nutrients must correspond as closely as practical with plant nutrient uptake (utilization by crops), and consider nutrient source, cropping system limitations, soil properties, weather conditions, drainage system, soil biology, and nutrient risk assessment results.
b. Nutrients shall not be applied to frozen, snow-covered or saturated soil, or when the top 2 inches of soil are saturated from rainfall or snow melt.

Land applications will be conducted in the spring, summer and fall.

d. Land application will be conducted in a manner which will prevent a discharge or drainage of manure to ground or surface waters of the State.

e. Land application practices are managed so as to reduce or minimize

ponding or puddling of liquid manure on the site, contamination of ground or surface waters, and occurrence of nuisance conditions such as odors, flies, and rodents.

f. Land application practices will minimize the possibility of contamination of surface and groundwaters of the State.

7. **Land Application of Liquid Manure**

a. The land application of the manure plans to be either knifed or sweeped directly into the ground.

8. **Amounts of Nitrogen Applied.**

a. Liquid and solid manure will typically be applied at agronomic rates for nitrogen, however, the phosphorus application will follow the North Dakota state phosphorous index risk assessment to ensure that the phosphorus levels are not becoming a risk to surface water pollution.

Section 10.B. lists the crop requirements for nitrogen as defined by a Licensed Professional Engineer.

b. Calculations for quantity of liquid manure that can be applied to agronomic rates to crop production land are performed by the staff soil scientist or contract professional. The maximum manure application rates can be seen in Section 10.B. The following land application formulas can be used for determining application rates or ones prepared by North Dakota State University Extension.

1) Nitrogen Need (lb/ac) = 35 + (1.2 x EY) - (8 x NO_3 - N ppm) - (0.14 x EY x OM) - other N credits
where, EY = Expected yield (bu/acre).
NO_3 - N ppm = average nitrate - nitrate concentration in the root zone.
OM = percent organic matter.
other N credits = nitrogen from legumes, manure and other organic waste products and irrigation water.

2) Manure N content (lbs/ac-in) = ((Total N ppm) x 0.2267)) x 0.4
where, 0.4 = nitrogen loss coefficient.
(The nitrogen loss coefficient may change with further improved research investigation.)

c. Max. application (lbs/ac)/Manure N Content (lbs/ac-in) = Max. manure application (ac-in).

d. Acres for application x Max. manure application (ac-in) x 27154 = Max. pumping volume (gallons).

e. The spreadsheet log for land application can be utilized for land application calculations.

9. Management Considerations for Nitrogen

Groundwater Concerns

The groundwater concern comes primary from nitrogen. If not captured by plant roots it can move down below the root zone and may enter the groundwater. The speed at which nitrate moves depends on the amount of precipitation received, soil texture and the amount of organic matter in the soil. Water moves through sandy soil much more rapidly than a clay soil.

Because nitrate moves through the soil with water, it is extremely important that the rate applied, either as manure or fertilizer, does not exceed that which can be used by the crops. Any nitrate remaining in the soil profile at the end of the season is subject to leaching.

Nitrogen Best Management Practices to Conserve N

- Match Manure Nutrient applications to crop needs.
- Apply manure as close to the time of crop utilization as possible. Apply commercial fertilizer nitrogen in a side-dress or split application when fields are located over shallow aquifers or on soils that have a high leaching potential.
- Delay fall manure applications until soil temperatures drop below 50 degrees F to minimize nitrate leaching and ammonia volatilization.
- Avoid applying manure on wet soils to minimize soil compaction, runoff, nitrate leaching, and denitrification.
- Inject or incorporate the manure into the soil preferably within 24 hours for maximum nutrient-use efficiency and to reduce odor and runoff chances. Significant volatilization losses will occur when manure is left on the surface for several days.

Water Quality Risk Assessment Maps will be labeled with the symbol "L" on fields that are vulnerable to N Leaching. These practices are not required only encouraged, specifically on fields that have high leaching capacity.

10. **Phosphorus Risk Assessment**

a. The phosphorus risk assessment was done for every field as can be seen in Section 10.B.2. The Best Managements Practices are shown in Section I.1 for site specific ratings. Subsequent assessments will be conducted if risk factors change or 5 years has passed since the previous assessment.

i. Low or Medium Risk

For a field or field segment with a low or medium risk of phosphorus movement from the field, a single year's application of manure may be based on the expected annual nitrogen requirement for the planned crop.

ii. High Risk

For a field or field segment where there is a high risk of phosphorus movement from the field, the manure will be applied at a rate equal to or less than the expected phosphorus removal in harvested plant biomass for a planned crop sequence of five years or less. The total nutrient application will not exceed the expected annual nutrient requirement for the planned crop.

iii. Very High Risk

For a field or field segment with a very high risk of phosphorus movement from the field, manure will not be applied.

11. Management Considerations for Phosphorus

Surface Water Concerns

Surface water concerns focus primarily on phosphorus. Phosphorus acts very differently in soils than nitrogen. It attaches tightly to soils and does not generally move down through the soil profile. This lack of movement through soils results in accumulations of phosphorus in soil if phosphorus rates, either from manure or fertilizer, are greater than crop removal. Increases in phosphorus concentrations in soil can result in more phosphorus moving off the field either attached to soil particles lost by erosion or dissolved in the runoff water. In some situations phosphorus could move into surface waters with manure itself if the manure is applied in such a manner that it moves directly into waterways.

Water Quality Risk Assessment Maps: will be labeled with the symbol "R" on fields that have limitations to Phosphorus applications.

1) In no case shall manure or organic by product applications (broadcast or incorporated/injected) be made within 100 feet of a surface water or conveyance.

Phosphorus Base Manure Application

If the manure application is required to be based on phosphorus crop removal, the application rate shall be based on phosphorus removed in the harvested portion of the crop.

Phosphorus Best Management Practices

1) Establish and maintain grass filter strips at the point where water leaves the field to trap sediment and nutrients

2) Control sheet and rill erosion by installing conservation practices including conservation tillage, contour farming, strip cropping, terraces and cover crops.

3) Control ephemeral erosion by installing grassed waterways, diversions and sediment retention structures.

4) Incorporate or inject manure and commercial fertilizer where possible while maintaining sufficient crop residue levels for erosion control.

5) Grow high yielding, high phosphorus removing crops on fields with already high soil test phosphorus to reduce test levels.

12. Solid Accumulation in the deep pits.

a. Solids will be agitated and land applied with the general liquid fertilizer utilizing available technology at the time of application.

13. Setback Requirements.

a. Manure shall not be applied any closer than a 100 feet to any down-gradient surface waters, open tile line intake structures, sinkholes, agricultural well heads or other conduits to surface waters.

b. Manure shall be injected or incorporated within eight hours if applied within ½ mile of an occupied residence (other than the owner's residence) building or public area where people may be present. The operator shall be required to inject or incorporate the manure into the soil if manure is applied in a manner such that is causes an odor reading, for two or more days within a 10-day period, (as measured with a scentometer) of 7 or greater within 100 feet of an occupied residence, building or public area. A plan to minimize excess odors will be required before future application of manure in this area.

14. Typical Crops Grown and Crop Yields for the Land Application Areas:

a. Soybeans – 37 bushels/acre
b. Corn Grain – 141 bushels/acre
c. Edible Beans – 1476 pounds/acre

15. Nutrient Utilization Plan Amendments.

a. This plan may be amended when it fails to provide for protection of environmental resources or as appropriate.

b. This plan will also need to be amended with Department of Health and Environment approval when one of the following conditions exist:

1) Additional land to which waste will be applies is not described in the approved plans.

2) A procedure will be used that is not described in an approved plan.

3) Land described in an approved plan is no longer available for nutrient application.

A test result exceed the phosphorous-holding capacity of the soil as determined by the North Dakota state phosphorus index risk assessment.

10. B. LAND APPLICATION CALCULATIONS

1. Calculating the Available Manure and Nutrients for Animal Feeding Operations
2. Nutrient Management Planner for ND Livestock Operations
3. Phosphorus Index
4. RUSLE 2 Calculations
5. Average County Yields

1. FARM NUTRIENT OUTPUT

Using the proposed animal numbers and ASAE D 384.2 Standard for Manure, the annual output was calculated. This along with existing Manure tests the total amount of nutrients available for land application was determined. Then by using NM-1629, North Dakota Manure Fertilizer Use Recommendations and MF-2562 Estimating Manure Nutrient Availability the amount available for the crop was determined. It is to be noted that the mineralization of organic N recommendations for the liquid manure is as follows:

1. Manure Application Year 1 = 30%
2. Manure Application Year 2 = 12%
3. Manure Application Year 3 = 6%

It is to be noted that the mineralization of organic N recommendations for the solid manure is as follows:

1. Manure Application Year 1 = 45%
2. Manure Application Year 2 = 12%
3. Manure Application Year 3 = 6%

2. Nutrient Management Planner for ND Livestock Feeding Operations and Planned Manure

The Nutrient Management Planner for ND Livestock Feeding Operations determines the recommended required nutrients along with the maximum amount of manure that can be applied based off the crop need, available manure nutrients and type of application method.

Planning the amount of manure to be land applied shall be up to the owner of the Diamond J Angus Ranch. For the crop year 2015 the following Planner on the next page makes recommendations for tons/acre per field along with supplemental commercial fertilizer. Things to consider when determining on how much to apply should be:

- Does the manure address the crop nutrient needs for N, P_2O_5 and K_2O. If the manure is applied on an N basis, this most likely means that P_2O_5 and K_2O are over applied, is this most economic solution? Or is it better to land apply on P_2O_5 basis and add commercial N?

Planning Manure Application

Using the crop recommendations from NDSU, SF 882 and the manure analysis from the ASAE, 2005, D384.2, the following nutrient% should be used to calculate the plant available nutrients.

Table 1. For **Inorganic N** (Ammonia N), MF-2562 Estimating Manure Nutrient Availability, Use:

1. Sweep Injected: 100% of Ammonia N
2. Knife injected or Immediate incorporated: 90% of Ammonia N
3. Incorporated after 1 day: 65% of Ammonia N
4. Sprinkler Irrigation or Incorporated at 2 days: 50% of Ammonia N
5. Incorporated at 3 days: 40%
6. Incorporated at 4 days: 30%
7. Incorporated at 5 days: 20%
8. Incorporated at 6 days: 10%
9. Incorporated at 7 days: 5%

Table 2. For **Organic N** %mineralization available for crop, NM-1629, North Dakota Manure Fertilizer Use Recommendations and MF-2562 Estimating Manure Nutrient Availability use:

1. Liquid Manure: Year 1= 30%, Year 2 = 12%, Year 3 = 6%
2. Solid Manure: Year 1= 45%, Year 2 = 12%, Year 3 = 6%
3. Compost Manure: Year 1= 20%, Year 2 = 6%, Year 3 = 3%

Table 3. For **P_2O_5** % nutrient available for crop use:

1. If Soil test for Olsen is lower than 32 ppm: Use 50% of Manure analysis
2. If Soil test for Olsen is greater than 32 ppm: Use 100% of Manure analysis

For **K_2O** use 85% of manure analysis for nutrient available for crop use

Table 4. Example of manure calculation

Assumptions:

- Wheat was planted previous year.
- 10-tons/acre of manure were applied previous year assuming the same as the ASAE, 2005, D 384.2 standard.

- Corn to be planted this year with SF-882 recommendations of 86, 24, 0
- The manure is to be broadcasted and not incorporated.
- Manure analysis results: lbs/ton, Total N =13.0, Total P_2O_5 = 13.0, Total K_2O = 6.6, Ammonia N = 3.0.

How many tons/acre to meet N requirements: Note 86.0 lbs recommended

Since the manure is to be broadcast all Ammonia N is lost, and referring to Table 2. 45% of Organic N is available for Year 1 = (13.0-3.0) * 0.45 = 4.5 lb/tons/acre

Year 2 credit manure credit = (13.0 lbs-3.0 lbs) * 0.12 *10 -tons/acre = 12.0 lbs.

Total tons/acre to meet Crop N needs = (86 lbs – 12.0 lbs)/4.5 = **16.4**-tons/acre.

How many tons/acre to meet P2O5 requirements: Note 24 lbs recommended

The soil test for P is 11 ppm so 100% of P_2O_5 is crop available.

Crop need is = 24 lbs /13 lbs-ton/acre = **1.8**-tons/acre

Summary

Crop needs, manure analysis, commercial fertilizer costs, transport costs all need to play a part in determining the amount of manure to land apply.

10B.1 Land Application Calculations

Rolling Green Family Farms RE, LLP
02-Dec-15

1. Estimate the total nutrients (NPK) in the excreted manure.

Nutrients per storage period = # of animals x weight (lbs) x daily nutrient production (lb/day/1,000 lb) x storage period (days).

		# of Animals	Average Weight (lbs.)	Daily Nutrient Production (lb/day/1,000 lbs)	Storage Period	Total Nutrients
Nitrogen						
	Farrowing Sows	1,344	400	0.45	365	88,301
	Breeding/Gestation	5,312	400	0.16	365	124,088
	Boars	0	500	0.14	365	0
	Nursery Pigs	800	45	0.92	365	12,089
	Finisher Pigs	1,600	150	0.54	365	47,304
Total Nitrogen		9,056				271,782
Phosphorus						
	Farrowing Sows	1,344	400	0.13	365	25,509
	Breeding/Gestation	5,312	400	0.05	365	38,778
	Boars	0	500	0.05	365	0
	Nursery Pigs	800	45	0.15	365	1,971
	Finisher Pigs	1,600	150	0.09	365	7,884
Total Phosphorus		9,056				74,142
Potassium	Lactating Sows	1,344	400	0.28	365	54,943
	Breeding/Gestation	5,312	400	0.11	365	85,311
	Boars	0	500	0.09	365	0
	Nursery Pigs	800	45	0.35	365	4,599
	Finisher Pigs	1,600	150	0.24	365	21,024
Total Potassium		9,056				165,876

2. Add nutrients contained in wastewater.

Nutrients in the wastewater = Number of animals x daily wastewater production (gal./day/cow) x da

		# of Animals	Daily Wastewater Production (gal./day/cow)	Daily Nutrient Production (lb/day/1,000 gal)	Storage Period	Total Nutrients
Nitrogen						
	Farrowing Sows	1,344	0	0	365	0
	Breeding/Gestation	5,312	0	0	365	0
	Boars	0	0	0	365	0
	Nursery Pigs	800	0	0	365	0
	Finisher Pigs	1,600	0	0	365	0
Total Nitrogen		9,056				0
Phosphorus						
	Farrowing Sows	1,344	0	0	365	0
	Breeding/Gestation	5,312	0	0	365	0
	Boars	0	0	0	365	0
	Nursery Pigs	800	0	0	365	0
	Finisher Pigs	1,600	0	0	365	0
Total Phosphorus		9,056				0
Potassium	Farrowing Sows	1,344	0	0	365	0
	Breeding/Gestation	5,312	0	0	365	0
	Boars	0	0	0	365	0
	Nursery Pigs	800	0	0	365	0
	Finisher Pigs	1,600	0	0	365	0
Total Potassium		9,056				0

Total Nutrients Produced

Total N	271,782 lbs
Total P	74,142 lbs
Total K	165,876 lbs

Convert to Fertilizer Form

Total N	271,782 lbs
Total P_2O_5	169,785 lbs
Total K_2O	200,710 lbs

3. Subtract nutrients lost during storage

Nutrients after storage losses = Total nutrients produced x fraction retained = Amount for land application

Solids (assume 0% of nutrients retained in solids)

Item	Nutrients (lbs)	Percent of Orig.	Available for Land Application (lbs)
Total N	0	0.65	0
Total P_2O_5	0	0.80	0
Total K_2O	0	0.80	0

Liquids (assume 100% of nutrients retained in liquids)

Item	Nutrients (lbs)	Percent of Orig.	Available for Land Application (lbs)
Total N	271,782	0.78	210,631
Total P_2O_5	169,785	0.93	157,051

Total K_2O	200,710	0.93	185,657

4. Determine the plant available nutrients

Estimate the amount of nutrients that will be available each year after the third consecutive year of application
Plant available nutrients = Amount applied x fraction available

Solids (assume 0% of nutrients retained in solids)

Item	Nutrients (lbs)	Percent Avail.	Available for Land Application (lbs)
Total N	0	0.73	0
Total P_2O_5	0	0.90	0
Total K_2O	0	0.93	0

Liquids (assume 100% of nutrients retained in liquids)

Item	Nutrients (lbs)	Percent Avail.	Available for Land Application (lbs)
Total N	210,631	0.73	153,761
Total P_2O_5	157,051	0.90	141,346
Total K_2O	185,657	0.93	172,661

HELP

Name: Melvin Family RE LLLP
County: Cass

Tract / Field(s) Field 1
Acres: 204.9

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	148	**BARNES-BUSE LOAMS, 3 TO 6 PERCENT SLOPES**	
NA	**Surface Water Risk**	**NA**	
NA	**Ground Water Risk**	**NA**	

The potential for runoff and leaching is not a concern for this soil map unit. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
0	greater than 1000 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

4 **Low** **Phosphorous Index Rating**

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

	Name:	Melvin Family RE LLLP	Tract / Field Number(s):	Field 1		Date:	06/30/15
HELP	County:	Cass		Acres:	204.9	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	146	bushels	175.2	102.2	170.2
Soybeans	37	bushels	0.0	57.4	81.4
Edible Beans	1476	pounds	73.8	34.1	51.1
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
14B	BARNES-BUSE LOAMS, 3 TO 6 PERCENT SLOPES	NA	NA

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	mmho / cm E.C.
Field 1	24	2	182	8	3.1	1.9

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	greater than 1000 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX	
Low	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 180 lbs./ac — **Phosphorous:** Maximum accumulation of P 150ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

See management statements above.

Additional Planning Remarks

Technical Service Provider — Date — Producer — Date — NRCS — Date

This worksheet is intended to provide nutrient and resource assessments. This worksheet is NOT intended to provide crop / fertilizer recommendations. The Natural Resources Conservation Service assumes no liability for any use of this worksheet outside of the intended purpose.

HELP

Name: Melvin Family RE LLLP
County: Cass

Tract / Field(s) Field 2
Acres: 75.6

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	50	**HAMERLY-TONKA LOAMS, 0 TO 3 PERCENT SLOPES**	
NA	**Surface Water Risk**	**NA**	
Moderate	**Ground Water Risk**	**Wetness**	

See "Management Considerations to Address Soil Surface Runoff or Leaching Concerns" on the "Nutrient Management Planner" sheet by clicking on the "Nutrient Management Planner" tab below. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
0	greater than 1000 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

4 **Low** **Phosphorous Index Rating**

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

	Name:	Melvin Family RE LLLP		Tract / Field Number(s):	Field 2	Date:	06/30/15
HELP	County:	Cass		Acres:	75.6	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	146	bushels	175.2	102.2	170.2
Soybeans	37	bushels	0.0	57.4	81.4
Edible Beans	1476	pounds	73.8	34.1	51.1
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
50	HAMERLY-TONKA LOAMS, 0 TO 3 PERCENT SLOPES	NA	Moderate

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth	ppm (Olsen) 0-6 in.	Optional Information for Documentation Only ppm 0-6 in.			mmho / cm
	N	P	K_2O	pH	O.M.%	E.C.
Field 2	41	2	150	8	3.5	2.39

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	greater than 1000 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.
Low	

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 150 lbs./ac — **Phosphorous:** Maximum accumulation of P 125 ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

Consider split nitrogen applications to include a preplant application and later application during early vegetative growth.

Additional Planning Remarks

Technical Service Provider — Date — Producer — Date — NRCS — Date

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HELP

Name: Melvin Family RE LLLP
County: **Cass**

Tract / Field(s) Field 3
Acres: 156.4

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	148	**BARNES-BUSE LOAMS, 3 TO 6 PERCENT SLOPES**	
NA	**Surface Water Risk**	**NA**	
NA	**Ground Water Risk**	**NA**	

The potential for runoff and leaching is not a concern for this soil map unit. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index

Phosphorous Index

HELP

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Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
0	greater than 1000 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

4 **Low** **Phosphorous Index Rating**

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

Name:	Melvin Family RE LLLP	Tract / Field Number(s):	Field 3	Date:	06/30/15
HELP County:	Cass	Acres:	156.4	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	141	bushels	169.2	98.7	164.4
Soybeans	37	bushels	0.0	57.4	81.4
Edible Beans	1476	pounds	73.8	34.1	51.1
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
148	BARNES-BUSE LOAMS, 3 TO 6 PERCENT SLOPES	NA	NA

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	greater than 1000 feet
Best Management Practices Planned	

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	mmho / cm E.C.
Field 3	35	3	132	8.1	3	1.88

PHOSPHOROUS INDEX	
Low	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 180 lbs./ac — **Phosphorous:** Maximum accumulation of P 150ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

See management statements above.

Additional Planning Remarks

Technical Service Provider — Date — Producer — Date — NRCS — Date

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HELP

Name: Melvin Family RE LLLP
County: Cass

Tract / Field(s) Field 4
Acres: 39.3

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	66	**WYARD-HAMERLY LOAMS, 1 TO 3 PERCENT SLOPES**	
NA	**Surface Water Risk**	**NA**	
NA	**Ground Water Risk**	**NA**	

The potential for runoff and leaching is not a concern for this soil map unit. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
0	greater than 1000 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

4 **Low** **Phosphorous Index Rating**

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

	Name:	Melvin Family RE LLLP	Tract / Field Number(s):	Field 4		Date:	06/30/15
HELP	County:	Cass	Acres:	39.3		Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	147	bushels	176.4	102.9	171.4
Soybeans	37	bushels	0.0	57.4	81.4
Edible Beans	1476	pounds	73.8	34.1	51.1
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
66	WYARD-HAMERLY LOAMS, 1 TO 3 PERCENT SLOPES	NA	NA

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	mmho / cm E.C.
Field 4	27	6	176	7.9	3.1	0.79

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	greater than 1000 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX	
Low	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 180 lbs./ac — **Phosphorous:** Maximum accumulation of P 150ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

See management statements above.

Additional Planning Remarks

Technical Service Provider — Date — Producer — Date — NRCS — Date

This worksheet is intended to provide nutrient and resource assessments. This worksheet is NOT intended to provide crop / fertilizer recommendations. The Natural Resources Conservation Service assumes no liability for any use of this worksheet outside of the intended purpose.

HELP

Name: Melvin Family RE LLLP
County: **Cass**

Tract / Field(s) Field 5
Acres: 243.5

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information 66 **WYARD-HAMERLY LOAMS, 1 TO 3 PERCENT SLOPES**

NA	**Surface Water Risk**	**NA**
NA	**Ground Water Risk**	**NA**

The potential for runoff and leaching is not a concern for this soil map unit. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
0	greater than 1000 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

4 **Low** **Phosphorous Index Rating**

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

Name:	Melvin Family RE LLLP	Tract / Field Number(s):	Field 5	Date:	06/30/15
HELP County:	Cass	Acres:	243.5	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	147	bushels	176.4	102.9	171.4
Soybeans	37	bushels	0.0	57.4	81.4
Edible Beans	1476	pounds	73.8	34.1	51.1
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
66	WYARD-HAMERLY LOAMS, 1 TO 3 PERCENT SLOPES	NA	NA

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	greater than 1000 feet
Best Management Practices Planned	

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	mmho / cm E.C.
Field 4	27	6	176	7.9	3.1	0.79

PHOSPHOROUS INDEX

Low

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds **Nitrogen:** Maximum accumulation of N 180 lbs./ac **Phosphorous:** Maximum accumulation of P 150ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

See management statements above.

Additional Planning Remarks

Technical Service Provider Date Producer Date NRCS Date

This worksheet is intended to provide nutrient and resource assessments. This worksheet is NOT intended to provide crop / fertilizer recommendations. The Natural Resources Conservation Service assumes no liability for any use of this worksheet outside of the intended purpose.

HELP

Name: Melvin Family RE LLLP
County: Cass

Tract / Field(s) Field 6
Acres: 78

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	50	**HAMERLY-TONKA LOAMS, 0 TO 3 PERCENT SLOPES**	
NA	**Surface Water Risk**	**NA**	
Moderate	**Ground Water Risk**	**Wetness**	

See "Management Considerations to Address Soil Surface Runoff or Leaching Concerns" on the "Nutrient Management Planner" sheet by clicking on the "Nutrient Management Planner" tab below. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
2	100-200 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

6 **Low** **Phosphorous Index Rating**

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

Name:	Melvin Family RE LLLP	Tract / Field Number(s):	Field 6	Date:	06/30/15
HELP County:	Cass	Acres:	78	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_20
Corn, Grain	141	bushels	169.2	98.7	164.4
Soybeans	37	bushels	0.0	57.4	81.4
Edible Beans	1476	pounds	73.8	34.1	51.1
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
50	HAMERLY-TONKA LOAMS, 0 TO 3 PERCENT SLOPES	NA	Moderate

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	100-200 feet
Best Management Practices Planned	

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_20	pH	O.M.%	mmho / cm E.C.
Field 6	28	4	166	8.1	2.3	1.2

PHOSPHOROUS INDEX	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.
Low	

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds **Nitrogen:** Maximum accumulation of N 150 lbs./ac **Phosphorous:** Maximum accumulation of P 125 ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

Consider split nitrogen applications to include a preplant application and later application during early vegetative growth.

Additional Planning Remarks

Technical Service Provider Date Producer Date NRCS Date

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HELP

Name: Eldwyn Van Bruggen
County: Cass

Tract / Field(s) Field 7 & 8
Acres: 141.2

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	S1	HAMERLY LOAM, SALINE, 0 TO 3 PERCENT SLOPES

NA	Surface Water Risk	NA
Moderate	Ground Water Risk	Wetness

See "Management Considerations to Address Soil Surface Runoff or Leaching Concerns" on the "Nutrient Management Planner" sheet by clicking on the "Nutrient Management Planner" tab below. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index

Phosphorous Index

HELP

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Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
2	100-200 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

6 **Low** **Phosphorous Index Rating**

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

	Name:	Eldwyn Van Bruggen	Tract / Field Number(s):	Field 7 & 8	Date:	06/30/15	
HELP	County:	Cass	Acres:	141.2	Assisted By:		

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	141	bushels	169.2	98.7	164.4
Soybeans	37	bushels	0.0	57.4	81.4
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
51	HAMERLY LOAM, SALINE, 0 TO 3 PERCENT SLOPES	NA	Moderate

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	E.C.
Field 7 & 8	37	6	278	8		

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	100-200 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.
Low	

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 150 lbs./ac — **Phosphorous:** Maximum accumulation of P 125 ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

Consider split nitrogen applications to include a preplant application and later application during early vegetative growth.

Additional Planning Remarks

Technical Service Provider — Date — Producer — Date — NRCS — Date

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HELP

Name: Eldwyn Van Bruggen
County: Cass

Tract / Field(s) Field 9
Acres: 150.1

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	51	**HAMERLY LOAM, SALINE, 0 TO 3 PERCENT SLOPES**	
NA	**Surface Water Risk**	**NA**	
Moderate	**Ground Water Risk**	**Wetness**	

See "Management Considerations to Address Soil Surface Runoff or Leaching Concerns" on the "Nutrient Management Planner" sheet by clicking on the "Nutrient Management Planner" tab below. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index

Phosphorous Index

HELP

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Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
2	100-200 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

6 **Low** **Phosphorous Index Rating**

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

Name:	Eldwyn Van Bruggen	Tract / Field Number(s):	Field 9	Date:	06/30/15
HELP County:	Cass	Acres:	150.1	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	141	bushels	169.2	98.7	164.4
Edible Beans	1476	pounds	73.8	34.1	51.1
Soybeans	37	bushels	0.0	57.4	81.4
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
51	HAMERLY LOAM, SALINE, 0 TO 3 PERCENT SLOPES	NA	Moderate

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-8 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	E.C.
Field 9	45	5	238	8		

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	100-200 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX	
Low	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 150 lbs./ac — **Phosphorous:** Maximum accumulation of P 125 ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

Consider split nitrogen applications to include a preplant application and later application during early vegetative growth.

Additional Planning Remarks

Technical Service Provider — Date — Producer — Date — NRCS — Date

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HELP

Name: Joseph Harbeke
County: **Cass**

Tract / Field(s) Field 10
Acres: 140.2

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information 178 **BARNES-SVEA LOAMS, 2 TO 5 PERCENT SLOPES**

NA	**Surface Water Risk**	**NA**
NA	**Ground Water Risk**	**NA**

The potential for runoff and leaching is not a concern for this soil map unit. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index

Phosphorus Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
0	greater than 1000 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

4 **Low** **Phosphorous Index Rating**

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

Name:	Joseph Harbeke	Tract / Field Number(s):	Field 10	Date:	07/16/15
HELP County:	Cass	Acres:	140.2	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	141	bushels	169.2	98.7	164.4
Edible Beans	1476	pounds	73.8	34.1	51.1
Soybeans	37	bushels	0.0	57.4	81.4
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
17B	BARNES-SVEA LOAMS, 2 TO 5 PERCENT SLOPES	NA	NA

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	E.C.
11/6/2014	28	6	195	8	4.1	1.1
11/20/2013	27	2	202	7.9		1

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	greater than 1000 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX	
Low	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 180 lbs./ac — **Phosphorous:** Maximum accumulation of P 150ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

See management statements above.

Additional Planning Remarks

Technical Service Provider — Date — Producer — Date — NRCS — Date

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Name:	Jonathon Melvin	Tract / Field Number(s):	Field 11	Date:	07/20/15
HELP County:	Cass	Acres:	158	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	141	bushels	169.2	98.7	164.4
Edible Beans	1476	pounds	73.8	34.1	51.1
Soybeans	37	bushels	0.0	57.4	81.4
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
50	HAMERLY-TONKA LOAMS, 0 TO 3 PERCENT SLOPES	NA	Moderate

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	less than 30 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	greater than 1000 feet
Best Management Practices Planned	

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	E.C.
Field 11	12	19	383	8.1	4	1.47

PHOSPHOROUS INDEX	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.
Low	

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds **Nitrogen:** Maximum accumulation of N 150 lbs./ac **Phosphorous:** Maximum accumulation of P 125 ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

Consider split nitrogen applications to include a preplant application and later application during early vegetative growth.

Additional Planning Remarks

Technical Service Provider Date Producer Date NRCS Date

This worksheet is intended to provide nutrient and resource assessments. This worksheet is NOT intended to provide crop / fertilizer recommendations. The Natural Resources Conservation Service assumes no liability for any use of this worksheet outside of the intended purpose.

HELP

Name: Jonathon Melvin
County: Cass

Tract / Field(s) Field 11
Acres: 158

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	50	**HAMERLY-TONKA LOAMS, 0 TO 3 PERCENT SLOPES**	
NA	**Surface Water Risk**	**NA**	
Moderate	**Ground Water Risk**	**Wetness**	

See "Management Considerations to Address Soil Surface Runoff or Leaching Concerns" on the "Nutrient Management Planner" sheet by clicking on the "Nutrient Management Planner" tab below. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index.

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
1	less than 30 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
0	greater than 1000 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

3 **Low** **Phosphorous Index Rating**

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

HELP

Name: Jonathon Melvin
County: Cass

Tract / Field(s) Field 12
Acres: 112.3

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	178	**BARNES-SVEA LOAMS, 2 TO 5 PERCENT SLOPES**	
NA	**Surface Water Risk**	**NA**	
NA	**Ground Water Risk**	**NA**	

The potential for runoff and leaching is not a concern for this soil map unit. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
3	20-100 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

7 **Low** **Phosphorous Index Rating**

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

	Name:	Jonathon Melvin	Tract / Field Number(s):	Field 12	Date: 07/20/15
HELP	County:	Cass	Acres:	112.3	Assisted By:

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	141	bushels	169.2	98.7	164.4
Edible Beans	1476	pounds	73.8	34.1	51.1
Soybeans	37	bushels	0.0	57.4	81.4
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
17B	BARNES-SVEA LOAMS, 2 TO 5 PERCENT SLOPES	NA	NA

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	E.C.
10/27/2014	44	6	242	7.3	4.4	1.09
11/4/2013	31	5	212	7.5	3.6	1.01

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	20-100 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX	
Low	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 180 lbs./ac — **Phosphorous:** Maximum accumulation of P 150ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

See management statements above.

Additional Planning Remarks

Technical Service Provider — Date — Producer — Date — NRCS — Date

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HELP

Name: Randy Melvin
County: Cass

Tract / Field(s) Field 13
Acres: 376.3

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	178	**BARNES-SVEA LOAMS, 2 TO 5 PERCENT SLOPES**	
NA	**Surface Water Risk**	**NA**	
NA	**Ground Water Risk**	**NA**	

The potential for runoff and leaching is not a concern for this soil map unit. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
3	20-100 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0	Best Management Practice Credit Total	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.
7	**Low** **Phosphorous Index Rating**	

Name:	Randy Melvin	Tract / Field Number(s):	Field 13	Date:	06/30/15
HELP County:	Cass	Acres:	376.3	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	141	bushels	169.2	98.7	164.4
Edible Beans	1476	pounds	73.8	34.1	51.1
Soybeans	37	bushels	0.0	57.4	81.4
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
17B	BARNES-SVEA LOAMS, 2 TO 5 PERCENT SLOPES	NA	NA

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	20-100 feet
Best Management Practices Planned	

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	mmho / cm E.C.
Field 13	37	5	205	7.7	3	1.4

PHOSPHOROUS INDEX	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.
Low	

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds **Nitrogen:** Maximum accumulation of N 180 lbs./ac **Phosphorous:** Maximum accumulation of P 150ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

See management statements above.

Additional Planning Remarks

Technical Service Provider Date Producer Date NRCS Date

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HELP

Name: Randy Melvin
County: Cass

Tract / Field(s) Field 14
Acres: 70.9

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	178	**BARNES-SVEA LOAMS, 2 TO 5 PERCENT SLOPES**	
NA	**Surface Water Risk**	**NA**	
NA	**Ground Water Risk**	**NA**	

The potential for runoff and leaching is not a concern for this soil map unit. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index

Phosphorous Index

HELP

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Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
3	20-100 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

7 **Low** **Phosphorous Index Rating**

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

	Name:	Randy Melvin	Tract / Field Number(s):	Field 14		Date:	06/30/15
HELP	County:	Cass		Acres:	70.9	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	141	bushels	169.2	98.7	164.4
Edible Beans	1476	pounds	73.8	34.1	51.1
Soybeans	37	bushels	0.0	57.4	81.4
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
17B	BARNES-SVEA LOAMS, 2 TO 5 PERCENT SLOPES	NA	NA

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	mmho / cm E.C.
Field 14	73	5	174	7.8	3.4	0.9

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	20-100 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.
Low	

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 180 lbs./ac — **Phosphorous:** Maximum accumulation of P 150ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

See management statements above.

Additional Planning Remarks

Technical Service Provider — Date — Producer — Date — NRCS — Date

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HELP

Name: Randy Melvin
County: Cass

Tract / Field(s) Field 15
Acres: 41.2

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	27	**DIVIDE LOAM**	
NA	**Surface Water Risk**	**NA**	
High	**Ground Water Risk**	**Poor Filter**	

See "Management Considerations to Address Soil Surface Runoff or Leaching Concerns" on the "Nutrient Management Planner" sheet by clicking on the "Nutrient Management Planner" tab below. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index

Phosphorus Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
3	20-100 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

7 **Low** **Phosphorous Index Rating**

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

Name:	Randy Melvin	Tract / Field Number(s):	Field 15	Date:	06/30/15
HELP County:	Cass	Acres:	41.2	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	141	bushels	169.2	98.7	164.4
Edible Beans	1476	pounds	73.8	34.1	51.1
Soybeans	37	bushels	0.0	57.4	81.4
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
27	DIVIDE LOAM	NA	High

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	20-100 feet
Best Management Practices Planned	

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	mmho / cm E.C.
Field 15	81	8	239	7.9	5.1	2.5

PHOSPHOROUS INDEX	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.
Low	

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds **Nitrogen:** Maximum accumulation of N 100 lbs./ac **Phosphorous:** Maximum accumulation of P 100 ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

Fall application not recommended.
Spring application should be delayed until after the soil is completely thawed. Consider split nitrogen applications to include a preplant application and later application during early vegetative growth.

Additional Planning Remarks

Technical Service Provider Date Producer Date NRCS Date

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HELP

Name: Randy Melvin
County: Cass

Tract / Field(s) Field 16
Acres: 63.8

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	66	**WYARD-HAMERLY LOAMS, 1 TO 3 PERCENT SLOPES**	
NA	**Surface Water Risk**	**NA**	
NA	**Ground Water Risk**	**NA**	

The potential for runoff and leaching is not a concern for this soil map unit. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
1	200-1000 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

5 **LOW** **Phosphorous Index Rating**

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

	Name:	Randy Melvin	Tract / Field Number(s):	Field 16		Date:	06/30/15
HELP	County:	Cass	Acres:	63.8	Assisted By:		

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	148	bushels	177.6	103.6	172.6
Edible Beans	1476	pounds	73.8	34.1	51.1
Soybeans	37	bushels	0.0	57.4	81.4
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
66	WYARD-HAMERLY LOAMS, 1 TO 3 PERCENT SLOPES	NA	NA

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	E.C.
Field 16	15	4	199	8		

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	200-1000 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX	
Low	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 180 lbs./ac — **Phosphorous:** Maximum accumulation of P 150ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

See management statements above.

Additional Planning Remarks

Technical Service Provider Date | Producer Date | NRCS Date

This worksheet is intended to provide nutrient and resource assessments. This worksheet is NOT intended to provide crop / fertilizer recommendations. The Natural Resources Conservation Service assumes no liability for any use of this worksheet outside of the intended purpose.

HELP

Name: Randy Melvin
County: Cass

Tract / Field(s) Field 17
Acres: 83.1

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	148	**BARNES-BUSE LOAMS, 3 TO 6 PERCENT SLOPES**	
NA	**Surface Water Risk**	**NA**	
NA	**Ground Water Risk**	**NA**	

The potential for runoff and leaching is not a concern for this soil map unit. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
2	100-200 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

6 **Low** **Phosphorous Index Rating**

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

	Name:	Randy Melvin	Tract / Field Number(s):	Field 17		Date:	06/30/15
HELP	County:	Cass		Acres:	83.1	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	148	bushels	177.6	103.6	172.6
Edible Beans	1476	pounds	73.8	34.1	51.1
Soybeans	37	bushels	0.0	57.4	81.4
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
14B	BARNES-BUSE LOAMS, 3 TO 6 PERCENT SLOPES	NA	NA

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	E.C.
Field 17	42	8	239	7.7		

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	100-200 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX	
Low	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 180 lbs./ac — **Phosphorous:** Maximum accumulation of P 150ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

See management statements above.

Additional Planning Remarks

Technical Service Provider — Date — Producer — Date — NRCS — Date

This worksheet is intended to provide nutrient and resource assessments. This worksheet is NOT intended to provide crop / fertilizer recommendations. The Natural Resources Conservation Service assumes no liability for any use of this worksheet outside of the intended purpose.

HELP

Name: Randy Melvin
County: Cass

Tract / Field(s) Field 18
Acres: 155.8

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	50	HAMERLY-TONKA LOAMS, 0 TO 3 PERCENT SLOPES	
NA	**Surface Water Risk**	**NA**	
Moderate	**Ground Water Risk**	**Wetness**	

See "Management Considerations to Address Soil Surface Runoff or Leaching Concerns" on the "Nutrient Management Planner" sheet by clicking on the "Nutrient Management Planner" tab below. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
0	greater than 1000 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

4 **Low** **Phosphorous Index Rating**

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

	Name:	Randy Melvin	Tract / Field Number(s):	Field 18		Date:	06/30/15
HELP	County:	Cass	Acres:	155.8		Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	141	bushels	169.2	98.7	164.4
Edible Beans	1476	pounds	73.8	34.1	51.1
Soybeans	37	bushels	0.0	57.4	81.4
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
50	HAMERLY-TONKA LOAMS, 0 TO 3 PERCENT SLOPES	NA	Moderate

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	greater than 1000 feet
Best Management Practices Planned	

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	E.C.
Field 18	46	4	196	8	3	1

PHOSPHOROUS INDEX	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.
Low	

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 150 lbs./ac — **Phosphorous:** Maximum accumulation of P 125 ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

Consider split nitrogen applications to include a preplant application and later application during early vegetative growth.

Additional Planning Remarks

Technical Service Provider — Date — Producer — Date — NRCS — Date

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HELP

Name: Randy Melvin
County: Cass

Tract / Field(s) Field 19
Acres: 148.8

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	50	**HAMERLY-TONKA LOAMS, 0 TO 3 PERCENT SLOPES**	
NA	**Surface Water Risk**	**NA**	
Moderate	**Ground Water Risk**	**Wetness**	

See "Management Considerations to Address Soil Surface Runoff or Leaching Concerns" on the "Nutrient Management Planner" sheet by clicking on the "Nutrient Management Planner" tab below. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
0	greater than 1000 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

4 **Low** **Phosphorous Index Rating**

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

Name:	Randy Melvin	Tract / Field Number(s):	Field 19	Date:	06/30/15
HELP County:	Cass	Acres:	148.8	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	141	bushels	169.2	98.7	164.4
Edible Beans	1476	pounds	73.8	34.1	51.1
Soybeans	37	bushels	0.0	57.4	81.4
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
50	HAMERLY-TONKA LOAMS, 0 TO 3 PERCENT SLOPES	NA	Moderate

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	mmho / cm E.C.
Field 19	36	10	231	8	3.9	1.9

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	greater than 1000 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.
Low	

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 150 lbs./ac — **Phosphorous:** Maximum accumulation of P 125 ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

Consider split nitrogen applications to include a preplant application and later application during early vegetative growth.

Additional Planning Remarks

Technical Service Provider — Date — Producer — Date — NRCS — Date

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HELP

Name: Randy Melvin
County: Cass

Tract / Field(s) Field 20
Acres: 57.6

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	66	**WYARD-HAMERLY LOAMS, 1 TO 3 PERCENT SLOPES**	
NA	**Surface Water Risk**	**NA**	
NA	**Ground Water Risk**	**NA**	

The potential for runoff and leaching is not a concern for this soil map unit. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
3	20-100 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

7 **Low** **Phosphorous Index Rating**

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

Name:	Randy Melvin	Tract / Field Number(s):	Field 20	Date:	06/30/15
HELP County:	Cass	Acres:	57.6	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	141	bushels	169.2	98.7	164.4
Edible Beans	1476	pounds	73.8	34.1	51.1
Soybeans	37	bushels	0.0	57.4	81.4
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
66	WYARD-HAMERLY LOAMS, 1 TO 3 PERCENT SLOPES	NA	NA

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	20-100 feet
Best Management Practices Planned	

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	mmho / cm E.C.
Field 20	10	3	170	8	2.7	1.75

PHOSPHOROUS INDEX	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.
Low	

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 180 lbs./ac — **Phosphorous:** Maximum accumulation of P 150ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

See management statements above.

Additional Planning Remarks

Technical Service Provider Date Producer Date NRCS Date

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HELP

Name: Randy Melvin
County: Cass

Tract / Field(s) Field 21
Acres: 107.7

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	148	**BARNES-BUSE LOAMS, 3 TO 6 PERCENT SLOPES**	
NA	**Surface Water Risk**	**NA**	
NA	**Ground Water Risk**	**NA**	

The potential for runoff and leaching is not a concern for this soil map unit. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index

Phosphorous Index

HELP

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Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
3	20-100 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

7 **Low** **Phosphorous Index Rating**

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

United States Dept. of Agriculture
Natural Resources Conservation Service

ND-CPA-343e(a)
Revised 1/04

Name:	Randy Melvin	Tract / Field Number(s):	Field 21	Date:	06/30/15
HELP County:	Cass	Acres:	107.7	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	141	bushels	169.2	98.7	164.4
Edible Beans	1476	pounds	73.8	34.1	51.1
Soybeans	37	bushels	0.0	57.4	81.4
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
14B	BARNES-BUSE LOAMS, 3 TO 6 PERCENT SLOPES	NA	NA

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	E.C.
Field 21	28	4	166	7.9	2.2	1.5

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	20-100 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX	
Low	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 180 lbs./ac — **Phosphorous:** Maximum accumulation of P 150ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

See management statements above.

Additional Planning Remarks

Technical Service Provider Date Producer Date NRCS Date

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000181

HELP

Name: Tim Bernston
County: Cass

Tract / Field(s) Field 22
Acres: 268.8

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	148	BARNES-BUSE LOAMS, 3 TO 6 PERCENT SLOPES
NA	Surface Water Risk	NA
NA	Ground Water Risk	NA

The potential for runoff and leaching is not a concern for this soil map unit. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
0	greater than 1000 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

4 **Low** **Phosphorous Index Rating**

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

	Name:	Tim Bernston	Tract / Field Number(s):	Field 22	Date:	06/30/15	
HELP	County:	Cass	Acres:	268.8	Assisted By:		

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_20
Corn, Grain	162	bushels	194.4	113.4	188.9
Soybeans	37	bushels	0.0	57.4	81.4
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
14B	BARNES-BUSE LOAMS, 3 TO 6 PERCENT SLOPES	NA	NA

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_20	pH	O.M.%	mmho / cm E.C.
Field 22	42	10	125	7.8	3.8	1.25

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	greater than 1000 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX	
Low	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 180 lbs./ac — **Phosphorous:** Maximum accumulation of P 150ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

See management statements above.

Additional Planning Remarks

Technical Service Provider — Date — Producer — Date — NRCS — Date

This worksheet is intended to provide nutrient and resource assessments. This worksheet is NOT intended to provide crop / fertilizer recommendations. The Natural Resources Conservation Service assumes no liability for any use of this worksheet outside of the intended purpose.

HELP

Name: Tim Bernston
County: **Cass**

Tract / Field(s) Field 23
Acres: 261.9

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information 178 **BARNES-SVEA LOAMS, 2 TO 5 PERCENT SLOPES**

NA	**Surface Water Risk**	**NA**
NA	**Ground Water Risk**	**NA**

The potential for runoff and leaching is not a concern for this soil map unit. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
0	greater than 1000 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

4 **Low** **Phosphorous Index Rating**

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

	Name:	Tim Bernston	Tract / Field Number(s):	Field 23	Date: 06/30/15
HELP	County:	Cass	Acres:	261.9	Assisted By:

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	162	bushels	194.4	113.4	188.9
Soybeans	37	bushels	0.0	57.4	81.4
Edible Beans	1476	pounds	73.8	34.1	51.1
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
17B	BARNES-SVEA LOAMS, 2 TO 5 PERCENT SLOPES	NA	NA

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	mmho / cm E.C.
Field 23	29	7	141	8	3.2	1.12

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	greater than 1000 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX	
Low	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 180 lbs./ac — **Phosphorous:** Maximum accumulation of P 150ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

See management statements above.

Additional Planning Remarks

Technical Service Provider Date Producer Date NRCS Date

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HELP

Name: Tim Bernston
County: Cass

Tract / Field(s) Field 24
Acres: 27

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	66	**WYARD-HAMERLY LOAMS, 1 TO 3 PERCENT SLOPES**	
NA	**Surface Water Risk**	**NA**	
NA	**Ground Water Risk**	**NA**	

The potential for runoff and leaching is not a concern for this soil map unit. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index

Phosphorous Index

HELP

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Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
0	greater than 1000 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

4 **Low** **Phosphorous Index Rating**

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

	Name:	Tim Bernston	Tract / Field Number(s):	Field 24	Date: 06/30/15
HELP	County:	Cass	Acres:	27	Assisted By:

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_20
Corn, Grain	140	bushels	168.0	98.0	163.2
Soybeans	37	bushels	0.0	57.4	81.4
Corn, Grain	162	bushels	194.4	113.4	188.9
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
66	WYARD-HAMERLY LOAMS, 1 TO 3 PERCENT SLOPES	NA	NA

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	mmho / cm E.C.
Field 24	30	10	144	8	3	1.33

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	greater than 1000 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX	
Low	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 180 lbs./ac — **Phosphorous:** Maximum accumulation of P 150ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

See management statements above.

Additional Planning Remarks

Technical Service Provider Date Producer Date NRCS Date

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HELP

Name: Tim Bernston
County: Cass

Tract / Field(s) Field 25
Acres: 150

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	148	BARNES-BUSE LOAMS, 3 TO 6 PERCENT SLOPES	
NA	Surface Water Risk	NA	
NA	Ground Water Risk	NA	

The potential for runoff and leaching is not a concern for this soil map unit. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index

Phosphorus Index

HELP

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Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
0	greater than 1000 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

4 **Low** **Phosphorous Index Rating**

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

Name:	Tim Bernston	Tract / Field Number(s):	Field 25	Date:	06/30/15
HELP County:	Cass	Acres:	150	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	150	bushels	180.0	105.0	174.9
Soybeans	37	bushels	0.0	57.4	81.4
Corn, Grain	156	bushels	187.2	109.2	181.9
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
14B	BARNES-BUSE LOAMS, 3 TO 6 PERCENT SLOPES	NA	NA

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	mmho / cm E.C.
Field 25	57	8	152	8	3	1.5

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	greater than 1000 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.
Low	

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 180 lbs./ac — **Phosphorous:** Maximum accumulation of P 150ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

See management statements above.

Additional Planning Remarks

Technical Service Provider _____ Date _____ Producer _____ Date _____ NRCS _____ Date _____

This worksheet is intended to provide nutrient and resource assessments. This worksheet is NOT intended to provide crop / fertilizer recommendations. The Natural Resources Conservation Service assumes no liability for any use of this worksheet outside of the intended purpose.

Plan Year: 2016

	Part 1: Field Information									Part 2. Estimated Nutrient Requirement							Part 3. Planned Nutrient Application		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Field #	Legal Description	Spreadable Acres	Irrigated	No-Till > 5 Years	No-Till < 5 Years	Current Soil Tested: 2014 and 2015 N lb/Ac (0-2'	Phosphorus (ppm)(Olsen)(0-6")	Potassium (ppm K)	Organic Matter	Previous Year Crop	Previous Year Crop Yield, lb, bu, ton	Planning Year (2013 Crop	Crop Yield, lb, bu, ton/acre	[1,2]Nutrient Recommendation (SF-882) N (lb/A)	P_2O_5 (lb/ac) (broadcast)	K_2O (lb/ac)	Manure Application Based on	Type of Manure and Equipment Used: Type of Manure	Application Method
1	NW 1/4, S 5, T 141 N, R 85 W	204.92				24	2	182	3.1	Corn, Grain	146	Soybean	37	0	47	0	1.0 x Crop N Removal	Liquid Manure	Sweep Injected
2	SE 1/4, S 5, T 141 N, R 85 W	75.6				41	2	150	3.5	Soybean	37	Corn, Grain	141	168	86	10	1.0 x Crop N Removal	Liquid Manure	Sweep Injected
3	NW 1/4, S 6, T 141 N, R 85 W	156.4				35	3	132	3	Soybean	37	Corn, Grain	141	174	80	29	1.0 x Crop N Removal	Liquid Manure	Sweep Injected
4	NW 1/4, S 6, T 141 N, R 85 W	39.3				27	6	176	3.1	Corn, Grain	146	Soybean	37	0	26	0	1.0 x Crop N Removal	Liquid Manure	Sweep Injected
5	SE 1/4, S 7, T 141 N, R 85 W	243.5				21	7	221	3.2	Corn, Grain	123	Soybean	37	0	21	0	1.0 x Crop N Removal	Liquid Manure	Sweep Injected
6	NW 1/4,S 18, T 141 N, R 85 W	78				28	4	166	2.3	Soybean	37	Corn, Grain	141	181	74	0	1.0 x Crop N Removal	Liquid Manure	Sweep Injected
7&8	N 1/2, S 18, T 141 N, R 85 W	141.2				37	6	278		Corn, Grain	140	Soybean	37	0	26	0	1.0 x Crop N Removal	Liquid Manure	Sweep Injected
9	NE 1/4, S 18, T 141 N, R 85 W	150.1				45	5	238		Soybean	37	Corn, Grain	140	163	67	0	1.0 x Crop N Removal	Liquid Manure	Sweep Injected
10	NE 1/4,S 32, T 141 N, R 85 W	140.2				28	6	195	4.1	Soybean	37	Corn, Grain	141	181	61	0	1.0 x Crop N Removal	Liquid Manure	Sweep Injected
11	SE 1/4 S 10, T 140 N, R 55 W	158				12	19	383	4	Corn, Grain	128	Soybean	37	0	0	0	1.0 x Crop N Removal	Liquid Manure	Sweep Injected
12	NW 1/4 S 14, T 139 N, R 55 W	112.3				44	6	242	4.4	Soybean	37	Corn, Grain	141	165	61	0	1.0 x Crop N Removal	Liquid Manure	Sweep Injected
13	S 11, T 140 N, R 55 W	376.3				37	5	205	3	Corn, Grain	132.0	Soybean	37	0	31	0	1.0 x Crop N Removal	Liquid Manure	Sweep Injected
14	S 11, T 140 N, R 55 W	70.9				73	5	174	3.4	Corn, Grain	134.0	Soybean	37	0	31	0	1.0 x Crop N Removal	Liquid Manure	Sweep Injected
	Total =	1,946.7																	

References: Estimating Manure Nutrient Availabilty: MF-2562
North Dakota Fertilizer Recommendation Tables and Equations, SF 882 (Revised)
North Dakota Manure Fertilizer Use Recommendations, NM-1629

[1]It is recommended to band 15 lbs P_2O_5 for Wheat with the starter fertilizer.
[2]Reduce P_2O_5 and K_2O by 1/3 if fertilizer is banded

Nutrient Management Plan
For ND Livestock Operations

Plan Year: 2016

	Part 1: Field Information									Part 2. Estimated Nutrient Requirement							Part 3. Planned Nutrient Application		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
						Current Soil Tested				Previous Year		Planning Year (2016)		[1,2]Nutrient Recommendation (SF-882)				Type of Manure and Equipment Used	
Field #	Legal Description	Spreadable Acres	Irrigated	No-Till > 5 Years	No-Till < 5 Years	N lb/Ac (0-2'	Phosphorus (ppm)(Olsen)(0-6")	Potassium (ppm K)	Organic Matter	Crop	Crop Yield, lb, bu, ton	Crop	Crop Yield, lb, bu, ton/acre	N (lb/A)	P_2O_5 (lb/ac) (broadcast)	K_2O (lb/ac)	Manure Application Based on	Type of Manure	Application Method
15	S 11, T 140 N, R 55 W	41.2				81	8	239	5.1	Soybean	37	Corn, Grain	141	128	49	0	1.0 x Crop N Removal	Liquid Manure	Sweep Injected
16	NE 1/4 S 2, T 139 N, R 55 W	63.8				15	4	199	2.6	Corn, Grain	156	Soybean	37	0	37	0	1.0 x Crop N Removal	Liquid Manure	Sweep Injected
17	NE 1/4 S 2, T 139 N, R 55 W	83.1				42	8	239	3	Soybean	37	Corn, Grain	160	190	56	0	1.0 x Crop N Removal	Liquid Manure	Sweep Injected
18	E 1/2 S 4, T 139 N, R 55 W	155.8				46	4	196	3.7	Soybean	37	Corn, Grain	140	162	73	0	1.0 x Crop N Removal	Liquid Manure	Sweep Injected
19	E 1/2 S 4, T 139 N, R 55 W	148.8				36	10	231	3.9	Corn, Grain	134	Soybean	37	0	6	0	1.0 x Crop N Removal	Liquid Manure	Sweep Injected
20	S 1/2 SE 1/4 S 11, T 139 N, R 55 W	57.6				10	3	170	2.7	Corn, Grain	127	Soybean	37	0	42	0	1.0 x Crop N Removal	Liquid Manure	Sweep Injected
21	NW 1/4 S 12, T 139 N, R 55 W	107.7				28	4	166	2.2	Soybean	37	Corn, Grain	140	180	73	0	1.0 x Crop N Removal	Liquid Manure	Sweep Injected
22	S 29, T 140 N, R 54 W	268.8				42	10	125	3.8	Corn, Grain	185	Soybean	37	0	6	0	1.0 x Crop N Removal	Liquid Manure	Sweep Injected
23	S 29, T 140 N, R 54 W	261.9				29	7	141	3.2	Soybean	37	Corn, Grain	160	203	63	22	1.0 x Crop N Removal	Liquid Manure	Sweep Injected
24	S 29, T 140 N, R 54 W	27				30	10	144	3	Corn, Grain	185	Soybean	37	0	6	0	1.0 x Crop N Removal	Liquid Manure	Sweep Injected
25	NE 1/4 S 32, T 140 N, R 54 W	150				57	8	152	3	Corn, Grain	153	Soybean	37	0	16	0	1.0 x Crop N Removal	Liquid Manure	Sweep Injected
														0	0	0			
														0	0	0			
	Total =	1,365.7																	

References: Estimating Manure Nutrient Availabilty: MF-2562
North Dakota Fertilizer Recommendation Tables and Equations, SF 882 (Revised)
North Dakota Manure Fertilizer Use Recommendations, NM-1629

[1]It is recommended to band 15 lbs P_2O_5 for Wheat with the starter fertilizer.
[4]Reduce P_2O_5 and K_2O by 1/3 if fertilizer is banded

Nutrient Management Plan
For ND Livestock Operations

Plan Year: 2013

	Part 3. Planned Nutrient Application									Part 4. Nutrient Application								Part 5. Nutrient Balance			
1	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
	Solids (lbs/ton,) ASAE, 2005, D 384.2			Liquid (lbs/acre-in), PART 651 Table 4-16			Manure Application		Maximum Manure Applied	Manure Applied			Manure Application (lbs/acre)		Commercial Application lbs/acre		Total lbs/acre		Crop Removal (lb/ac)		Soil Nutrient Balance	
Field #	Organic N	Ammonium N	P_2O_5	Organic N	Ammonium N	P_2O_5	N Credit, (Prior year and year before that) (lbs/acre)	Available N (First Crop Year) lbs/ton or lbs/acre-in	Tons/Acre or acre-in/acre	Tons or Acre-in	Tons or Acre-in per Field	Time Period When Manure Applied	N	P_2O_5	N	P_2O_5	N	P_2O_5	Estimated N	Estimated P_2O_5	Nitrogen Balance lb/ac	P_2O_5 Balance ppm
1	0	0	0	270	185	416.9	0	266.28	0.52	0	0.0	Spring	0.0	0	0	47.0	0	47	138.8	18.5	24.0	-2.6
2	0	0	0	270	185	416.9	0	266.28	0.63	0.5	37.8	Spring	133.1	0	35.06	86.3	168	86.3	127.1	49.4	82.1	0.0
3	0	0	0	270	185	416.9	0	266.28	0.65	0.5	78.2	Spring	133.1	0	41.06	80.1	174	80.1	127.1	49.4	82.1	0.6
4	0	0	0	270	185	416.9	0	266.28	0.52	0	0.0	Spring	0.0	0	0	26.3	0	26.3	138.8	18.5	27.0	0.4
5	0	0	0	270	185	416.9	0	266.28	0.52	0	0.0	Spring	0.0	0	0	21.1	0	21.1	138.8	18.5	21.0	1.1
6	0	0	0	270	185	416.9	0	266.28	0.68	0.5	39.0	Spring	133.1	0	48.06	73.9	181	73.9	127.1	109.4	82.1	1.3
7&8	0	0	0	270	185	416.9	0	266.28	0.52	0	0.0	Spring	0.0	0	0	26.3	0	26.3	138.8	78.5	37.0	0.4
9	0	0	0	270	185	416.9	0	266.28	0.61	0.5	75.1	Spring	133.1	0	29.86	67.2	163	67.2	126.2	49.0	81.8	2.0
10	0	0	0	270	185	416.9	0	266.28	0.68	0.5	70.1	Spring	133.1	0	48.06	61.5	181	61.5	127.1	49.4	82.1	2.7
11	0	0	0	270	185	416.9	0	266.28	0.52	0	0.0	Spring	0.0	0	0	0.0	0	0	138.8	18.5	12.0	12.1
12	0	0	0	270	185	416.9	0	266.28	0.62	0.25	28.1	Spring	66.6	0	98.63	61.5	165	61.5	127.1	49.4	82.1	2.7
13	0	0	0	270	185	416.9	0	266.28	0.52	0	0.0	Spring	0.0	0	0	31.5	0	31.5	138.8	18.5	37.0	-0.4
14	0	0	0	270	185	416.9	0	266.28	0.52	0	0.0	Spring	0.0	0	0	31.5	0	31.5	138.8	18.5	73.0	-0.4
	Note: Column 28. shows the estimated manure application for each field for the Plan year											Total Nutrient Removal from Crops (lbs)=							261,689	71,097		

Total Estimated Liquid Effluent for Spreading =	318.1	Acre-Inch	Total Planned Liquid Effluent for spreading =	328.2	Acre-Inch
Total Esitmated Manure for Spreading =	0.00	Tons	Total Planned Manure for spreading =	0.0	Tons

Columns 39 and 40 show the Soil Nutrient Balance after the inputs and the crop nutrient uptake.

Plan Year: 2013

	Part 3. Planned Nutrient Application									Part 4. Nutrient Application								Part 5. Nutrient Balance			
1	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
	Solids (lbs/ton,) ASAE, 2005, D 384.2			Liquid (lbs/acre-in), PART 651 Table 4-16			Manure Application		Maximum Manure Applied	Manure Applied			Manure Application (lbs/acre)		Commercial Application lbs/acre		Total lbs/acre		Crop Removal (lb/ac)		Soil Nutrient Balance	
Field #	Organic N	Ammonium N	P_2O_5	Organic N	Ammonium N	P_2O_5	N Credit, (Prior year and year before that) (lbs/acre)	Available N (First Crop Year) lbs/ton or lbs/acre-in	Tons/Acre or acre-in/acre	Tons or Acre-in	Tons or Acre-in per Field	Time Period When Manure Applied	N	P_2O_5	N	P_2O_5	N	P_2O_5	Estimated N	Estimated P_2O_5	Nitrogen Balance lb/ac	P_2O_5 Balance ppm
15	0	0	0	270	185	416.9	0	266.28	0.48	0	0.0	Spring	0.0	0	128	49.1	128	49.1	127.1	49.4	82.1	4.1
16	0	0	0	270	185	416.9	0	266.28	0.52	0	0.0	Spring	0.0	0	0	36.6	0	36.6	138.8	18.5	15.0	-1.1
17	0	0	0	270	185	416.9	0	266.28	0.71	0	0.0	Spring	0.0	0	190	55.7	190	55.7	144.3	56.0	87.7	3.6
18	0	0	0	270	185	416.9	0	266.28	0.61	0	0.0	Spring	0.0	0	162	73.4	162	73.4	126.2	49.0	81.8	1.4
19	0	0	0	270	185	416.9	0	266.28	0.52	0	0.0	Spring	0.0	0	0	5.6	0	5.55	138.8	18.5	36.0	3.3
20	0	0	0	270	185	416.9	0	266.28	0.52	0	0.0	Spring	0.0	0	0	41.8	0	41.8	138.8	78.5	10.0	-1.8
21	0	0	0	270	185	416.9	0	266.28	0.68	0	0.0	Spring	0.0	0	180	73.4	180	73.4	126.2	109.0	81.8	1.4
22	0	0	0	270	185	416.9	0	266.28	0.52	0	0.0	Spring	0.0	0	0	5.6	0	5.55	138.8	18.5	42.0	3.3
23	0	0	0	270	185	416.9	0	266.28	0.76	0	0.0	Spring	0.0	0	203	62.7	203	62.7	144.3	56.0	87.7	2.9
24	0	0	0	270	185	416.9	0	266.28	0.52	0	0.0	Spring	0.0	0	0	5.6	0	5.55	138.8	18.5	30.0	3.3
25	0	0	0	270	185	416.9	0	266.28	0.52	0	0.0	Spring	0.0	0	0	15.9	0	15.9	138.8	18.5	57.0	1.9
							0	0	0.00	0	0.0		0.0	0	0	0.0	0	0	0.0	0.0	0.0	0.0
							0	0	0.00	0	0.0		0.0	0	0	0.0	0	0	0.0	0.0	0.0	0.0
	Note: Column 28. shows the estimated manure application for each field for the Plan year											Total Nutrient Removal from Crops (lbs)=							187,611	57,429		

Total Estimated Liquid Effluent for Spreading =	0.0	Acre-Inch	Total Planned Liquid Effluent for spreading =	0.0	Acre-Inch
Total Esitmated Manure for Spreading =	0.00	Tons	Total Planned Manure for spreading =	0.0	Tons

Columns 39 and 40 show the Soil Nutrient Balance after the inputs and the crop nutrient uptake.

USDA NRCS Natural Resources Conservation Service

North Dakota

RUSLE2 CSP Record

Info:
Date: August 26, 2015

Name: Rolling Green Sow Farm

Tract and Field #'s: Site 1, Field 1

Inputs:
Location: North Dakota\Cass County
Soil: G144B Barnes-Buse loams, 3 to 6 percent slopes\Barnes loam 25%
Slope length (horiz): 150 ft
Avg. slope steepness: 4.5 %

Man.	*Management*
1	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
2	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
3	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
4	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
5	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
6	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
7	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1

Vegetation	*Yield units*	*Yield (# of units)*
Corn, seed	bu	60.000
Soybean, mw 7in rows	bu	20.000

Adjust res. burial level: Normal res. burial
General yield level: Set by user

Outputs:
T value: 5.0 t/ac/yr
Soil loss for cons. plan: 1.5 t/ac/yr

Soil conditioning index (SCI): 0.17
Avg. annual slope STIR: 60.4
Wind & irrigation-induced erosion for SCI: 0 t/ac/yr

The SCI is the Soil Conditioning Index rating.

- If the calculated index is a negative value, soil organic matter levels are predicted to decline under that production system.
- If the index is a positive value, soil organic matter levels are predicted to increase under that system.
- A positive SCI meets the soil criteria for the Conservation Security Program.

The STIR value is the Soil Tillage Intensity Rating.

- It utilizes the speed, depth, surface disturbance percent and tillage type parameters to calculate a tillage intensity rating for the system used in growing a crop or a rotation.
- STIR ratings tend to show the differences in the degree of soil disturbance between systems. The kind, severity and number of ground disturbing passes are evaluated for the entire cropping rotation as shown in the management description.

USDA NRCS Natural Resources Conservation Service

North Dakota

RUSLE2 CSP Record

Info:
Date: August 26, 2015

Name: Rolling Green Sow Farm

Tract and Field #'s: Site 1, Field 2

Inputs:
Location: North Dakota\Cass County
Soil: G100A Hamerly-Tonka complex, 0 to 3 percent slopes\Hamerly loam 37%
Slope length (horiz): 150 ft
Avg. slope steepness: 1.5 %

Man.	*Management*
1	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
2	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
3	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
4	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
5	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
6	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
7	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1

Vegetation	*Yield units*	*Yield (# of units)*
Corn, seed	bu	60.000
Soybean, mw 7in rows	bu	20.000

Adjust res. burial level: Normal res. burial
General yield level: Set by user

Outputs:
T value: 5.0 t/ac/yr
Soil loss for cons. plan: 0.53 t/ac/yr

Soil conditioning index (SCI): 0.25
Avg. annual slope STIR: 60.4
Wind & irrigation-induced erosion for SCI: 0 t/ac/yr

The SCI is the Soil Conditioning Index rating.

- If the calculated index is a negative value, soil organic matter levels are predicted to decline under that production system.
- If the index is a positive value, soil organic matter levels are predicted to increase under that system.
- A positive SCI meets the soil criteria for the Conservation Security Program.

The STIR value is the Soil Tillage Intensity Rating.

- It utilizes the speed, depth, surface disturbance percent and tillage type parameters to calculate a tillage intensity rating for the system used in growing a crop or a rotation.
- STIR ratings tend to show the differences in the degree of soil disturbance between systems. The kind, severity and number of ground disturbing passes are evaluated for the entire cropping rotation as shown in the management description.

USDA NRCS Natural Resources Conservation Service

North Dakota

RUSLE2 CSP Record

Info:
Date: August 26, 2015

Name: Rolling Green Sow Farm

Tract and Field #'s: Site 1, Field 3

Inputs:
Location: North Dakota\Cass County
Soil: G144B Barnes-Buse loams, 3 to 6 percent slopes\Barnes loam 25%
Slope length (horiz): 150 ft
Avg. slope steepness: 4.5 %

Man.	*Management*
1	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
2	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
3	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
4	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
5	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
6	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
7	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1

Vegetation	*Yield units*	*Yield (# of units)*
Corn, seed	bu	60.000
Soybean, mw 7in rows	bu	20.000

Adjust res. burial level: Normal res. burial
General yield level: Set by user

Outputs:
T value: 5.0 t/ac/yr
Soil loss for cons. plan: 1.5 t/ac/yr

Soil conditioning index (SCI): 0.17
Avg. annual slope STIR: 60.4
Wind & irrigation-induced erosion for SCI: 0 t/ac/yr

The SCI is the Soil Conditioning Index rating.

- If the calculated index is a negative value, soil organic matter levels are predicted to decline under that production system.
- If the index is a positive value, soil organic matter levels are predicted to increase under that system.
- A positive SCI meets the soil criteria for the Conservation Security Program.

The STIR value is the Soil Tillage Intensity Rating.

- It utilizes the speed, depth, surface disturbance percent and tillage type parameters to calculate a tillage intensity rating for the system used in growing a crop or a rotation.
- STIR ratings tend to show the differences in the degree of soil disturbance between systems. The kind, severity and number of ground disturbing passes are evaluated for the entire cropping rotation as shown in the management description.

USDA NRCS Natural Resources Conservation Service

North Dakota

RUSLE2 CSP Record

Info:
Date: **August 26, 2015**

Name: Rolling Green Sow Farm

Tract and Field #'s: Site 1, Fields 4

Inputs:
Location: North Dakota\Cass County
Soil: G101A Hamerly-Wyard loams, 0 to 3 percent slopes\Hamerly loam 46%
Slope length (horiz): 150 ft
Avg. slope steepness: 1.5 %

Man.	*Management*
1	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
2	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
3	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
4	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
5	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
6	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
7	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1

Vegetation	*Yield units*	*Yield (# of units)*
Corn, seed	bu	60.000
Soybean, mw 7in rows	bu	20.000

Adjust res. burial level: Normal res. burial
General yield level: Set by user

Outputs:
T value: 5.0 t/ac/yr
Soil loss for cons. plan: 0.53 t/ac/yr

Soil conditioning index (SCI): 0.25
Avg. annual slope STIR: 60.4
Wind & irrigation-induced erosion for SCI: 0 t/ac/yr

The SCI is the Soil Conditioning Index rating.

- If the calculated index is a negative value, soil organic matter levels are predicted to decline under that production system.
- If the index is a positive value, soil organic matter levels are predicted to increase under that system.
- A positive SCI meets the soil criteria for the Conservation Security Program.

The STIR value is the Soil Tillage Intensity Rating.

- It utilizes the speed, depth, surface disturbance percent and tillage type parameters to calculate a tillage intensity rating for the system used in growing a crop or a rotation.
- STIR ratings tend to show the differences in the degree of soil disturbance between systems. The kind, severity and number of ground disturbing passes are evaluated for the entire cropping rotation as shown in the management description.

USDA NRCS Natural Resources Conservation Service

North Dakota

RUSLE2 CSP Record

Info:
Date: August 26, 2015

Name: Rolling Green Sow Farm

Tract and Field #'s: Site 1, Fields 5

Inputs:
Location: North Dakota\Cass County
Soil: G101A Hamerly-Wyard loams, 0 to 3 percent slopes\Hamerly loam 46%
Slope length (horiz): 150 ft
Avg. slope steepness: 1.5 %

Man.	*Management*
1	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
2	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
3	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
4	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
5	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
6	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
7	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1

Vegetation	*Yield units*	*Yield (# of units)*
Corn, seed	bu	60.000
Soybean, mw 7in rows	bu	20.000

Adjust res. burial level: Normal res. burial
General yield level: Set by user

Outputs:
T value: 5.0 t/ac/yr
Soil loss for cons. plan: 0.53 t/ac/yr

Soil conditioning index (SCI): 0.25
Avg. annual slope STIR: 60.4
Wind & irrigation-induced erosion for SCI: 0 t/ac/yr

The SCI is the Soil Conditioning Index rating.

- If the calculated index is a negative value, soil organic matter levels are predicted to decline under that production system.
- If the index is a positive value, soil organic matter levels are predicted to increase under that system.
- A positive SCI meets the soil criteria for the Conservation Security Program.

The STIR value is the Soil Tillage Intensity Rating.

- It utilizes the speed, depth, surface disturbance percent and tillage type parameters to calculate a tillage intensity rating for the system used in growing a crop or a rotation.
- STIR ratings tend to show the differences in the degree of soil disturbance between systems. The kind, severity and number of ground disturbing passes are evaluated for the entire cropping rotation as shown in the management description.

USDA NRCS Natural Resources Conservation Service

North Dakota

RUSLE2 CSP Record

Info:
Date: August 26, 2015

Name: Rolling Green Sow Farm

Tract and Field #'s: Site 1, Field 6

Inputs:
Location: North Dakota\Cass County
Soil: G100A Hamerly-Tonka complex, 0 to 3 percent slopes\Hamerly loam 37%
Slope length (horiz): 150 ft
Avg. slope steepness: 1.5 %

Man.	*Management*
1	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
2	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
3	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
4	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
5	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
6	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
7	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1

Vegetation	*Yield units*	*Yield (# of units)*
Corn, seed	bu	60.000
Soybean, mw 7in rows	bu	20.000

Adjust res. burial level: Normal res. burial
General yield level: Set by user

Outputs:
T value: 5.0 t/ac/yr
Soil loss for cons. plan: 0.53 t/ac/yr

Soil conditioning index (SCI): 0.25
Avg. annual slope STIR: 60.4
Wind & irrigation-induced erosion for SCI: 0 t/ac/yr

The SCI is the Soil Conditioning Index rating.

- If the calculated index is a negative value, soil organic matter levels are predicted to decline under that production system.
- If the index is a positive value, soil organic matter levels are predicted to increase under that system.
- A positive SCI meets the soil criteria for the Conservation Security Program.

The STIR value is the Soil Tillage Intensity Rating.

- It utilizes the speed, depth, surface disturbance percent and tillage type parameters to calculate a tillage intensity rating for the system used in growing a crop or a rotation.
- STIR ratings tend to show the differences in the degree of soil disturbance between systems. The kind, severity and number of ground disturbing passes are evaluated for the entire cropping rotation as shown in the management description.

USDA NRCS Natural Resources Conservation Service

North Dakota

RUSLE2 CSP Record

Info:
Date: **August 26, 2015**

Name: Rolling Green Sow Farm

Tract and Field #'s: Site 2, Field 7

Inputs:
Location: North Dakota\Cass County
Soil: G117A Hamerly loam, saline, 0 to 3 percent slopes\Hamerly loam moderately saline 55%
Slope length (horiz): 150 ft
Avg. slope steepness: 1.5 %

Man.	*Management*
1	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
2	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
3	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
4	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
5	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
6	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
7	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1

Vegetation	*Yield units*	*Yield (# of units)*
Corn, seed	bu	60.000
Soybean, mw 7in rows	bu	20.000

Adjust res. burial level: Normal res. burial
General yield level: Set by user

Outputs:
T value: 5.0 t/ac/yr
Soil loss for cons. plan: 0.53 t/ac/yr

Soil conditioning index (SCI): 0.25
Avg. annual slope STIR: 60.4
Wind & irrigation-induced erosion for SCI: 0 t/ac/yr

The SCI is the Soil Conditioning Index rating.

- If the calculated index is a negative value, soil organic matter levels are predicted to decline under that production system.
- If the index is a positive value, soil organic matter levels are predicted to increase under that system.
- A positive SCI meets the soil criteria for the Conservation Security Program.

The STIR value is the Soil Tillage Intensity Rating.

- It utilizes the speed, depth, surface disturbance percent and tillage type parameters to calculate a tillage intensity rating for the system used in growing a crop or a rotation.
- STIR ratings tend to show the differences in the degree of soil disturbance between systems. The kind, severity and number of ground disturbing passes are evaluated for the entire cropping rotation as shown in the management description.

USDA NRCS Natural Resources Conservation Service

North Dakota

RUSLE2 CSP Record

Info:
Date: August 26, 2015

Name: Rolling Green Sow Farm

Tract and Field #'s: Site 2, Field 8

Inputs:
Location: North Dakota\Cass County
Soil: G117A Hamerly loam, saline, 0 to 3 percent slopes\Hamerly loam moderately saline 55%
Slope length (horiz): 150 ft
Avg. slope steepness: 1.5 %

Man.	*Management*
1	b.Mulit-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
2	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
3	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
4	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
5	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
6	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
7	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1

Vegetation	*Yield units*	*Yield (# of units)*
Corn, seed	bu	60.000
Soybean, mw 7in rows	bu	20.000

Adjust res. burial level: Normal res. burial
General yield level: Set by user

Outputs:
T value: 5.0 t/ac/yr
Soil loss for cons. plan: 0.53 t/ac/yr

Soil conditioning index (SCI): 0.25
Avg. annual slope STIR: 60.4
Wind & irrigation-induced erosion for SCI: 0 t/ac/yr

The SCI is the Soil Conditioning Index rating.

- If the calculated index is a negative value, soil organic matter levels are predicted to decline under that production system.
- If the index is a positive value, soil organic matter levels are predicted to increase under that system.
- A positive SCI meets the soil criteria for the Conservation Security Program.

The STIR value is the Soil Tillage Intensity Rating.

- It utilizes the speed, depth, surface disturbance percent and tillage type parameters to calculate a tillage intensity rating for the system used in growing a crop or a rotation.
- STIR ratings tend to show the differences in the degree of soil disturbance between systems. The kind, severity and number of ground disturbing passes are evaluated for the entire cropping rotation as shown in the management description.

USDA NRCS Natural Resources Conservation Service

North Dakota

RUSLE2 CSP Record

Info:
Date: August 26, 2015

Name: Rolling Green Sow Farm

Tract and Field #'s: Site 2, Field 9

Inputs:
Location: North Dakota\Cass County
Soil: G117A Hamerly loam, saline, 0 to 3 percent slopes\Hamerly loam moderately saline 55%
Slope length (horiz): 150 ft
Avg. slope steepness: 1.5 %

Man.	*Management*
1	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
2	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
3	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
4	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
5	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
6	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
7	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1

Vegetation	*Yield units*	*Yield (# of units)*
Corn, seed	bu	60.000
Soybean, mw 7in rows	bu	20.000

Adjust res. burial level: Normal res. burial
General yield level: Set by user

Outputs:
T value: 5.0 t/ac/yr
Soil loss for cons. plan: 0.53 t/ac/yr

Soil conditioning index (SCI): 0.25
Avg. annual slope STIR: 60.4
Wind & irrigation-induced erosion for SCI: 0 t/ac/yr

The SCI is the Soil Conditioning Index rating.

- If the calculated index is a negative value, soil organic matter levels are predicted to decline under that production system.
- If the index is a positive value, soil organic matter levels are predicted to increase under that system.
- A positive SCI meets the soil criteria for the Conservation Security Program.

The STIR value is the Soil Tillage Intensity Rating.

- It utilizes the speed, depth, surface disturbance percent and tillage type parameters to calculate a tillage intensity rating for the system used in growing a crop or a rotation.
- STIR ratings tend to show the differences in the degree of soil disturbance between systems. The kind, severity and number of ground disturbing passes are evaluated for the entire cropping rotation as shown in the management description.

USDA NRCS Natural Resources Conservation Service

North Dakota

RUSLE2 CSP Record

Info:
Date: August 26, 2015

Name: Rolling Green Sow Farm

Tract and Field #'s: Site 3, Field 10

Inputs:
Location: North Dakota\Cass County
Soil: G143B Barnes-Svea loams, 3 to 6 percent slopes\Barnes loam 42%
Slope length (horiz): 150 ft
Avg. slope steepness: 4.5 %

Man.	*Management*
1	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
2	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
3	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
4	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
5	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
6	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
7	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1

Vegetation	*Yield units*	*Yield (# of units)*
Corn, seed	bu	60.000
Soybean, mw 7in rows	bu	20.000

Adjust res. burial level: Normal res. burial
General yield level: Set by user

Outputs:
T value: 5.0 t/ac/yr
Soil loss for cons. plan: 1.5 t/ac/yr

Soil conditioning index (SCI): 0.17
Avg. annual slope STIR: 60.4
Wind & irrigation-induced erosion for SCI: 0 t/ac/yr

The SCI is the Soil Conditioning Index rating.

- If the calculated index is a negative value, soil organic matter levels are predicted to decline under that production system.
- If the index is a positive value, soil organic matter levels are predicted to increase under that system.
- A positive SCI meets the soil criteria for the Conservation Security Program.

The STIR value is the Soil Tillage Intensity Rating.

- It utilizes the speed, depth, surface disturbance percent and tillage type parameters to calculate a tillage intensity rating for the system used in growing a crop or a rotation.
- STIR ratings tend to show the differences in the degree of soil disturbance between systems. The kind, severity and number of ground disturbing passes are evaluated for the entire cropping rotation as shown in the management description.

USDA NRCS Natural Resources Conservation Service

North Dakota

RUSLE2 CSP Record

Info:
Date: **August 26, 2015**

Name: Rolling Green Sow Farm

Tract and Field #'s: Site 4, Field 11

Inputs:
Location: North Dakota\Cass County
Soil: G100A Hamerly-Tonka complex, 0 to 3 percent slopes\Hamerly loam 37%
Slope length (horiz): 150 ft
Avg. slope steepness: 1.5 %

Man.	*Management*
1	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
2	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
3	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
4	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
5	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
6	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
7	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1

Vegetation	*Yield units*	*Yield (# of units)*
Corn, seed	bu	60.000
Soybean, mw 7in rows	bu	20.000

Adjust res. burial level: Normal res. burial
General yield level: Set by user

Outputs:
T value: 5.0 t/ac/yr
Soil loss for cons. plan: 0.53 t/ac/yr

Soil conditioning index (SCI): 0.25
Avg. annual slope STIR: 60.4
Wind & irrigation-induced erosion for SCI: 0 t/ac/yr

The SCI is the Soil Conditioning Index rating.

- If the calculated index is a negative value, soil organic matter levels are predicted to decline under that production system.
- If the index is a positive value, soil organic matter levels are predicted to increase under that system.
- A positive SCI meets the soil criteria for the Conservation Security Program.

The STIR value is the Soil Tillage Intensity Rating.

- It utilizes the speed, depth, surface disturbance percent and tillage type parameters to calculate a tillage intensity rating for the system used in growing a crop or a rotation.
- STIR ratings tend to show the differences in the degree of soil disturbance between systems. The kind, severity and number of ground disturbing passes are evaluated for the entire cropping rotation as shown in the management description.

USDA NRCS Natural Resources Conservation Service

North Dakota

RUSLE2 CSP Record

Info:
Date: August 26, 2015

Name: Rolling Green Sow Farm

Tract and Field #'s: Site 4. Field 12

Inputs:
Location: North Dakota\Cass County
Soil: G143B Barnes-Svea loams, 3 to 6 percent slopes\Barnes loam 42%
Slope length (horiz): 150 ft
Avg. slope steepness: 4.5 %

Man.	*Management*
1	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
2	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
3	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
4	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
5	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
6	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
7	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1

Vegetation	*Yield units*	*Yield (# of units)*
Corn, seed	bu	60.000
Soybean, mw 7in rows	bu	20.000

Adjust res. burial level: Normal res. burial
General yield level: Set by user

Outputs:
T value: 5.0 t/ac/yr
Soil loss for cons. plan: 1.5 t/ac/yr

Soil conditioning index (SCI): 0.17
Avg. annual slope STIR: 60.4
Wind & irrigation-induced erosion for SCI: 0 t/ac/yr

The SCI is the Soil Conditioning Index rating.

- If the calculated index is a negative value, soil organic matter levels are predicted to decline under that production system.
- If the index is a positive value, soil organic matter levels are predicted to increase under that system.
- A positive SCI meets the soil criteria for the Conservation Security Program.

The STIR value is the Soil Tillage Intensity Rating.

- It utilizes the speed, depth, surface disturbance percent and tillage type parameters to calculate a tillage intensity rating for the system used in growing a crop or a rotation.
- STIR ratings tend to show the differences in the degree of soil disturbance between systems. The kind, severity and number of ground disturbing passes are evaluated for the entire cropping rotation as shown in the management description.

USDA NRCS Natural Resources Conservation Service

North Dakota

RUSLE2 CSP Record

Info:
Date: August 26, 2015

Name: Rolling Green Sow Farm

Tract and Field #'s: Site 5. Field 13

Inputs:
Location: North Dakota\Cass County
Soil: G143B Barnes-Svea loams, 3 to 6 percent slopes\Barnes loam 42%
Slope length (horiz): 150 ft
Avg. slope steepness: 4.5 %

Man.	*Management*
1	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
2	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
3	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
4	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
5	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
6	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
7	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1

Vegetation	*Yield units*	*Yield (# of units)*
Corn, seed	bu	60.000
Soybean, mw 7in rows	bu	20.000

Adjust res. burial level: Normal res. burial
General yield level: Set by user

Outputs:
T value: 5.0 t/ac/yr
Soil loss for cons. plan: 1.5 t/ac/yr

Soil conditioning index (SCI): 0.17
Avg. annual slope STIR: 60.4
Wind & irrigation-induced erosion for SCI: 0 t/ac/yr

The SCI is the Soil Conditioning Index rating.

- If the calculated index is a negative value, soil organic matter levels are predicted to decline under that production system.
- If the index is a positive value, soil organic matter levels are predicted to increase under that system.
- A positive SCI meets the soil criteria for the Conservation Security Program.

The STIR value is the Soil Tillage Intensity Rating.

- It utilizes the speed, depth, surface disturbance percent and tillage type parameters to calculate a tillage intensity rating for the system used in growing a crop or a rotation.
- STIR ratings tend to show the differences in the degree of soil disturbance between systems. The kind, severity and number of ground disturbing passes are evaluated for the entire cropping rotation as shown in the management description.

USDA NRCS Natural Resources Conservation Service

North Dakota

RUSLE2 CSP Record

Info:
Date: **August 26, 2015**

Name: Rolling Green Sow Farm

Tract and Field #'s: Site 5. Field 14

Inputs:
Location: North Dakota\Cass County
Soil: G143B Barnes-Svea loams, 3 to 6 percent slopes\Barnes loam 42%
Slope length (horiz): 150 ft
Avg. slope steepness: 4.5 %

Man.	*Management*
1	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
2	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
3	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
4	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
5	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
6	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
7	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1

Vegetation	*Yield units*	*Yield (# of units)*
Corn, seed	bu	60.000
Soybean, mw 7in rows	bu	20.000

Adjust res. burial level: Normal res. burial
General yield level: Set by user

Outputs:
T value: 5.0 t/ac/yr
Soil loss for cons. plan: 1.5 t/ac/yr

Soil conditioning index (SCI): 0.17
Avg. annual slope STIR: 60.4
Wind & irrigation-induced erosion for SCI: 0 t/ac/yr

The SCI is the Soil Conditioning Index rating.

- If the calculated index is a negative value, soil organic matter levels are predicted to decline under that production system.
- If the index is a positive value, soil organic matter levels are predicted to increase under that system.
- A positive SCI meets the soil criteria for the Conservation Security Program.

The STIR value is the Soil Tillage Intensity Rating.

- It utilizes the speed, depth, surface disturbance percent and tillage type parameters to calculate a tillage intensity rating for the system used in growing a crop or a rotation.
- STIR ratings tend to show the differences in the degree of soil disturbance between systems. The kind, severity and number of ground disturbing passes are evaluated for the entire cropping rotation as shown in the management description.

USDA NRCS Natural Resources Conservation Service

North Dakota

RUSLE2 CSP Record

Info:
Date: **August 26, 2015**

Name: Rolling Green Sow Farm

Tract and Field #'s: Site 5, Field 15

Inputs:
Location: North Dakota\Cass County
Soil: G250A Divide loam, 0 to 2 percent slopes\Divide loam 66%
Slope length (horiz): 150 ft
Avg. slope steepness: 1.0 %

Man.	*Management*
1	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
2	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
3	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
4	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
5	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
6	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
7	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1

Vegetation	*Yield units*	*Yield (# of units)*
Corn, seed	bu	60.000
Soybean, mw 7in rows	bu	20.000

Adjust res. burial level: Normal res. burial
General yield level: Set by user

Outputs:
T value: 4.0 t/ac/yr
Soil loss for cons. plan: 0.37 t/ac/yr

Soil conditioning index (SCI): 0.26
Avg. annual slope STIR: 60.4
Wind & irrigation-induced erosion for SCI: 0 t/ac/yr

The SCI is the Soil Conditioning Index rating.

- If the calculated index is a negative value, soil organic matter levels are predicted to decline under that production system.
- If the index is a positive value, soil organic matter levels are predicted to increase under that system.
- A positive SCI meets the soil criteria for the Conservation Security Program.

The STIR value is the Soil Tillage Intensity Rating.

- It utilizes the speed, depth, surface disturbance percent and tillage type parameters to calculate a tillage intensity rating for the system used in growing a crop or a rotation.
- STIR ratings tend to show the differences in the degree of soil disturbance between systems. The kind, severity and number of ground disturbing passes are evaluated for the entire cropping rotation as shown in the management description.

USDA NRCS Natural Resources Conservation Service

North Dakota

RUSLE2 CSP Record

Info:
Date: August 26, 2015

Name: Rolling Green Sow Farm

Tract and Field #'s: Site 5, Field 16

Inputs:
Location: North Dakota\Cass County
Soil: G101A Hamerly-Wyard loams, 0 to 3 percent slopes\Hamerly loam 46%
Slope length (horiz): 150 ft
Avg. slope steepness: 1.5 %

Man.	*Management*
1	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
2	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
3	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
4	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
5	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
6	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
7	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1

Vegetation	*Yield units*	*Yield (# of units)*
Corn, seed	bu	60.000
Soybean, mw 7in rows	bu	20.000

Adjust res. burial level: Normal res. burial
General yield level: Set by user

Outputs:
T value: 5.0 t/ac/yr
Soil loss for cons. plan: 0.53 t/ac/yr

Soil conditioning index (SCI): 0.25
Avg. annual slope STIR: 60.4
Wind & irrigation-induced erosion for SCI: 0 t/ac/yr

The SCI is the Soil Conditioning Index rating.

- If the calculated index is a negative value, soil organic matter levels are predicted to decline under that production system.
- If the index is a positive value, soil organic matter levels are predicted to increase under that system.
- A positive SCI meets the soil criteria for the Conservation Security Program.

The STIR value is the Soil Tillage Intensity Rating.

- It utilizes the speed, depth, surface disturbance percent and tillage type parameters to calculate a tillage intensity rating for the system used in growing a crop or a rotation.
- STIR ratings tend to show the differences in the degree of soil disturbance between systems. The kind, severity and number of ground disturbing passes are evaluated for the entire cropping rotation as shown in the management description.

USDA NRCS Natural Resources Conservation Service

North Dakota

RUSLE2 CSP Record

Info:
Date: August 26, 2015

Name: Rolling Green Sow Farm

Tract and Field #'s: Site 5, Field 17

Inputs:
Location: North Dakota\Cass County
Soil: G144B Barnes-Buse loams, 3 to 6 percent slopes\Barnes loam 25%
Slope length (horiz): 150 ft
Avg. slope steepness: 4.5 %

Man.	*Management*
1	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
2	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
3	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
4	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
5	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
6	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
7	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1

Vegetation	*Yield units*	*Yield (# of units)*
Corn, seed	bu	60.000
Soybean, mw 7in rows	bu	20.000

Adjust res. burial level: Normal res. burial
General yield level: Set by user

Outputs:
T value: 5.0 t/ac/yr
Soil loss for cons. plan: 1.5 t/ac/yr

Soil conditioning index (SCI): 0.17
Avg. annual slope STIR: 60.4
Wind & irrigation-induced erosion for SCI: 0 t/ac/yr

The SCI is the Soil Conditioning Index rating.

- If the calculated index is a negative value, soil organic matter levels are predicted to decline under that production system.
- If the index is a positive value, soil organic matter levels are predicted to increase under that system.
- A positive SCI meets the soil criteria for the Conservation Security Program.

The STIR value is the Soil Tillage Intensity Rating.

- It utilizes the speed, depth, surface disturbance percent and tillage type parameters to calculate a tillage intensity rating for the system used in growing a crop or a rotation.
- STIR ratings tend to show the differences in the degree of soil disturbance between systems. The kind, severity and number of ground disturbing passes are evaluated for the entire cropping rotation as shown in the management description.

USDA NRCS Natural Resources Conservation Service

North Dakota

RUSLE2 CSP Record

Info:
Date: August 26, 2015

Name: Rolling Green Sow Farm

Tract and Field #'s: Site 5, Field 18

Inputs:
Location: North Dakota\Cass County
Soil: G100A Hamerly-Tonka complex, 0 to 3 percent slopes\Hamerly loam 37%
Slope length (horiz): 150 ft
Avg. slope steepness: 1.5 %

Man.	*Management*
1	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
2	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
3	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
4	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
5	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
6	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
7	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1

Vegetation	*Yield units*	*Yield (# of units)*
Corn, seed	bu	60.000
Soybean, mw 7in rows	bu	20.000

Adjust res. burial level: Normal res. burial
General yield level: Set by user

Outputs:
T value: 5.0 t/ac/yr
Soil loss for cons. plan: 0.53 t/ac/yr

Soil conditioning index (SCI): 0.25
Avg. annual slope STIR: 60.4
Wind & irrigation-induced erosion for SCI: 0 t/ac/yr

The SCI is the Soil Conditioning Index rating.

- If the calculated index is a negative value, soil organic matter levels are predicted to decline under that production system.
- If the index is a positive value, soil organic matter levels are predicted to increase under that system.
- A positive SCI meets the soil criteria for the Conservation Security Program.

The STIR value is the Soil Tillage Intensity Rating.

- It utilizes the speed, depth, surface disturbance percent and tillage type parameters to calculate a tillage intensity rating for the system used in growing a crop or a rotation.
- STIR ratings tend to show the differences in the degree of soil disturbance between systems. The kind, severity and number of ground disturbing passes are evaluated for the entire cropping rotation as shown in the management description.

USDA NRCS Natural Resources Conservation Service

North Dakota

RUSLE2 CSP Record

Info:
Date: August 26, 2015

Name: Rolling Green Sow Farm

Tract and Field #'s: Site 5, Field 19

Inputs:
Location: North Dakota\Cass County
Soil: G100A Hamerly-Tonka complex, 0 to 3 percent slopes\Hamerly loam 37%
Slope length (horiz): 150 ft
Avg. slope steepness: 1.5 %

Man.	*Management*
1	b.Mulit-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
2	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
3	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
4	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
5	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
6	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
7	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1

Vegetation	*Yield units*	*Yield (# of units)*
Corn, seed	bu	60.000
Soybean, mw 7in rows	bu	20.000

Adjust res. burial level: Normal res. burial
General yield level: Set by user

Outputs:
T value: 5.0 t/ac/yr
Soil loss for cons. plan: 0.53 t/ac/yr

Soil conditioning index (SCI): 0.25
Avg. annual slope STIR: 60.4
Wind & irrigation-induced erosion for SCI: 0 t/ac/yr

The SCI is the Soil Conditioning Index rating.

- If the calculated index is a negative value, soil organic matter levels are predicted to decline under that production system.
- If the index is a positive value, soil organic matter levels are predicted to increase under that system.
- A positive SCI meets the soil criteria for the Conservation Security Program.

The STIR value is the Soil Tillage Intensity Rating.

- It utilizes the speed, depth, surface disturbance percent and tillage type parameters to calculate a tillage intensity rating for the system used in growing a crop or a rotation.
- STIR ratings tend to show the differences in the degree of soil disturbance between systems. The kind, severity and number of ground disturbing passes are evaluated for the entire cropping rotation as shown in the management description.

USDA NRCS Natural Resources Conservation Service

North Dakota

RUSLE2 CSP Record

Info:
Date: August 26, 2015

Name: Rolling Green Sow Farm

Tract and Field #'s: Site 5, Field 20

Inputs:
Location: North Dakota\Cass County
Soil: G101A Hamerly-Wyard loams, 0 to 3 percent slopes\Hamerly loam 46%
Slope length (horiz): 150 ft
Avg. slope steepness: 1.5 %

Man.	*Management*
1	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
2	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
3	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
4	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
5	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
6	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
7	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1

Vegetation	*Yield units*	*Yield (# of units)*
Corn, seed	bu	60.000
Soybean, mw 7in rows	bu	20.000

Adjust res. burial level: Normal res. burial
General yield level: Set by user

Outputs:
T value: 5.0 t/ac/yr
Soil loss for cons. plan: 0.53 t/ac/yr

Soil conditioning index (SCI): 0.25
Avg. annual slope STIR: 60.4
Wind & irrigation-induced erosion for SCI: 0 t/ac/yr

The SCI is the Soil Conditioning Index rating.

- If the calculated index is a negative value, soil organic matter levels are predicted to decline under that production system.
- If the index is a positive value, soil organic matter levels are predicted to increase under that system.
- A positive SCI meets the soil criteria for the Conservation Security Program.

The STIR value is the Soil Tillage Intensity Rating.

- It utilizes the speed, depth, surface disturbance percent and tillage type parameters to calculate a tillage intensity rating for the system used in growing a crop or a rotation.
- STIR ratings tend to show the differences in the degree of soil disturbance between systems. The kind, severity and number of ground disturbing passes are evaluated for the entire cropping rotation as shown in the management description.

USDA NRCS Natural Resources Conservation Service

North Dakota

RUSLE2 CSP Record

Info:
Date: August 26, 2015

Name: Rolling Green Sow Farm

Tract and Field #'s: Site 5, Field 21

Inputs:
Location: North Dakota\Cass County
Soil: G144B Barnes-Buse loams, 3 to 6 percent slopes\Barnes loam 25%
Slope length (horiz): 150 ft
Avg. slope steepness: 4.5 %

Man.	*Management*
1	b.Multi-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
2	b.Multi-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
3	b.Multi-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
4	b.Multi-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
5	b.Multi-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
6	b.Multi-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
7	b.Multi-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1

Vegetation	*Yield units*	*Yield (# of units)*
Corn, seed	bu	60.000
Soybean, mw 7in rows	bu	20.000

Adjust res. burial level: Normal res. burial
General yield level: Set by user

Outputs:
T value: 5.0 t/ac/yr
Soil loss for cons. plan: 1.5 t/ac/yr

Soil conditioning index (SCI): 0.17
Avg. annual slope STIR: 60.4
Wind & irrigation-induced erosion for SCI: 0 t/ac/yr

The SCI is the Soil Conditioning Index rating.

- If the calculated index is a negative value, soil organic matter levels are predicted to decline under that production system.
- If the index is a positive value, soil organic matter levels are predicted to increase under that system.
- A positive SCI meets the soil criteria for the Conservation Security Program.

The STIR value is the Soil Tillage Intensity Rating.

- It utilizes the speed, depth, surface disturbance percent and tillage type parameters to calculate a tillage intensity rating for the system used in growing a crop or a rotation.
- STIR ratings tend to show the differences in the degree of soil disturbance between systems. The kind, severity and number of ground disturbing passes are evaluated for the entire cropping rotation as shown in the management description.

USDA NRCS Natural Resources Conservation Service

North Dakota

RUSLE2 CSP Record

Info:
Date: August 26, 2015

Name: Rolling Green Sow Farm

Tract and Field #'s: Site 5, Field 22

Inputs:
Location: North Dakota\Cass County
Soil: G144B Barnes-Buse loams, 3 to 6 percent slopes\Barnes loam 25%
Slope length (horiz): 150 ft
Avg. slope steepness: 4.5 %

Man.	*Management*
1	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
2	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
3	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
4	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
5	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
6	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
7	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1

Vegetation	*Yield units*	*Yield (# of units)*
Corn, seed	bu	60.000
Soybean, mw 7in rows	bu	20.000

Adjust res. burial level: Normal res. burial
General yield level: Set by user

Outputs:
T value: 5.0 t/ac/yr
Soil loss for cons. plan: 1.5 t/ac/yr

Soil conditioning index (SCI): 0.17
Avg. annual slope STIR: 60.4
Wind & irrigation-induced erosion for SCI: 0 t/ac/yr

The SCI is the Soil Conditioning Index rating.

- If the calculated index is a negative value, soil organic matter levels are predicted to decline under that production system.
- If the index is a positive value, soil organic matter levels are predicted to increase under that system.
- A positive SCI meets the soil criteria for the Conservation Security Program.

The STIR value is the Soil Tillage Intensity Rating.

- It utilizes the speed, depth, surface disturbance percent and tillage type parameters to calculate a tillage intensity rating for the system used in growing a crop or a rotation.
- STIR ratings tend to show the differences in the degree of soil disturbance between systems. The kind, severity and number of ground disturbing passes are evaluated for the entire cropping rotation as shown in the management description.

USDA NRCS Natural Resources Conservation Service

North Dakota

RUSLE2 CSP Record

Info:
Date: August 26, 2015

Name: Rolling Green Sow Farm

Tract and Field #'s: Site 5, Field 23

Inputs:
Location: North Dakota\Cass County
Soil: G143B Barnes-Svea loams, 3 to 6 percent slopes\Barnes loam 42%
Slope length (horiz): 150 ft
Avg. slope steepness: 4.5 %

Man.	*Management*
1	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
2	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
3	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
4	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
5	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
6	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
7	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1

Vegetation	*Yield units*	*Yield (# of units)*
Corn, seed	bu	60.000
Soybean, mw 7in rows	bu	20.000

Adjust res. burial level: Normal res. burial
General yield level: Set by user

Outputs:
T value: 5.0 t/ac/yr
Soil loss for cons. plan: 1.5 t/ac/yr

Soil conditioning index (SCI): 0.17
Avg. annual slope STIR: 60.4
Wind & irrigation-induced erosion for SCI: 0 t/ac/yr

The SCI is the Soil Conditioning Index rating.

- If the calculated index is a negative value, soil organic matter levels are predicted to decline under that production system.
- If the index is a positive value, soil organic matter levels are predicted to increase under that system.
- A positive SCI meets the soil criteria for the Conservation Security Program.

The STIR value is the Soil Tillage Intensity Rating.

- It utilizes the speed, depth, surface disturbance percent and tillage type parameters to calculate a tillage intensity rating for the system used in growing a crop or a rotation.
- STIR ratings tend to show the differences in the degree of soil disturbance between systems. The kind, severity and number of ground disturbing passes are evaluated for the entire cropping rotation as shown in the management description.

USDA NRCS Natural Resources Conservation Service

North Dakota

RUSLE2 CSP Record

Info:
Date: August 26, 2015

Name: Rolling Green Sow Farm

Tract and Field #'s: Site 5, Field 24

Inputs:
Location: North Dakota\Cass County
Soil: G101A Hamerly-Wyard loams, 0 to 3 percent slopes\Hamerly loam 46%
Slope length (horiz): 150 ft
Avg. slope steepness: 1.5 %

Man.	*Management*
1	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
2	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
3	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
4	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
5	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
6	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
7	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1

Vegetation	*Yield units*	*Yield (# of units)*
Corn, seed	bu	60.000
Soybean, mw 7in rows	bu	20.000

Adjust res. burial level: Normal res. burial
General yield level: Set by user

Outputs:
T value: 5.0 t/ac/yr
Soil loss for cons. plan: 0.53 t/ac/yr

Soil conditioning index (SCI): 0.25
Avg. annual slope STIR: 60.4
Wind & irrigation-induced erosion for SCI: 0 t/ac/yr

The SCI is the Soil Conditioning Index rating.

- If the calculated index is a negative value, soil organic matter levels are predicted to decline under that production system.
- If the index is a positive value, soil organic matter levels are predicted to increase under that system.
- A positive SCI meets the soil criteria for the Conservation Security Program.

The STIR value is the Soil Tillage Intensity Rating.

- It utilizes the speed, depth, surface disturbance percent and tillage type parameters to calculate a tillage intensity rating for the system used in growing a crop or a rotation.
- STIR ratings tend to show the differences in the degree of soil disturbance between systems. The kind, severity and number of ground disturbing passes are evaluated for the entire cropping rotation as shown in the management description.

USDA NRCS Natural Resources Conservation Service

North Dakota

RUSLE2 CSP Record

Info:
Date: **August 26, 2015**

Name: Rolling Green Sow Farm

Tract and Field #'s: Site 6, Field 25

Inputs:
Location: North Dakota\Cass County
Soil: G144B Barnes-Buse loams, 3 to 6 percent slopes\Barnes loam 25%
Slope length (horiz): 150 ft
Avg. slope steepness: 4.5 %

Man.	*Management*
1	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
2	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
3	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
4	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
5	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
6	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1
7	b.Mullti-year Rotation Templates\CB FC\ Corn (seed);FC, st pt, fcult, z1-- Soybeans (nr) Fdisk, fcult, z1

Vegetation	*Yield units*	*Yield (# of units)*
Corn, seed	bu	60.000
Soybean, mw 7in rows	bu	20.000

Adjust res. burial level: Normal res. burial
General yield level: Set by user

Outputs:
T value: 5.0 t/ac/yr
Soil loss for cons. plan: 1.5 t/ac/yr

Soil conditioning index (SCI): 0.17
Avg. annual slope STIR: 60.4
Wind & irrigation-induced erosion for SCI: 0 t/ac/yr

The SCI is the Soil Conditioning Index rating.

- If the calculated index is a negative value, soil organic matter levels are predicted to decline under that production system.
- If the index is a positive value, soil organic matter levels are predicted to increase under that system.
- A positive SCI meets the soil criteria for the Conservation Security Program.

The STIR value is the Soil Tillage Intensity Rating.

- It utilizes the speed, depth, surface disturbance percent and tillage type parameters to calculate a tillage intensity rating for the system used in growing a crop or a rotation.
- STIR ratings tend to show the differences in the degree of soil disturbance between systems. The kind, severity and number of ground disturbing passes are evaluated for the entire cropping rotation as shown in the management description.

Corn, Grain Yield

USDA Ag Statistics - Oliver County

Commodity	Practice	Year	State	County	Yield	Yield_unit
Corn, Grain	Total	2010	North Dakota	Cass	143.4	bushel/acre
Corn, Grain	Total	2011	North Dakota	Cass	101.6	bushel/acre
Corn, Grain	Total	2012	North Dakota	Cass	129.7	bushel/acre
Corn, Grain	Total	2013	North Dakota	Cass	126.2	bushel/acre
Corn, Grain	Total	2014	North Dakota	Cass	138.9	bushel/acre
5-Year Average					**128.0**	**bushel**
5-Year Average + 10%					**140.8**	**bushel**

Soybeans Yield

USDA Ag Statistics -Cass County

Commodity	Practice	Year	State	County	Yield	Yield_unit
Soybeans	Total	2010	North Dakota	Cass	35.5	bushel/acre
Soybeans	Total	2011	North Dakota	Cass	27.0	bushel/acre
Soybeans	Total	2012	North Dakota	Cass	34.0	bushel/acre
Soybeans	Total	2013	North Dakota	Cass	32.5	bushel/acre
Soybeans	Total	2014	North Dakota	Cass	38.0	bushel/acre
5-Year Average					**33.4**	**bushel/acre**
5-Year Average + 10%					**36.7**	**bushel/acre**

Edible Beans Yield

USDA Ag Statistics -Cass County

Commodity	Practice	Year	State	County	Yield	Yield_unit
Edible Beans	Total	2010	North Dakota	Cass	1650.0	lb/acre
Edible Beans	Total	2011	North Dakota	Cass	910.0	lb/acre
Edible Beans	Total	2012	North Dakota	Cass	1300.0	lb/acre
Edible Beans	Total	2013	North Dakota	Cass	1300.0	lb/acre
Edible Beans	Total	2014	North Dakota	Cass	1550.0	lb/acre
5-Year Average					**1342.0**	lb/acre
5-Year Average + 10%					**1476.2**	lb/acre

APH and Liability Worksheet

Name: Tim Berntson - Cass
Crop Yr: 2015
Company: RCIS Policy # 971957
Policy Liability: $ -

					Wheat - EU							Corn - EU							Soybeans - EU						
					Plan: RP	Cov Lvl: 70%	Projected Price: $5.85	Harvest Price	PP Factor: 60%	Guarantees at 100% Share		Plan: RP	Cov Lvl: 70%	Projected Price: $4.15	Harvest Price	PP Factor: 60%	Guarantees at 100% Share		Plan: RP	Cov Lvl: 70%	Projected Price: $9.73	Harvest Price	PP Factor: 60%	Guarantees at 100% Share	
Unit	Section	Township	Range	Map Area	APH Yld	Bushel Guar.	Liability if Complete Loss	Prevent Plant Liability	Acres	Bushel Guarantee	Total Liability if Complete Loss	APH Yld w/ TA	Bushel Guar.	Liability if Complete Loss	Prevent Plant Liability	Acres	Bushel Guarantee	Total Liability if Complete Loss	APH Yld w/ TA	Bushel Guar.	Liability if Complete Loss	Prevent Plant Liability	Acres	Bushel Guarantee	Total Liability if Complete Loss	APH Yld
0101	29	140	54	2	41	28.7	$167.90	$100.74				162	113.4	$470.61	$282.37				39	27.3	$265.63	$159.38				152
0102	32	140	54	2	49	34.3	$200.66	$120.39				156	109.2	$453.18	$271.91				39	27.3	$265.63	$159.38				
0103	27	140	54									149	104.3	$432.85	$259.71				41	28.7	$279.25	$167.55				
										Enterprise Unit Guarantee							Enterprise Unit Guarantee							Enterprise Unit Guarantee		
TOTALS					45	115% of avg. yld. = 52			-	-	$ -	156	115% of avg. yld. = 179				-	-	$ -	40	115% of avg. yld. = 46				-	-	$ -	152
					EU Bushel Guarantee Per Acre = #DIV/0!							EU Bushel Guarantee Per Acre = #DIV/0!							EU Bushel Guarantee Per Acre = #DIV/0!							

Cass Copy of (1_Wrkshts-MP_Cust(1)_b11\whz2.xls \ 2015 APH Liab

RCIS®
Representing RURAL COMMUNITY INSURANCE COMPANY

Production and Yield Worksheet/Report

1. Insured Information	2. Agent / Agency Information	3. Crop Year	4. Policy Number
TIM BERNTSON 3311 142ND AVE SE BUFFALO, ND 58011-9767 Person Type MARRIED Phone (701) 633-5602 SSN XXX-XX-8319	AGCOUNTRY FCS FARGO MN BRADLEY D SCHWAB 1900 44TH ST S PO BOX 6020 FARGO, ND 58108 Phone (701) 235-9858 Agency Code 22-3188 11	2015	ND-951-971957
		5. State Code / Name: ND	NORTH DAKOTA
		6. County Code / Name: 017	CASS

7. Crop BEANS **8. Farm Name**
9. Plan YP **10. Map Area** 002 **11. T-Yield** 1,523.0
12. Unit 0001-0000-000 **13. Area Class**
14. Type PINTO **15. Record Type****
16. Practice IBRNI **17. Insurability** I **18.** ☒ New Prod^
19. Multi Crop Year Reporting Reason *** **20.** ☐ CRP/USDA ☐ NB ☐ NS
21. Estimated Share
22. Shareholder[LLT]
23. Remarks
****NEW PRODUCER

24. Year	25. Production	26. Acres	27. Yield	28. Desc.	29. Sect Twp Rng or Other	FSA Farm/ Tract/Field #
2005	0.0	0.0	0	Z	29 140N054W	9838
2006	0.0	0.0	0	Z		
2007	0.0	0.0	0	Z		
2008	0.0	0.0	0	Z		
2009	0.0	0.0	0	Z		
2010	0.0	0.0	0	Z		
2011	0.0	0.0	1,523	I		
2012	0.0	0.0	1,523	I		
2013	0.0	0.0	1,523	I	30. Date Signed 11/12/2014	
2014	0.0	0.0	1,523	I		

31. Prior Yield	32. Approved Yield	33. Adj Yld	34. SA Yld
1,523	1,523.0	0.0	

7. Crop CORN **8. Farm Name**
9. Plan RP **10. Map Area** **11. T-Yield** 129.0
12. Unit 0001-0001-000 **13. Area Class**
14. Type GRAIN **15. Record Type****
16. Practice NIRR **17. Insurability** I **18.** ☐ New Prod^
19. Multi Crop Year Reporting Reason *** **20.** ☐ CRP/USDA ☐ NB ☐ NS
21. Estimated Share 1.000
22. Shareholder[LLT]
23. Remarks

24. Year	25. Production	26. Acres	27. Yield	28. Desc.	29. Sect Twp Rng or Other	FSA Farm/ Tract/Field #
2005	0.0	0.0	0	Z	29 140N054W	9838
2006	31,816.3	268.0	119	A		
2007	0.0	0.0	0	Z		
2008	39,718.8	259.6	153	A		
2009	34,600.0	228.0	152	A		
2010	52,300.0	288.3	181	A		
2011	39,210.8	275.8	142	A		
2012	43,225.0	288.4	150	A		
2013	36,861.9	276.6	133	A	30. Date Signed 11/12/2014	
2014	48,192.0	261.0	185	A		

31. Prior Yield	32. Approved Yield	33. Adj Yld	34. SA Yld
156	162.0 TA	152.0	
Trend Adjusted Yield (TA)			

7. Crop CORN **8. Farm Name**
9. Plan RP **10. Map Area** **11. T-Yield** 129.0
12. Unit 0001-0002-000 **13. Area Class**
14. Type GRAIN **15. Record Type****
16. Practice NIRR **17. Insurability** I **18.** ☐ New Prod^
19. Multi Crop Year Reporting Reason *** **20.** ☐ CRP/USDA ☐ NB ☐ NS
21. Estimated Share 1.000
22. Shareholder[LLT]
23. Remarks

24. Year	25. Production	26. Acres	27. Yield	28. Desc.	29. Sect Twp Rng or Other	FSA Farm/ Tract/Field #
2005	16,939.1	86.0	197	A	32 140N054W	9838
2006	0.0	0.0	0	Z		
2007	10,784.7	153.1	70	A		
2008	0.0	0.0	0	Z		
2009	10,400.0	72.0	144	A		
2010	14,898.0	78.0	191	A		
2011	10,988.4	75.1	146	A		
2012	13,968.0	112.2	124	A		
2013	8,830.6	76.1	116	A	30. Date Signed 11/12/2014	
2014	26,459.0	153.1	173	A		

31. Prior Yield	32. Approved Yield	33. Adj Yld	34. SA Yld
151	156.0 TA	145.0	
Trend Adjusted Yield (TA)			

7. Crop CORN **8. Farm Name**
9. Plan RP **10. Map Area** **11. T-Yield** 159.0
12. Unit 0001-0003-000 **13. Area Class**
14. Type GRAIN **15. Record Type****
16. Practice NIRR **17. Insurability** I **18.** ☐ New Prod^
19. Multi Crop Year Reporting Reason *** **20.** ☐ CRP/USDA ☐ NB ☐ NS
21. Estimated Share 1.000
22. Shareholder[LLT]
23. Remarks
Added Land

24. Year	25. Production	26. Acres	27. Yield	28. Desc.	29. Sect Twp Rng or Other	FSA Farm/ Tract/Field #
2005	0.0	0.0	0	Z	27 140N054W	7295
2006	0.0	0.0	0	Z		
2007	0.0	0.0	0	Z		
2008	0.0	0.0	0	Z		
2009	0.0	0.0	0	Z		
2010	0.0	0.0	159	L		
2011	0.0	0.0	159	L		
2012	18,759.0	117.6	160	A		
2013	13,165.8	117.6	112	A	30. Date Signed 11/12/2014	
2014	0.0	0.0	0	Z		

31. Prior Yield	32. Approved Yield	33. Adj Yld	34. SA Yld
148	149.0 TA	148.0	
Trend Adjusted Yield (TA)			

**Record Type 1. Production Sold / Commercial Storage 2. Farm Stored Measured by Insured 3. Pick / Daily Sales Record 4. Automated Yield Monitoring System 5. Farm-Stored Measured by Authorized Representative 6. Livestock Feeding Records 7. Claim for Indemnity 8. Appraisal (non-loss) 9. Field Harvest Records 10. Other

***** Please see Instructions for Reporting Reason codes

Please do not write over this section.

10C. LAND APPLICATION MAPS

The following Information is attached

1. Application Site Summary and Best Management Practices
2. Overall Land Application Map
3. Water Quality Risk Assessment Land Application Maps
4. Soil Survey Maps

Application Site Summary & Best Management Practices

Rolling Green Sow Farm

Field Id Area	Useable Acreage(Acres)	Land Use	Quarter	S	T	R	Owner of Land	Easements	*Nitrogen Risk Assessment	Phosphorus Index Rating	#Runoff Setbacks	Application Rate Limitations	^Best Management Practices
1	204.9	Cropland	E 1/2	9	139 N	54 W	Melvin Family RE LLLP	Yes	Low	Low	Yes	Crop N Removal	Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
2	75.6	Cropland	E 1/2	9	139 N	54 W	Melvin Family RE LLLP	Yes	Moderate	Low	Yes	Crop N Removal	Consider split nitrogen applications to include a preplant application and later application during early vegetative growth.
3	156.4	Cropland	NW 1/4	4	139 N	54 W	Melvin Family RE LLLP	Yes	Low	Low	No	Crop N Removal	Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
4	39.3	Cropland	NW 1/4	36	140 N	55 W	Melvin Family RE LLLP	Yes	Low	Low	Yes	Crop N Removal	Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
5	243.5	Cropland	N 1/2	36	140 N	55 W	Melvin Family RE LLLP	Yes	Low	Low	Yes	Crop N Removal	Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
6	78.0	Cropland	SW 1/4	12	139 N	55 W	Melvin Family RE LLLP	Yes	Moderate	Low	No	Crop N Removal	Consider split nitrogen applications to include a preplant application and later application during early vegetative growth.
7 & 8	141.2	Cropland	NE 1/4	32	139 N	54 W	Eldwyn Van Bruggen	Yes	Moderate	Low	Yes	Crop N Removal	Consider split nitrogen applications to include a preplant application and later application during early vegetative growth.
9	150.1	Cropland	SE 1/4	32	139 N	54 W	Eldwyn Van Bruggen	Yes	Moderate	Low	Yes	Crop N Removal	Consider split nitrogen applications to include a preplant application and later application during early vegetative growth.
10	140.2	Cropland	NE 1/4	14	139 N	55 W	Joseph Harbeke	Yes	Low	Low	Yes	Crop N Removal	Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
11	158.0	Cropland	SE 1/4	10	140 N	55 W	Jonathan Melvin	Yes	Moderate	Low	No	Crop N Removal	Consider split nitrogen applications to include a preplant application and later application during early vegetative growth.
12	112.3	Cropland	NW 1/4	14	140 N	55 W	Jonathan Melvin	Yes	Low	Low	Yes	Crop N Removal	Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
13	376.3	Cropland	NE 1/4	11	140 N	55 W	Randy Melvin	Yes	Low	Low	Yes	Crop N Removal	Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
14	70.9	Cropland	SE 1/4	11	140 N	55 W	Randy Melvin	Yes	Low	Low	Yes	Crop N Removal	Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
15	41.2	Cropland	W 1/2	11	140 N	55 W	Randy Melvin	Yes	High	Low	No	Crop N Removal	Spring application should be delayed until after the soil is completely thawed. Consider split nitrogen applications to include a preplant application and later application during early vegetative growth. Fall applicaton not recommended.
16	63.8	Cropland	NE 1/4	2	139 N	55 W	Randy Melvin	Yes	Low	Low	Yes	Crop N Removal	Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
17	83.1	Cropland	NE 1/4	2	139 N	55 W	Randy Melvin	Yes	Low	Low	Yes	Crop N Removal	Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
18	155.8	Cropland	NE 1/4	4	139 N	54 W	Randy Melvin	Yes	Moderate	Low	No	Crop N Removal	Consider split nitrogen applications to include a preplant application and later application during early vegetative growth.
19	144.8	Cropland	SE 1/4	4	139 N	54 W	Randy Melvin	Yes	Moderate	Low	No	Crop N Removal	Consider split nitrogen applications to include a preplant application and later application during early vegetative growth.

Field Id Area	Useable Acreage(Acres)	Land Use	Quarter	S	T	R	Owner of Land	Easements	*Nitrogen Risk Assessment	Phosphorus Index Rating	#Runoff Setbacks	Application Rate Limitations	^Best Management Practices
20	57.6	Cropland	SE 1/4	11	139 N	55 W	Randy Melvin	Yes	Low	Low	Yes	Crop N Removal	Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
21	107.7	Cropland	NW 1/4	12	139 N	55 W	Randy Melvin	Yes	Low	Low	Yes	Crop N Removal	Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
22	268.8	Cropland	W 1/2	29	140 N	54 W	Tim Bernston	Yes	Low	Low	No	Crop N Removal	Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
23	261.9	Cropland	E 1/2	29	140 N	54 W	Tim Bernston	Yes	Low	Low	Yes	Crop N Removal	Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
24	27.0	Cropland	N 1/2	29	140 N	54 W	Tim Bernston	Yes	Low	Low	Yes	Crop N Removal	Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
25	150.0	Cropland	NE 1/4	32	140 N	54 W	Tim Bernston	Yes	Low	Low	No	Crop N Removal	Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.

SCALE, FEET
0 2250 4500 6750 9000

FIELD 1
FIELD 2
FIELD 3
FIELD 4
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FIELD 18
FIELD 19
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FIELD 21
FIELD 22
FIELD 23
FIELD 24
FIELD 25

GENERAL NOTES

LEGEND

DeHaan, Grabs & Associates, LLC
Certificate of Authority: 725 PE

No.	Revision/Issue	Date

DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
PO Box 522 | Mandan, ND | 58554

ROLLING GREEN FAMILY FARMS RE, LLC

CASS COUNTY, ND

LAND APPLICATION OVERALL MAP

DATE: OCT 23, 2015	SHEET:
SCALE: AS SHOWN	
DRAWN BY: NAP	
CHECKED BY: NAP	

FILE NAME: ND PROJECT FILES/SWINE/ROLLING GREEN/CFILES/NMP MAP

DEHAAN, GRABS &
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Water Quality Risk Assessment Map

Name: Rolling Green Sow Farm

Landowner: Tim Bernston

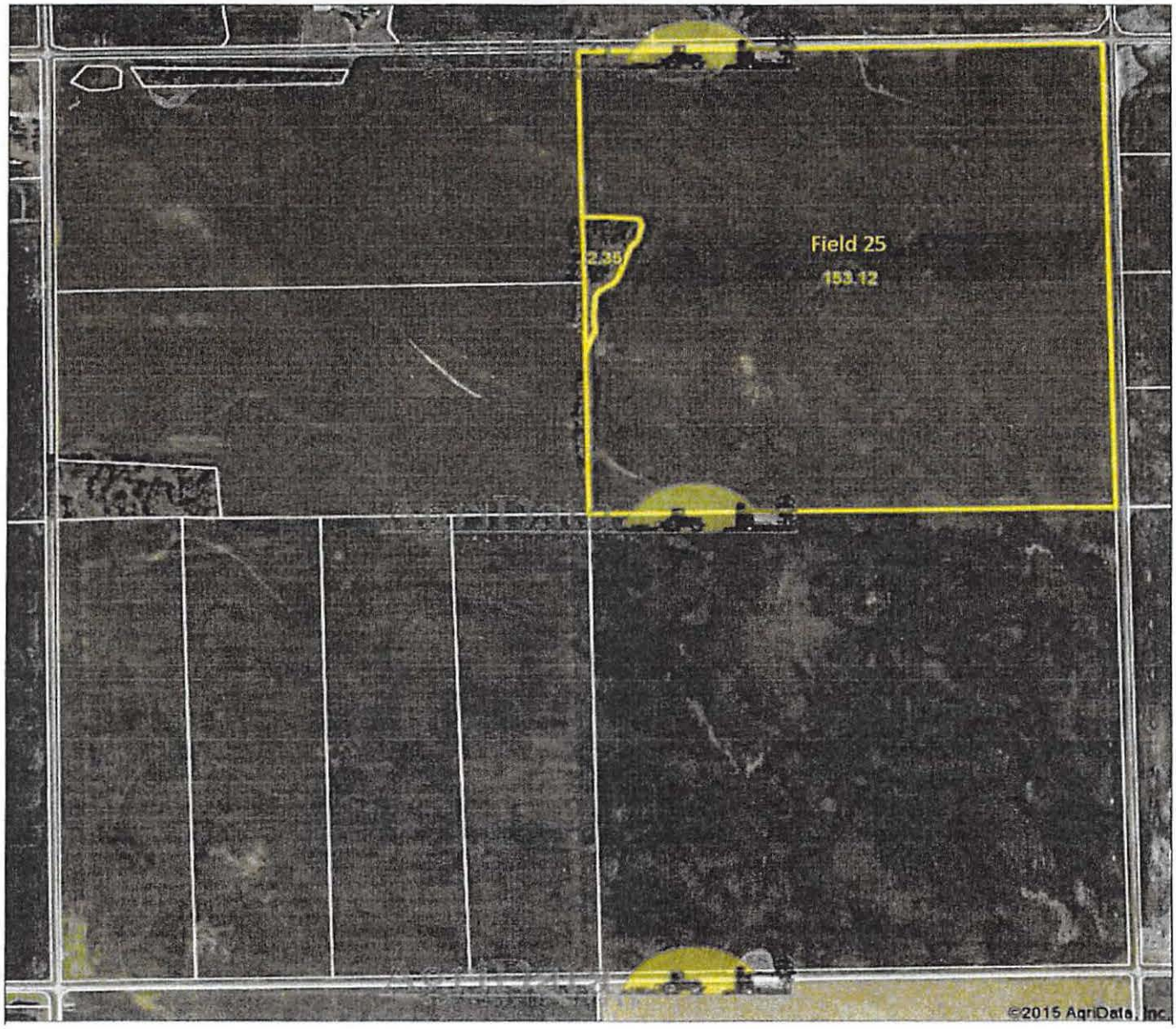
Legal: NE ¼ S32-T140N-R54W, Cass County, ND

Acres: 150

Legend

Boundary | Registered Wells | Setback | Tile Inlets

"L" Nitrogen Leaching – High Risk | "R" Phosphorus Runoff – High Risk



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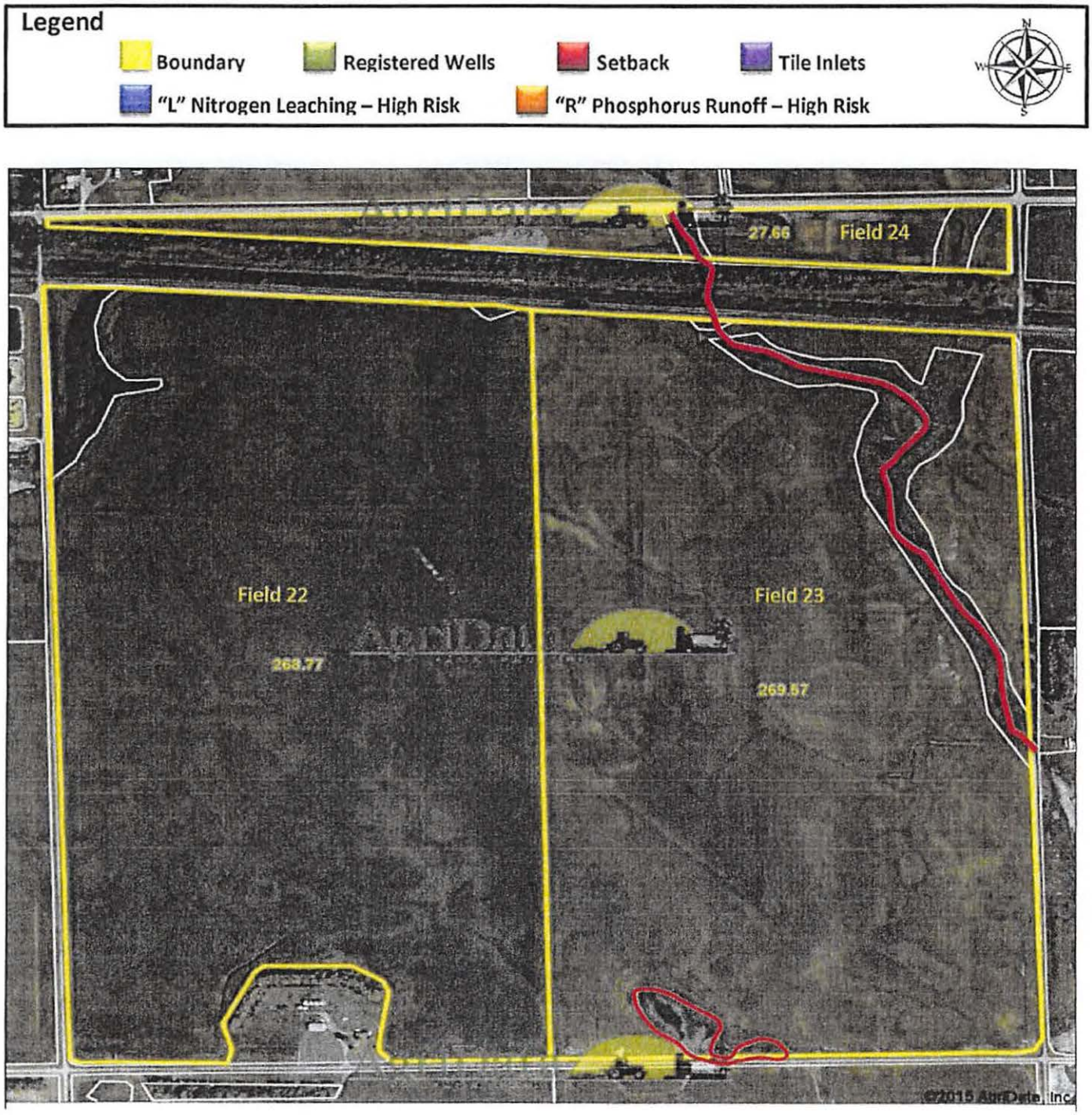
Water Quality Risk Assessment Map

Name: Rolling Green Sow Farm

Landowner: Tim Bernston

Legal: S29-T140N-R54W, Cass County, ND

Acres: 557.7 Combined



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Consulting Engineers
PO Box 522 | Mandan, ND | 58554

Water Quality Risk Assessment Map

Name: Rolling Green Sow Farm

Landowner: Randy Melvin

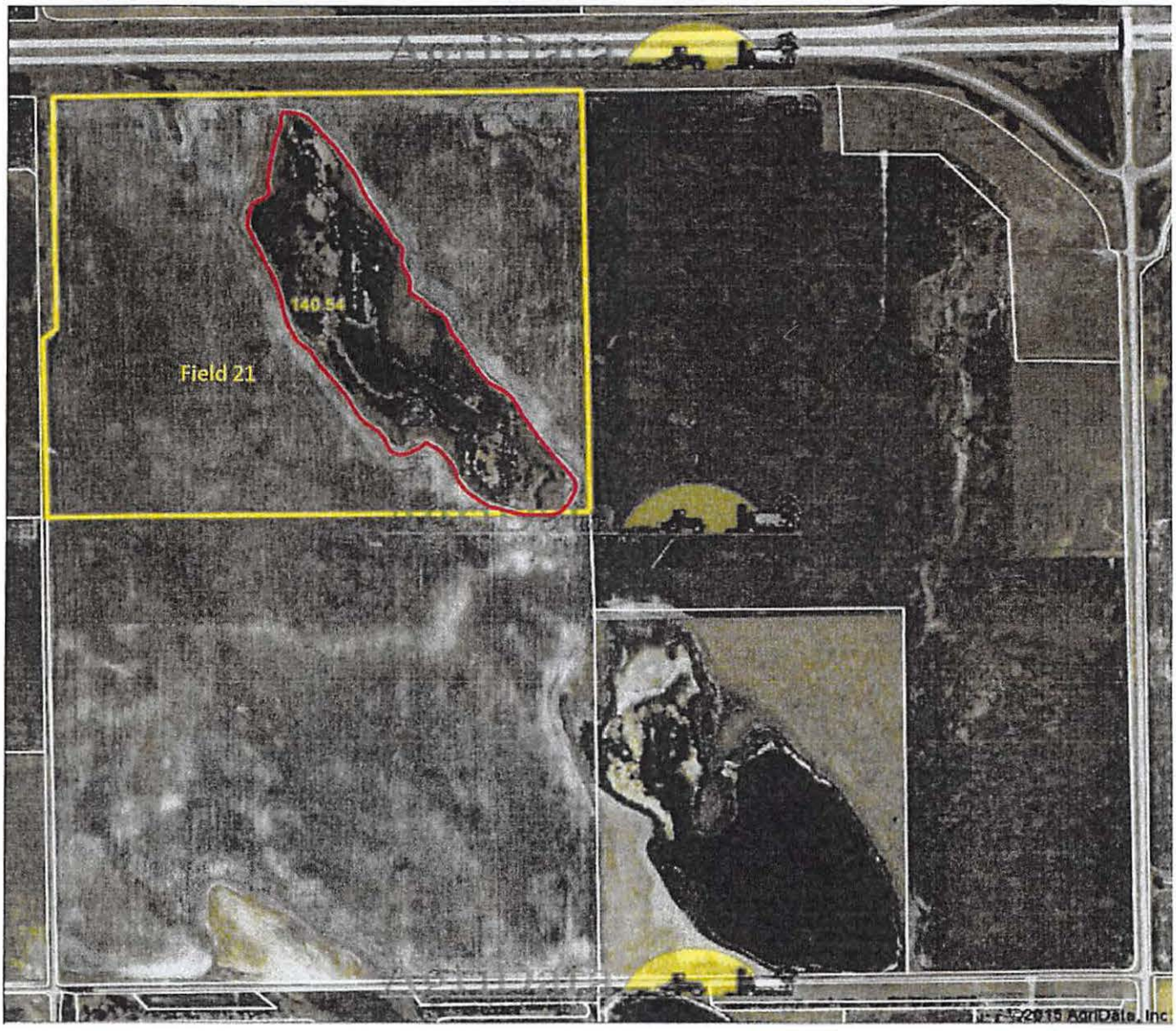
Legal: NW ¼ S12-T139N-R55W, Cass County, ND

Acres: 107.7

Legend

Boundary | Registered Wells | Setback | Tile Inlets

"L" Nitrogen Leaching – High Risk | "R" Phosphorus Runoff – High Risk



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Water Quality Risk Assessment Map

Name: Rolling Green Sow Farm

Landowner: Randy Melvin

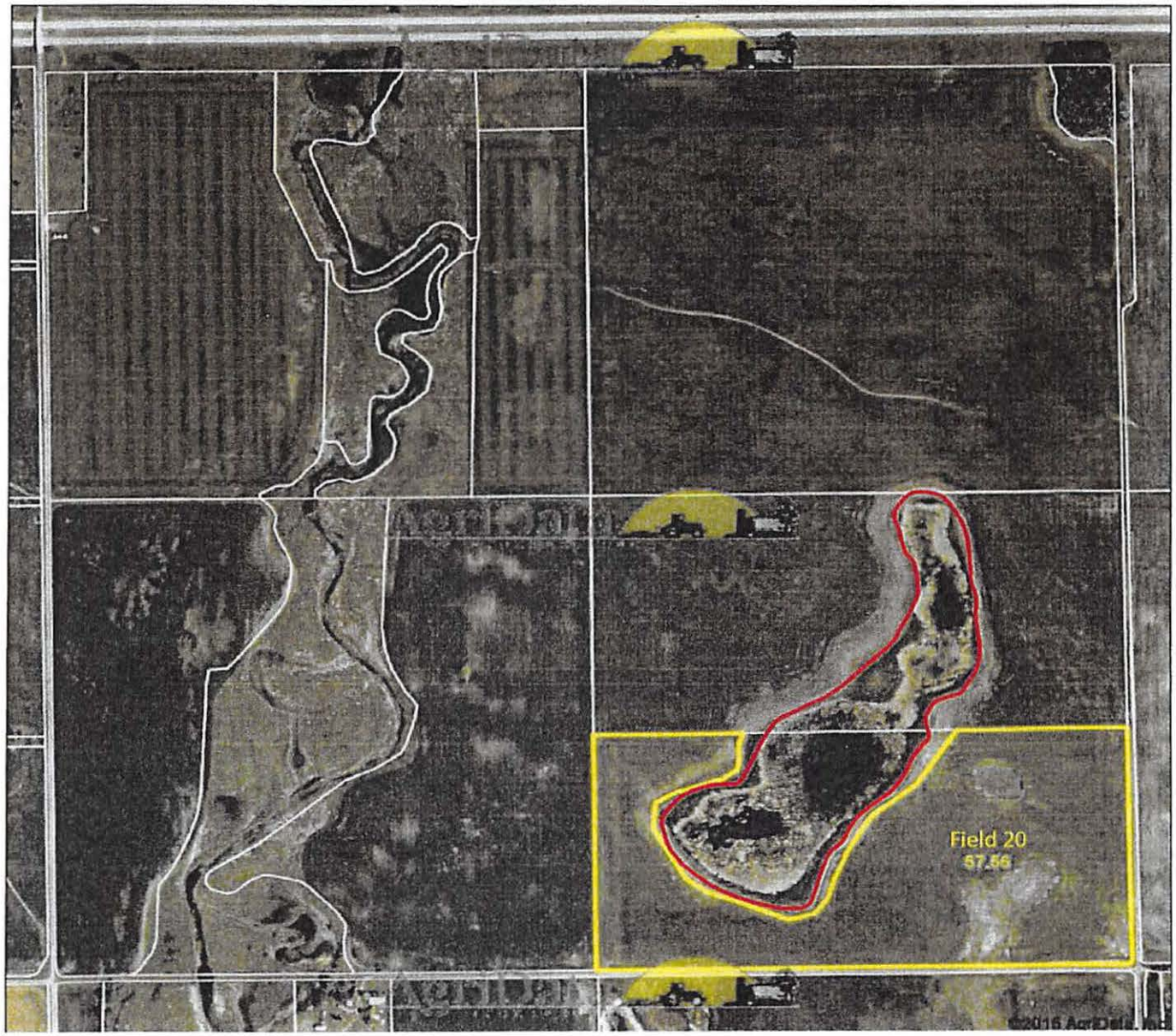
Legal: S ½ SE ¼ S11-T139N-R55W, Cass County, ND

Acres: 57.6

Legend

Boundary | Registered Wells | Setback | Tile Inlets

"L" Nitrogen Leaching – High Risk | "R" Phosphorus Runoff – High Risk



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Water Quality Risk Assessment Map

Name: Rolling Green Sow Farm

Landowner: Randy Melvin

Legal: E ½ S4-T139N-R55W, Cass County, ND

Acres: 300.68

Legend

Boundary | Registered Wells | Setback | Tile Inlets | "L" Nitrogen Leaching – High Risk | "R" Phosphorus Runoff – High Risk

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Water Quality Risk Assessment Map

Name: Rolling Green Sow Farm

Landowner: Randy Melvin

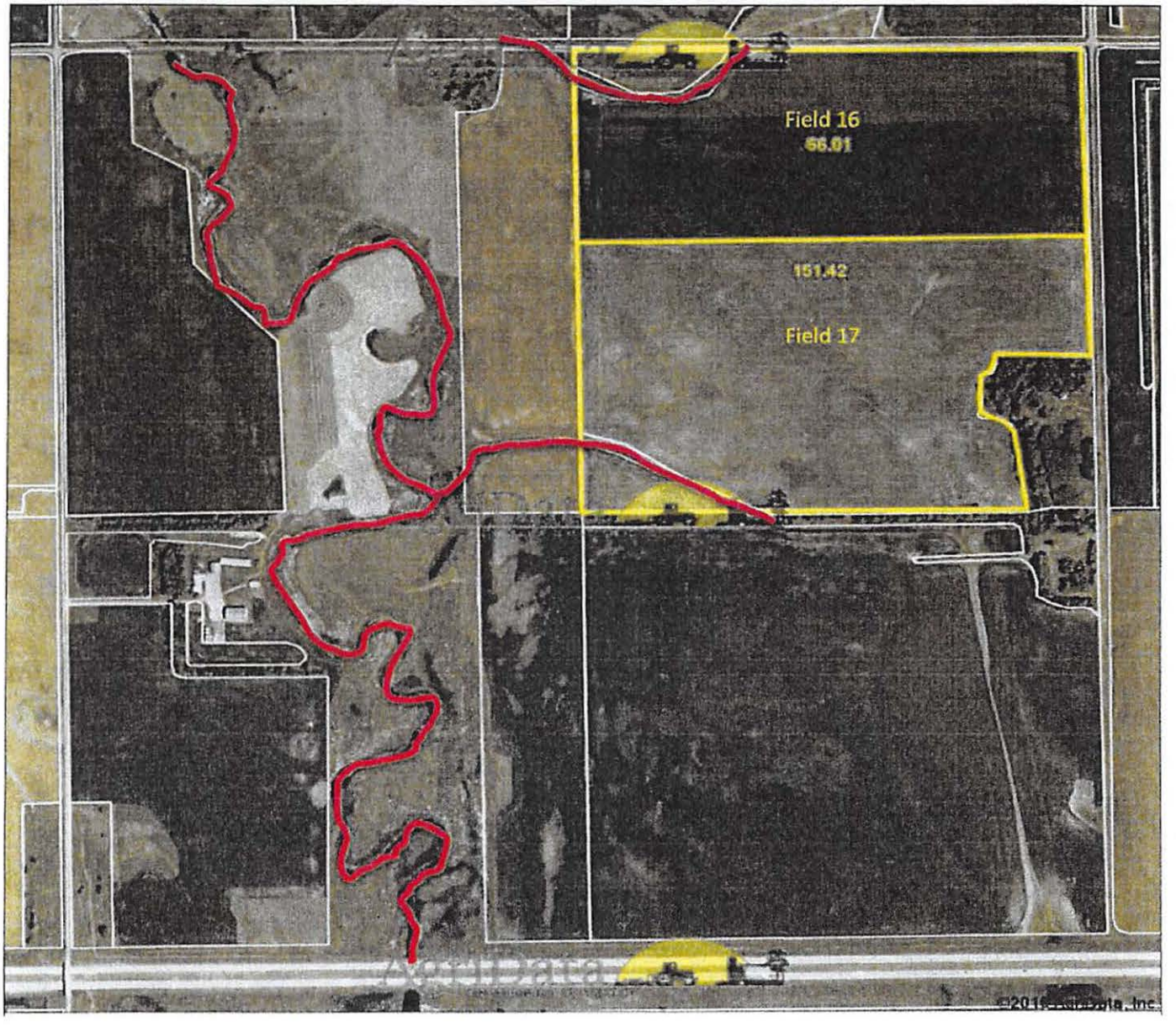
Legal: NE ¼ S2-T139N-R55W, Cass County, ND

Acres: 146.9 Combined

Legend

Boundary | Registered Wells | Setback | Tile Inlets

"L" Nitrogen Leaching – High Risk | "R" Phosphorus Runoff – High Risk



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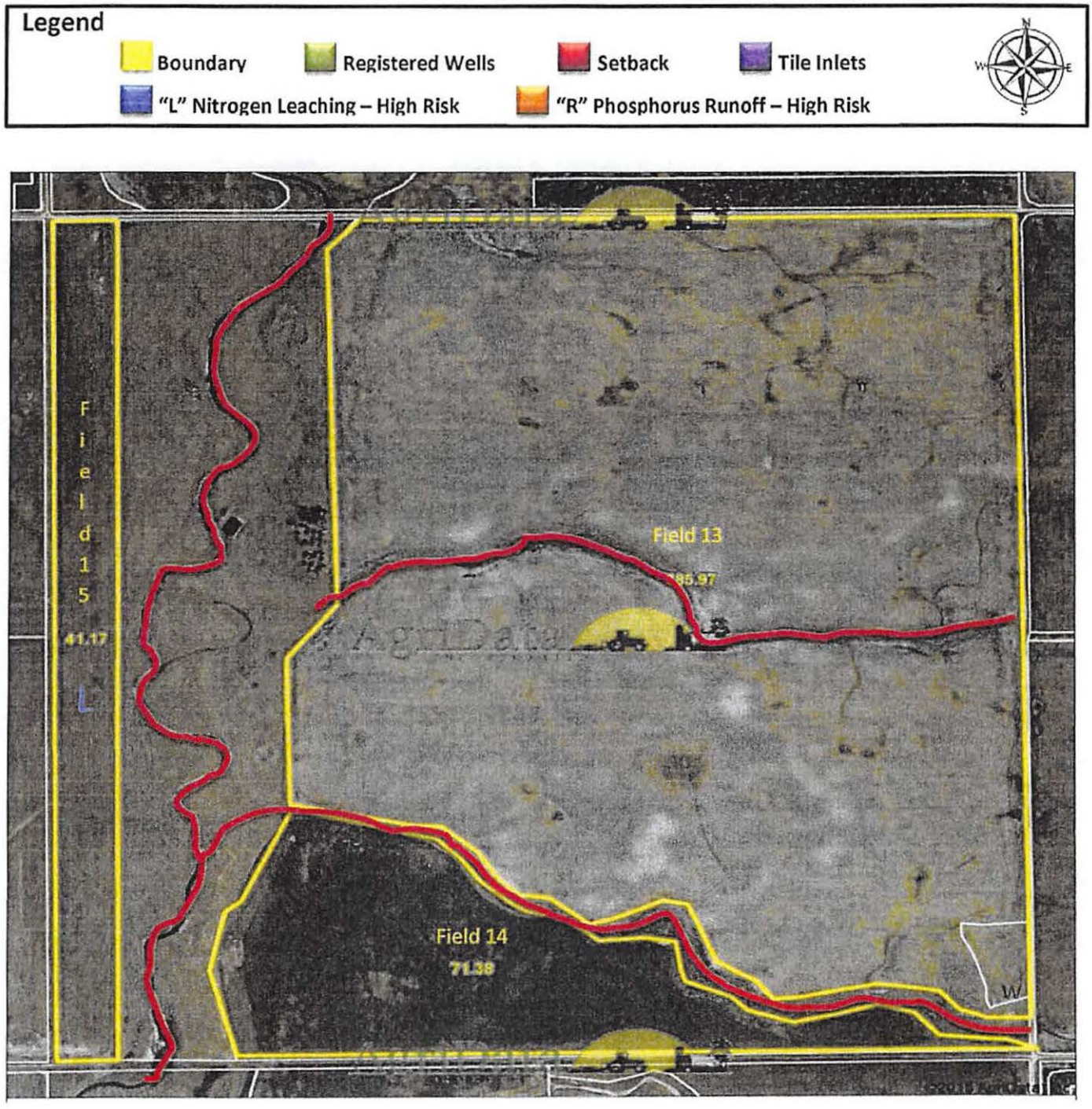
Water Quality Risk Assessment Map

Name: Rolling Green Sow Farm

Landowner: Randy Melvin

Legal: S11-T140N-R55W, Cass County, ND

Acres: 488.4 Combined



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Water Quality Risk Assessment Map

Name: Rolling Green Sow Farm

Landowner: Jonathan Melvin

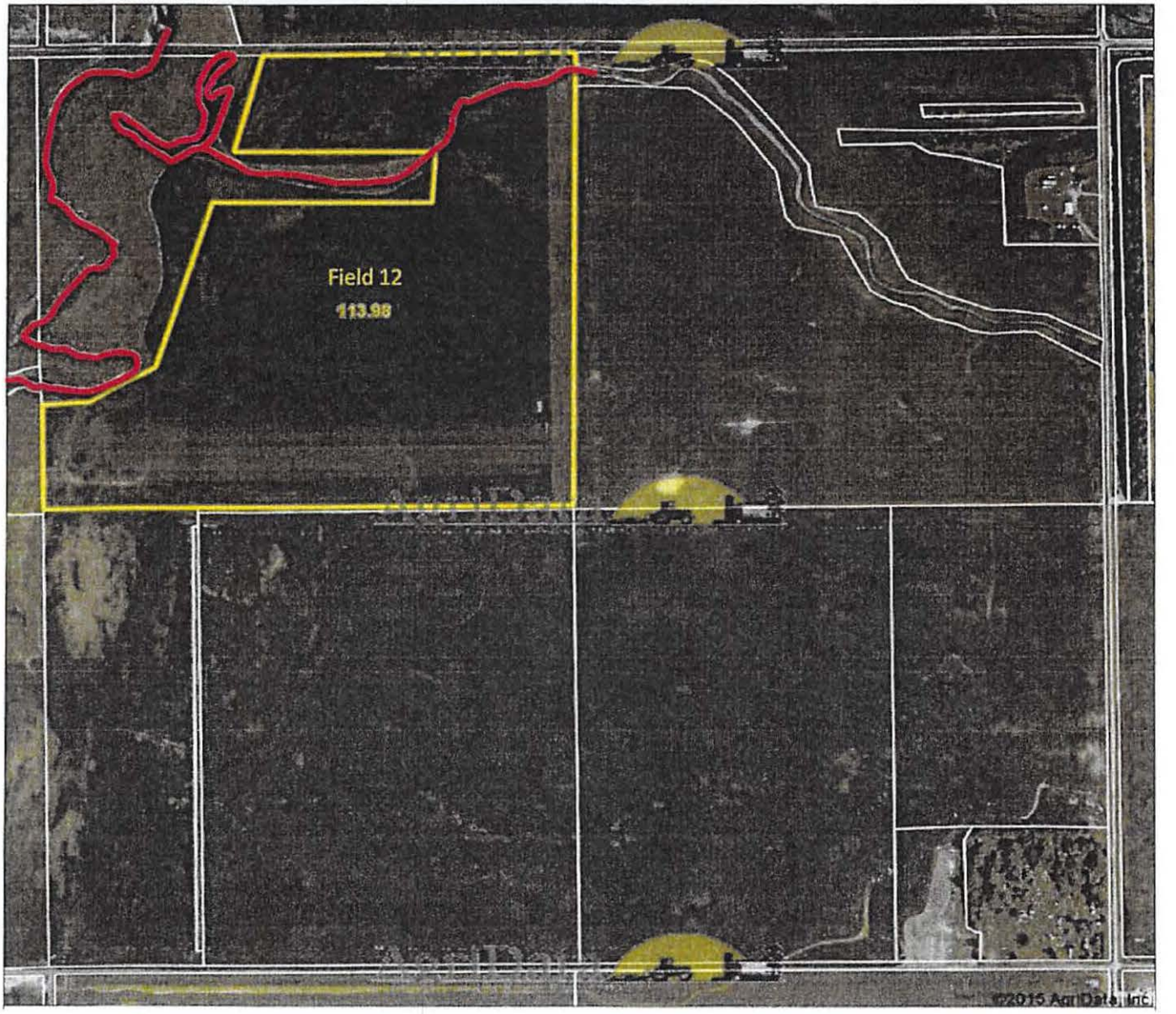
Legal: NW ¼ S14-T140N-R55W, Cass County, ND

Acres: 112.3

Legend

Boundary | Registered Wells | Setback | Tile Inlets

"L" Nitrogen Leaching – High Risk | "R" Phosphorus Runoff – High Risk



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Water Quality Risk Assessment Map

Name: Rolling Green Sow Farm

Landowner: Jonathan Melvin

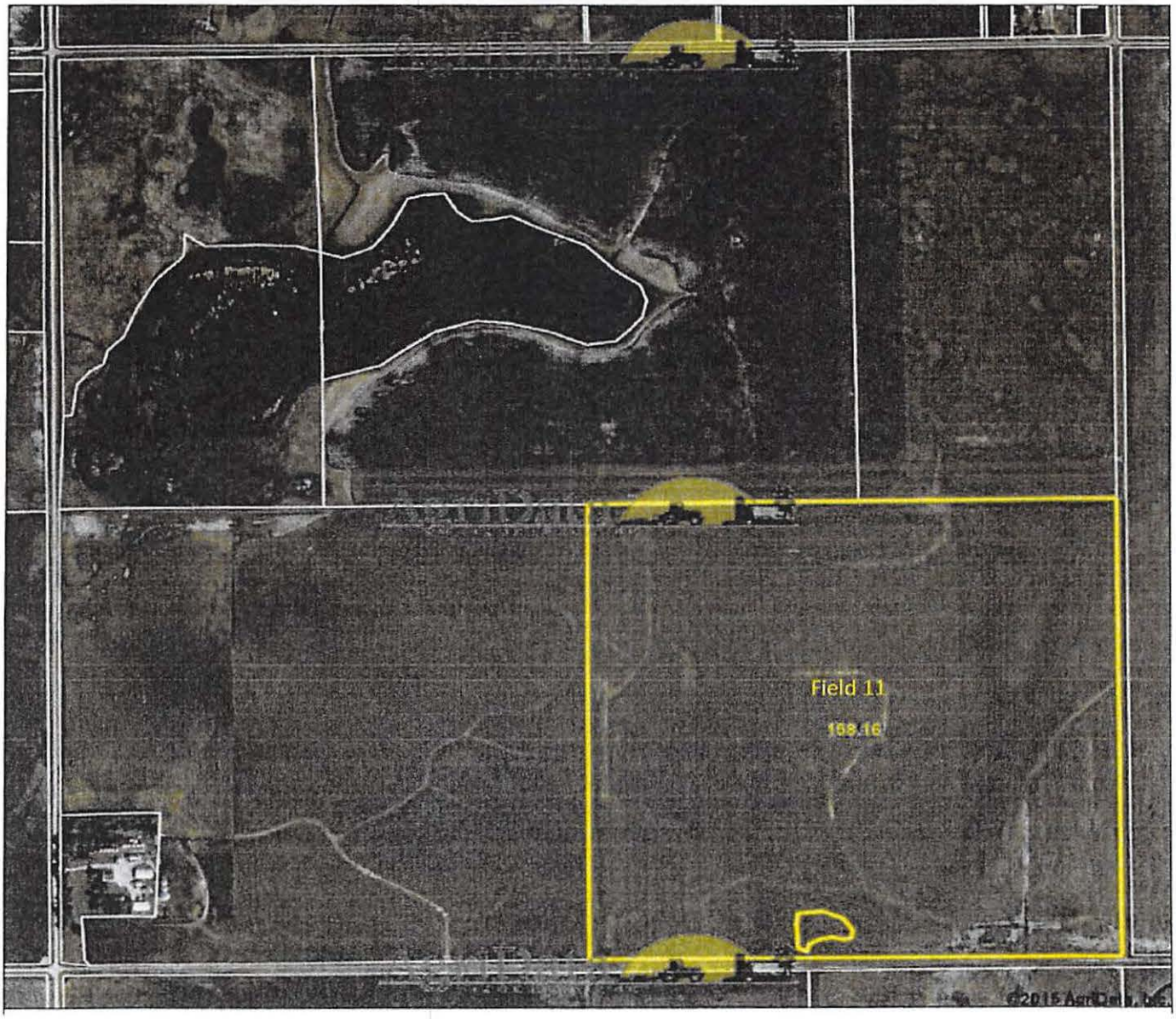
Legal: SE ¼ S10-T140N-R55W, Cass County, ND

Acres: 158

Legend

Boundary | Registered Wells | Setback | Tile Inlets

"L" Nitrogen Leaching – High Risk | "R" Phosphorus Runoff – High Risk



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Water Quality Risk Assessment Map

Name: Rolling Green Sow Farm

Landowner: Joseph Harbeke

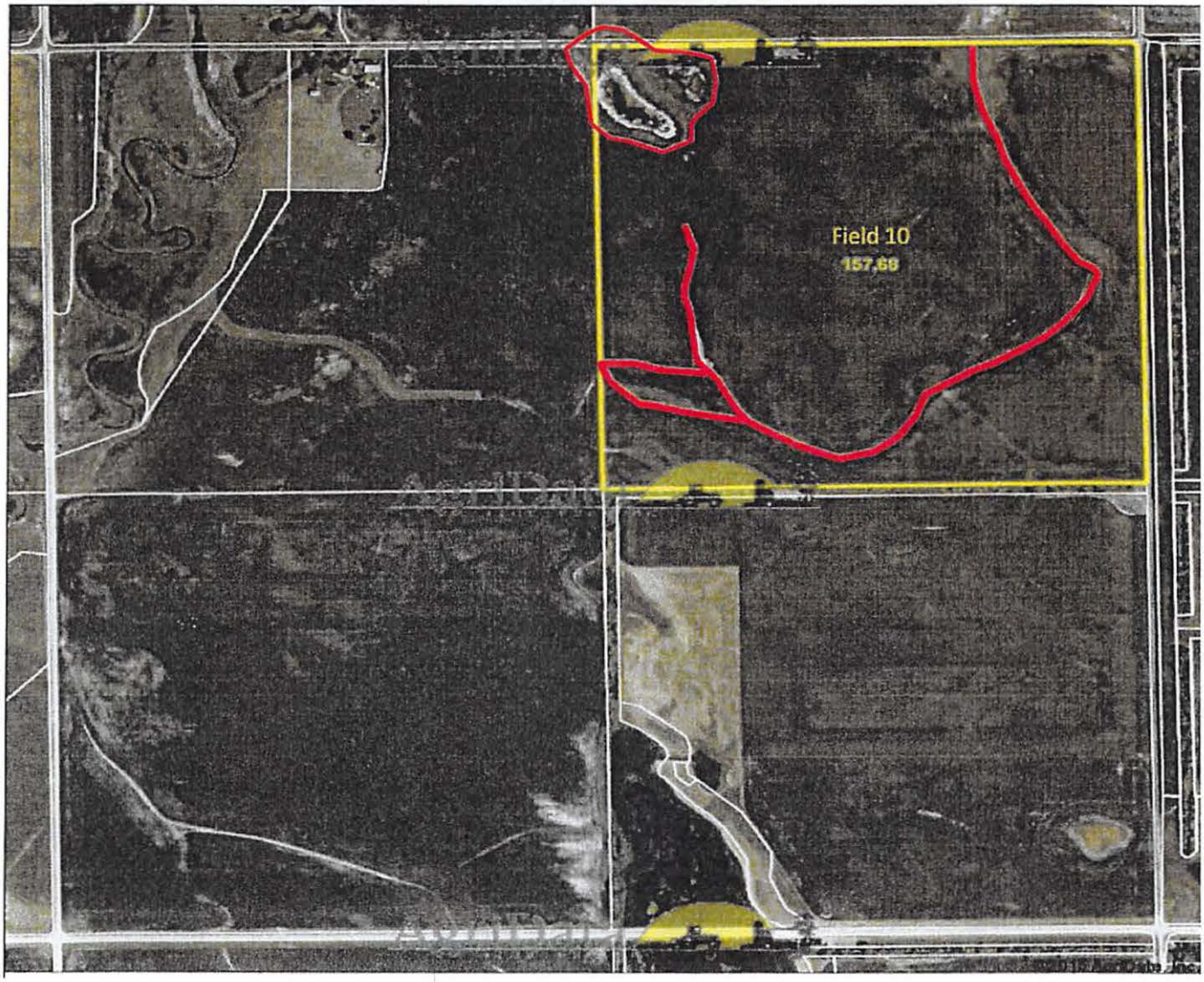
Legal: NE ¼ S14-T139N-R55W, Cass County, ND

Acres: 140.2

Legend

Boundary | Registered Wells | Setback | Tile Inlets

"L" Nitrogen Leaching – High Risk | "R" Phosphorus Runoff – High Risk



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Water Quality Risk Assessment Map

Name: Rolling Green Sow Farm

Landowner: Eldwyn Van Bruggen

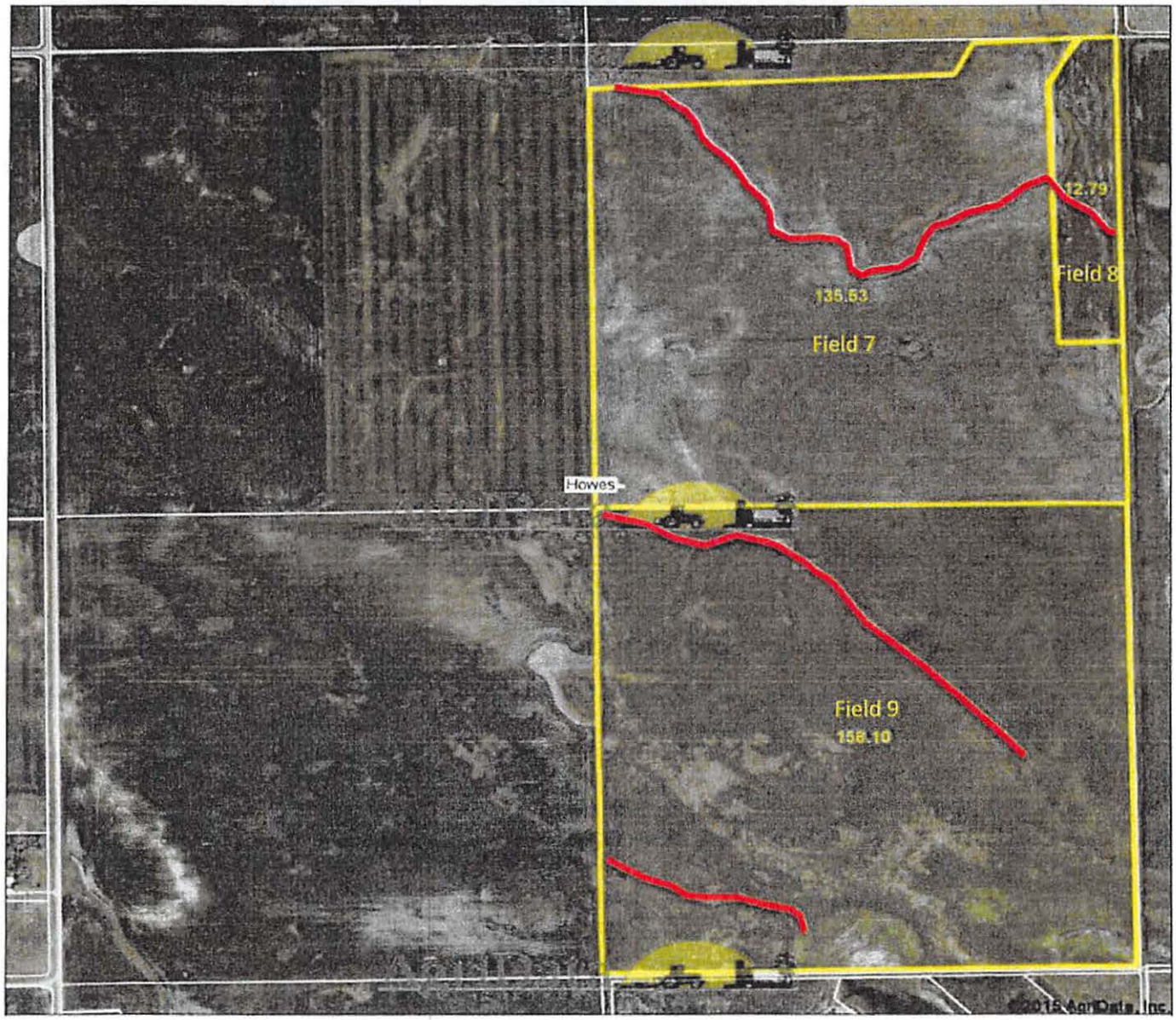
Legal: E ½ S32-T139N-R54W, Cass County, ND

Acres: 291.3 Combined

Legend

Boundary | Registered Wells | Setback | Tile Inlets

"L" Nitrogen Leaching – High Risk | "R" Phosphorus Runoff – High Risk



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Water Quality Risk Assessment Map

Name: Rolling Green Sow Farm

Landowner: Melvin Family RE LLLP

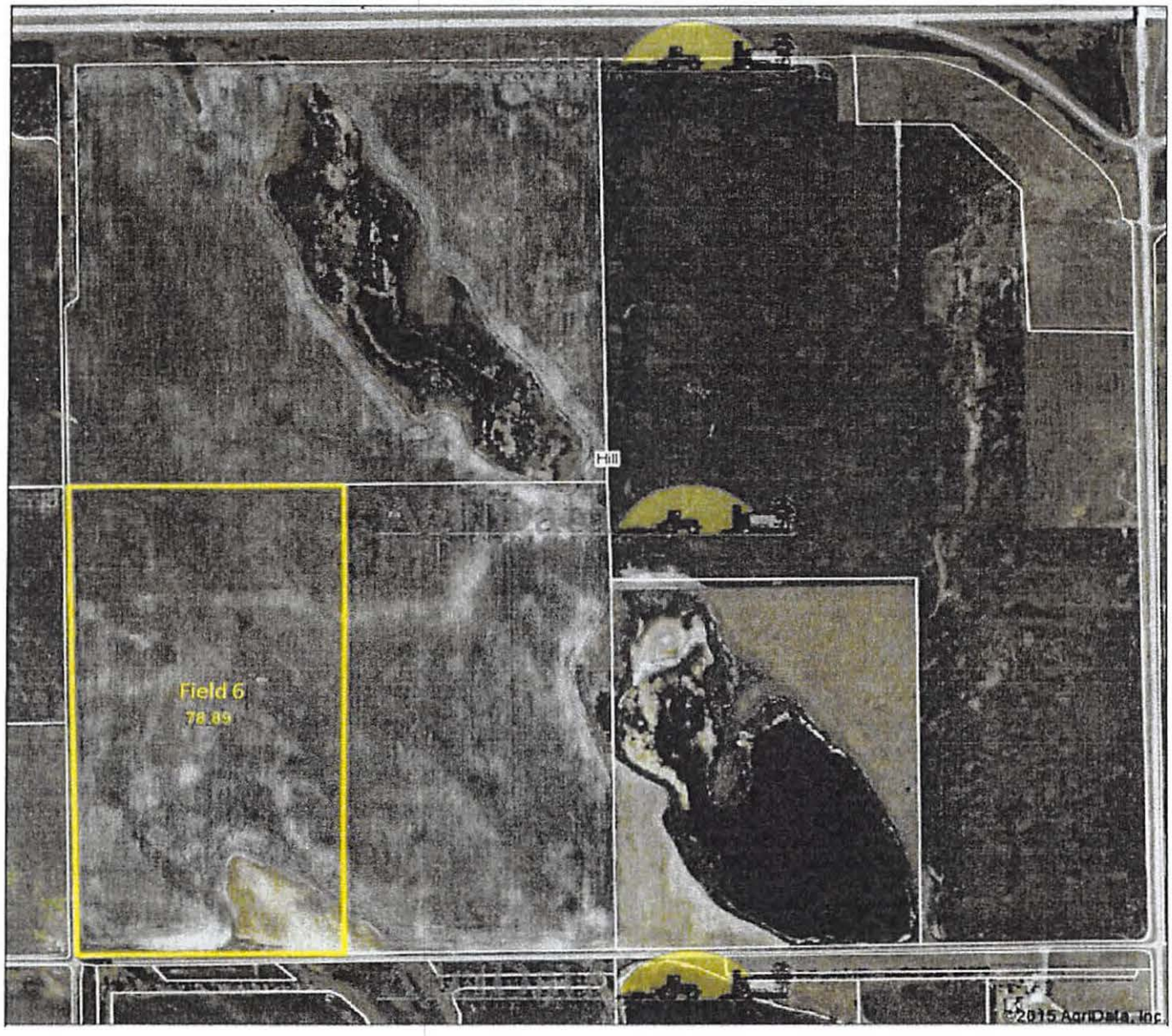
Legal: W ½ SW ¼ S12-T139N-R55W, Cass County, ND

Acres: 78

Legend

Boundary | Registered Wells | Setback | Tile Inlets

"L" Nitrogen Leaching – High Risk | "R" Phosphorus Runoff – High Risk



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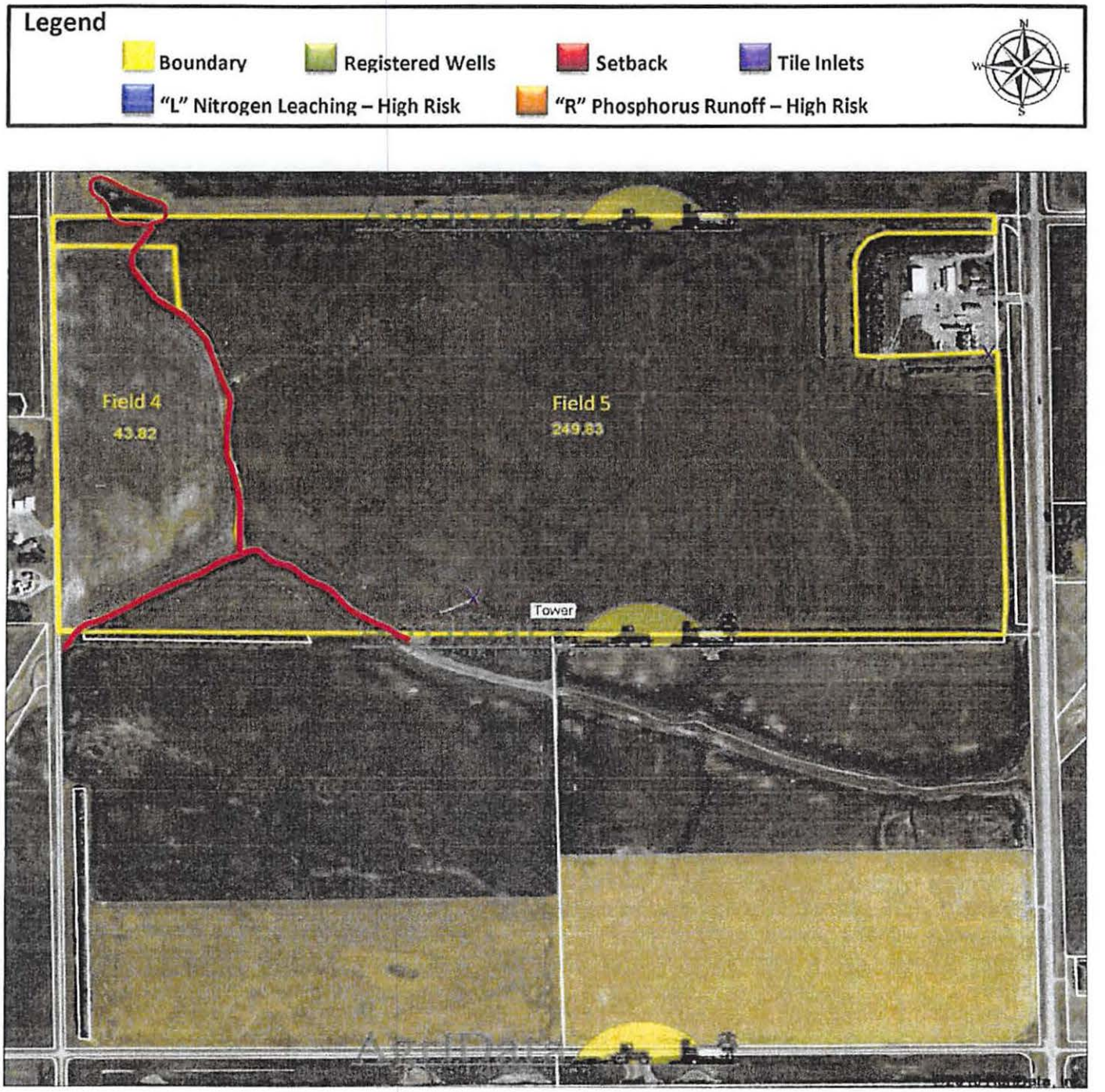
Water Quality Risk Assessment Map

Name: Rolling Green Sow Farm

Landowner: Melvin Family RE LLLP

Legal: N ½ S36-T140N-R55W, Cass County, ND

Acres: 282.8 Combined



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Water Quality Risk Assessment Map

Name: Rolling Green Sow Farm

Landowner: Melvin Family RE LLLP

Legal: NW ¼ S4-T139N-R54W, Cass County, ND

Acres: 156.4

Legend

Boundary | Registered Wells | Setback | Tile Inlets

"L" Nitrogen Leaching – High Risk | "R" Phosphorus Runoff – High Risk

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Water Quality Risk Assessment Map

Name: Rolling Green Sow Farm

Landowner: Melvin Family RE LLLP

Legal: E ½ S9-T139N-R54W, Cass County, ND

Acres: 280.5 Combined

Legend

Boundary | Registered Wells | Setback | Tile Inlets

"L" Nitrogen Leaching – High Risk | "R" Phosphorus Runoff – High Risk

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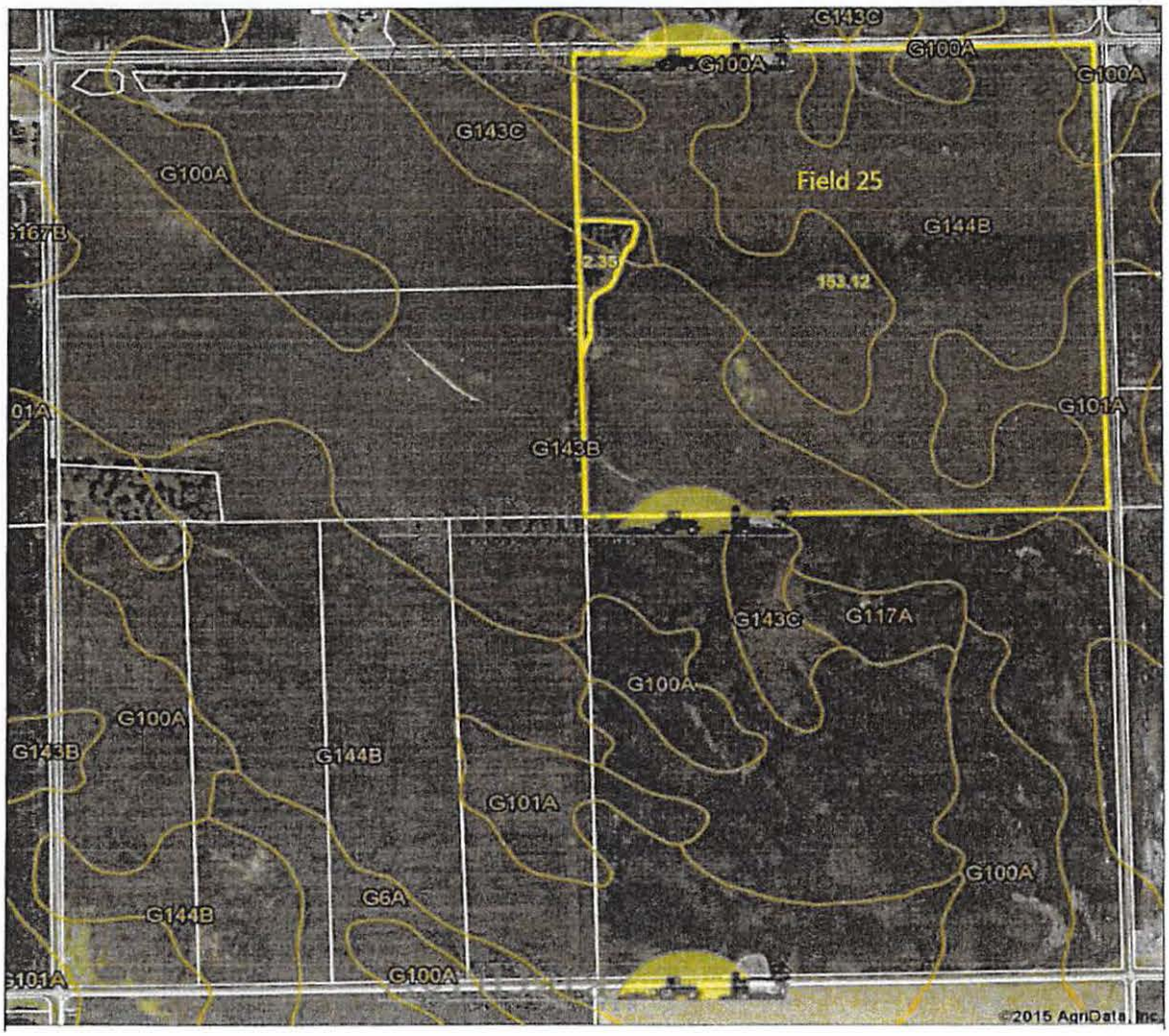
Soil Map

Name: Rolling Green Sow Farm

Landowner: Tim Bernston

Legal: NE ¼ S32-T140N-R54W, Cass County, ND

Acres: 150



Area Symbol: ND017, Soil Area Version: 14						
Code	Soil Description	Acres	Percent of field	PI Legend	Non-Irr Class *c	Productivity Index
G144B	Barnes-Buse loams, 3 to 6 percent slopes	72.38	46.6%		IIe	69
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	36.01	23.2%		IIe	64
G143B	Barnes-Svea loams, 3 to 6 percent slopes	31.69	20.4%		IIe	75
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	12.40	8.0%		IIe	77
G143C	Barnes-Buse-Langhei loams, 6 to 9 percent slopes	2.99	1.9%		IVe	56
					Weighted Average	69.5

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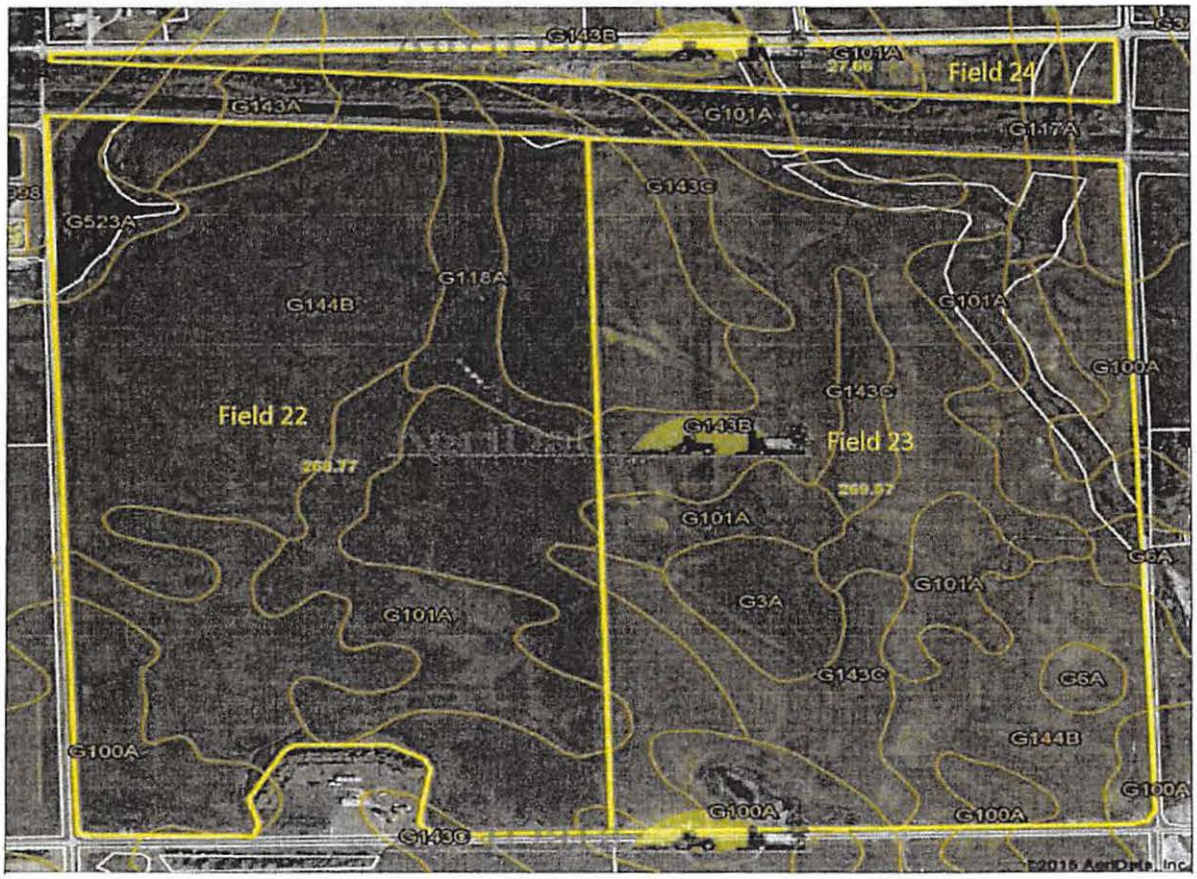
Soil Map

Name: Rolling Green Sow Farm

Landowner: Randy Melvin

Legal: S29-T140N-R54W, Cass County, ND

Acres: 557.7 Combined



Area Symbol: ND017, Soil Area Version: 14						
Code	Soil Description	Acres	Percent of field	PI Legend	Non-Irr Class *c	Productivity Index
G143B	Barnes-Svea loams, 3 to 6 percent slopes	167.55	29.6%		IIe	75
G144B	Barnes-Buse loams, 3 to 6 percent slopes	161.79	28.6%		IIe	69
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	76.98	13.6%		IIe	77
G143C	Barnes-Buse-Langhei loams, 6 to 9 percent slopes	55.11	9.7%		IVe	56
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	47.70	8.4%		IIe	64
G118A	Vallers loam, saline, 0 to 1 percent slopes	15.53	2.7%		IVw	42
G3A	Parnell silty clay loam, 0 to 1 percent slopes	12.93	2.3%		Vw	25
G523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	10.27	1.8%		VIw	22
G117A	Hamerly loam, saline, 0 to 3 percent slopes	6.66	1.2%		IIIs	56
G143A	Barnes-Svea loams, 0 to 3 percent slopes	5.81	1.0%		IIc	85
G6A	Vallers loam, 0 to 1 percent slopes	5.67	1.0%		IVw	46
					Weighted Average	67.4

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PO Box 522 | Mandan, ND | 58554

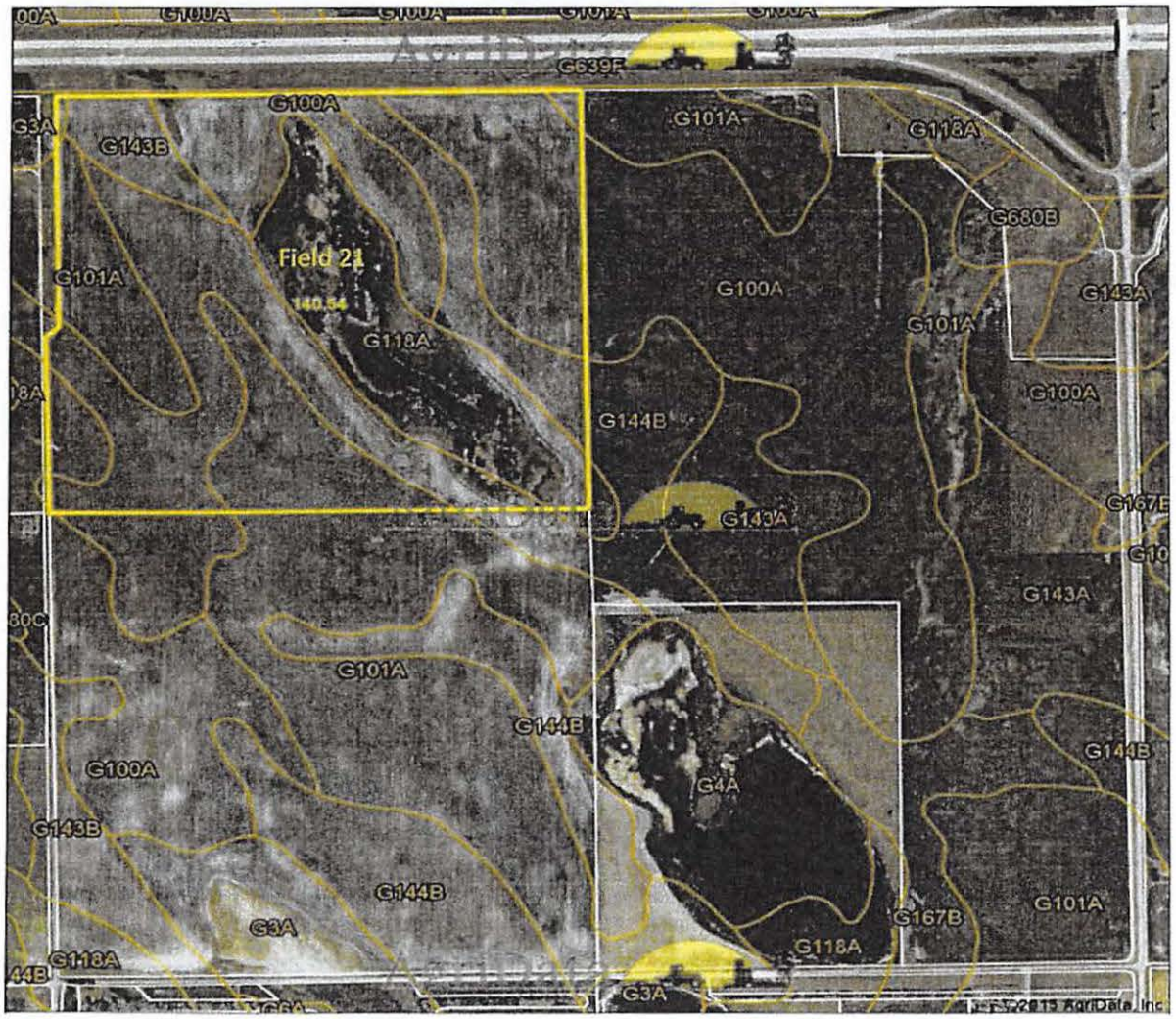
Soil Map

Name: Rolling Green Sow Farm

Landowner: Randy Melvin

Legal: NW ¼ S12-T139N-R55W, Cass County, ND

Acres: 107.7



Area Symbol: ND017, Soil Area Version: 14						
Code	Soil Description	Acres	Percent of field	PI Legend	Non-Irr Class *c	Productivity Index
G144B	Barnes-Buse loams, 3 to 6 percent slopes	43.56	31.0%		IIe	69
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	37.32	26.6%		IIe	64
G118A	Vallers loam, saline, 0 to 1 percent slopes	28.92	20.6%		IVw	42
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	24.50	17.4%		IIe	77
G143B	Barnes-Svea loams, 3 to 6 percent slopes	5.99	4.3%		IIe	75
G3A	Parnell silty clay loam, 0 to 1 percent slopes	0.25	0.2%		Vw	25
					Weighted Average	63.7

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PO Box 522 | Mandan, ND | 58554

Soil Map

Name: Rolling Green Sow Farm

Landowner: Randy Melvin

Legal: S ½ SE ¼ S11-T139N-R55W, Cass County, ND

Acres: 57.6

Area Symbol: ND017, Soil Area Version: 14						
Code	Soil Description	Acres	Percent of field	PI Legend	Non-Irr Class *c	Productivity Index
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	13.49	23.4%		IIIe	77
G143B	Barnes-Svea loams, 3 to 6 percent slopes	11.72	20.4%		IIe	75
G118A	Vallers loam, saline, 0 to 1 percent slopes	11.15	19.4%		IVw	42
G143A	Barnes-Svea loams, 0 to 3 percent slopes	6.38	11.1%		IIc	85
G167B	Balaton-Wyard loams, 0 to 6 percent slopes	5.21	9.1%		IIe	73
G144B	Barnes-Buse loams, 3 to 6 percent slopes	3.81	6.6%		IIe	69
G6A	Vallers loam, 0 to 1 percent slopes	3.06	5.3%		IVw	46
G143C	Barnes-Buse-Langhei loams, 6 to 9 percent slopes	2.55	4.4%		IVe	56
G147C	Buse-Barnes-Dahlen loams, 3 to 9 percent slopes	0.19	0.3%		IVe	60
					Weighted Average	67.2

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Consulting Engineers
PO Box 522 | Mandan, ND | 58554

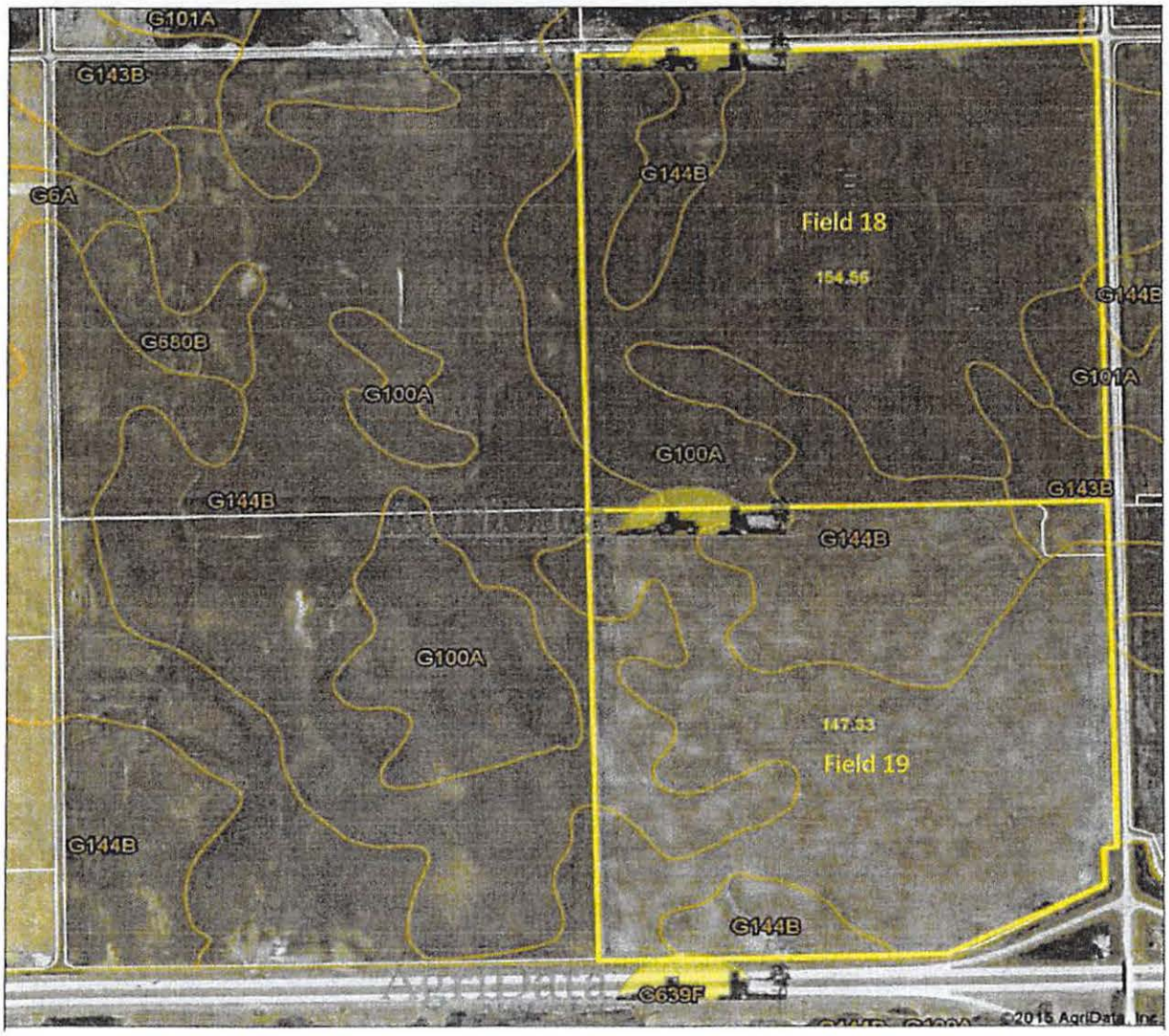
Soil Map

Name: Rolling Green Sow Farm

Landowner: Randy Melvin

Legal: E ½ S4-T139N-R54W, Cass County, ND

Acres: 300.68



Area Symbol: ND017 Soil Area Version: 14						
Code	Soil Description	Acres	Percent of field	PI Legend	Non-Irr Class *c	Productivity Index
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	207.64	68.8%		IIe	64
G144B	Barnes-Buse loams, 3 to 6 percent slopes	78.26	25.9%		IIe	69
G143B	Barnes-Svea loams, 3 to 6 percent slopes	9.87	3.3%		IIe	75
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	6.12	2.0%		IIe	77
					Weighted Average	65.9

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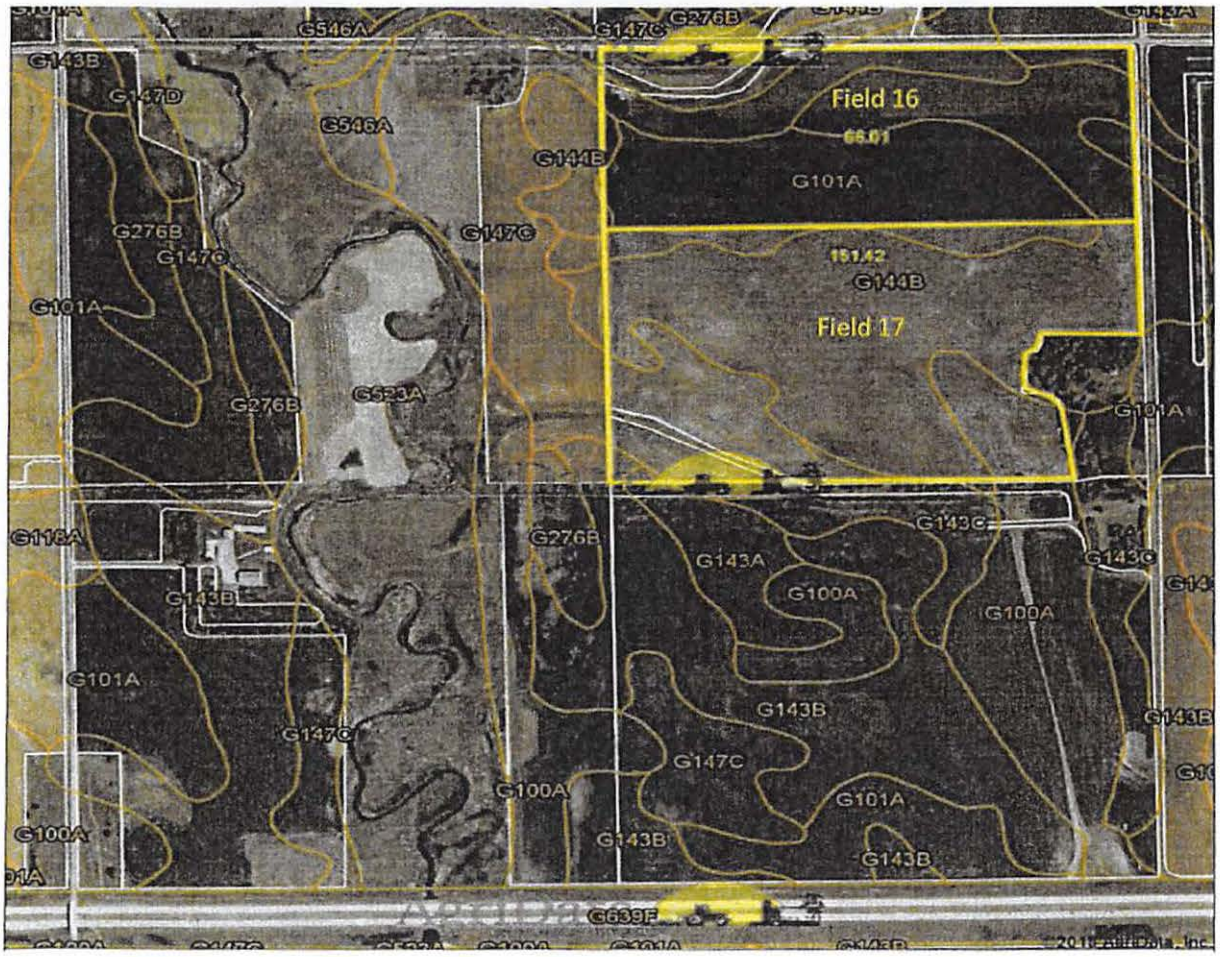
Soil Map

Name: Rolling Green Sow Farm

Landowner: Randy Melvin

Legal: NE ½ S2-T139N-R55W, Cass County, ND

Acres: 146.9 Combined



Area Symbol: ND017, Soil Area Version: 14						
Code	Soil Description	Acres	Percent of field	PI Legend	Non-Irr Class *c	Productivity Index
G144B	Barnes-Buse loams, 3 to 6 percent slopes	80.86	41.3%		IIe	69
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	70.34	32.4%		IIe	77
G147C	Buse-Barnes-Darnen loams, 3 to 9 percent slopes	37.14	17.1%		IVe	60
G523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	10.98	5.0%		VIw	22
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	7.31	3.4%		IIe	64
G143C	Barnes-Buse-Langhei loams, 6 to 9 percent slopes	0.98	0.5%		IVe	56
G143B	Barnes-Svea loams, 3 to 6 percent slopes	0.50	0.2%		IIe	75
G143A	Barnes-Svea loams, 0 to 3 percent slopes	0.32	0.1%		IIc	85
					Weighted Average	67.5

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Consulting Engineers
PO Box 522 | Mandan, ND | 58554

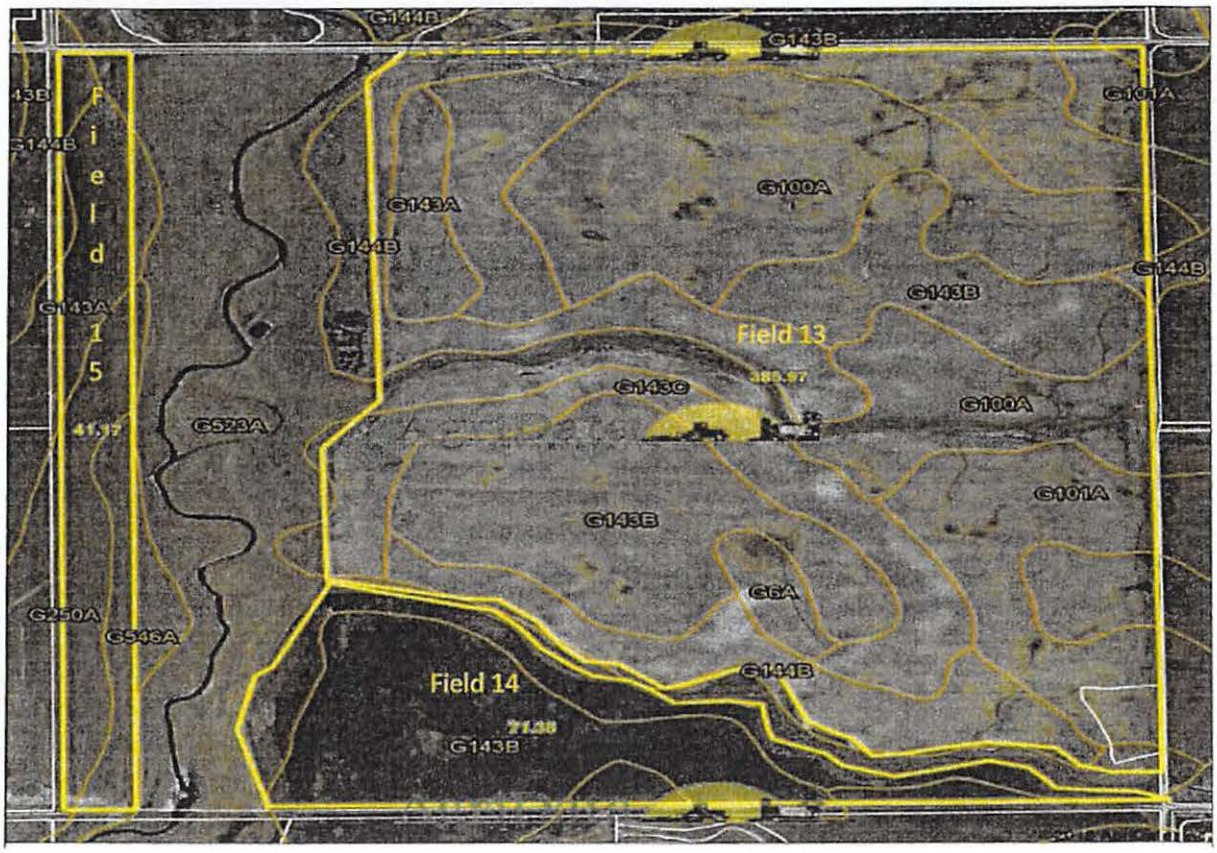
Soil Map

Name: Rolling Green Sow Farm

Landowner: Randy Melvin

Legal: S11-T140N-R55W, Cass County, ND

Acres: 488.4 Combined



Area Symbol: ND017 Soil Area Version: 14						
Code	Soil Description	Acres	Percent of field	PI Legend	Non-Irr Class *c	Productivity Index
G143B	Barnes-Svea loams, 3 to 6 percent slopes	167.10	33.5%		IIe	75
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	111.03	22.3%		IIe	64
G144B	Barnes-Buse loams, 3 to 6 percent slopes	53.57	10.7%		IIe	69
G523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	39.27	7.9%		VIw	22
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	38.79	7.8%		IIe	77
G143C	Barnes-Buse-Langhei loams, 6 to 9 percent slopes	34.90	7.0%		IVe	56
G143A	Barnes-Svea loams, 0 to 3 percent slopes	22.42	4.5%		IIc	85
G250A	Divide loam, 0 to 2 percent slopes	16.47	3.3%		IIs	58
G546A	Lowe loam, saline, 0 to 1 percent slopes, occasionally flooded	8.88	1.8%		IVw	36
G6A	Vallers loam, 0 to 1 percent slopes	6.03	1.2%		IVw	46
					Weighted Average	65.4

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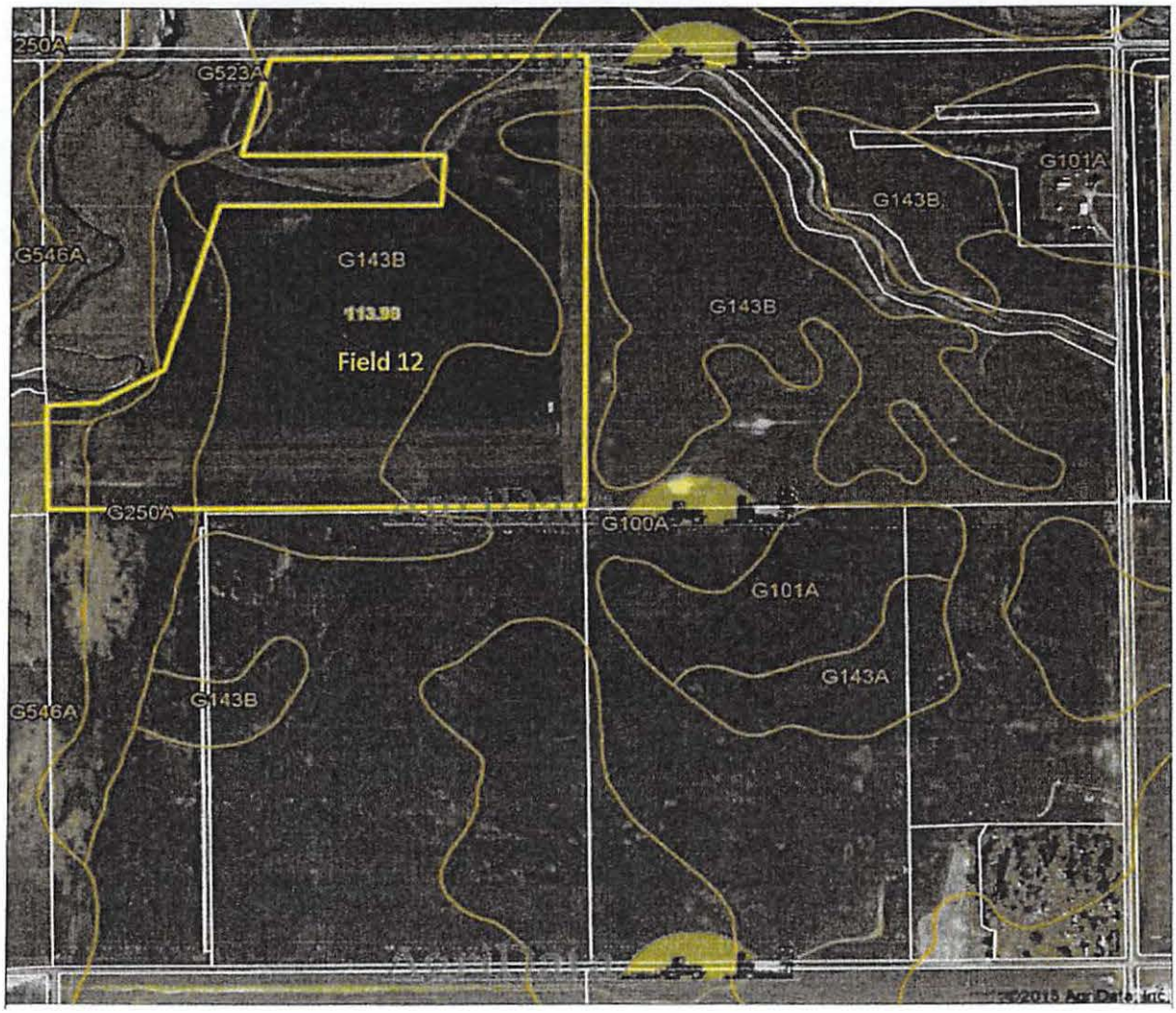
Soil Map

Name: Rolling Green Sow Farm

Landowner: Jonathan Melvin

Legal: NW ¼ S14-T140N-R55W, Cass County, ND

Acres: 112.3



Area Symbol: ND017, Soil Area Version: 14						
Code	Soil Description	Acres	Percent of field	PI Legend	Non-Irr Class *c	Productivity Index
G143B	Barnes-Svea loams, 3 to 6 percent slopes	65.50	57.5%		IIe	75
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	32.37	28.4%		IIc	64
G250A	Divide loam, 0 to 2 percent slopes	12.35	10.8%		IIs	58
G546A	Lowe loam, saline, 0 to 1 percent slopes, occasionally flooded	2.10	1.9%		IVw	36
G523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	1.60	1.4%		Vlw	22
					Weighted Average	68.6

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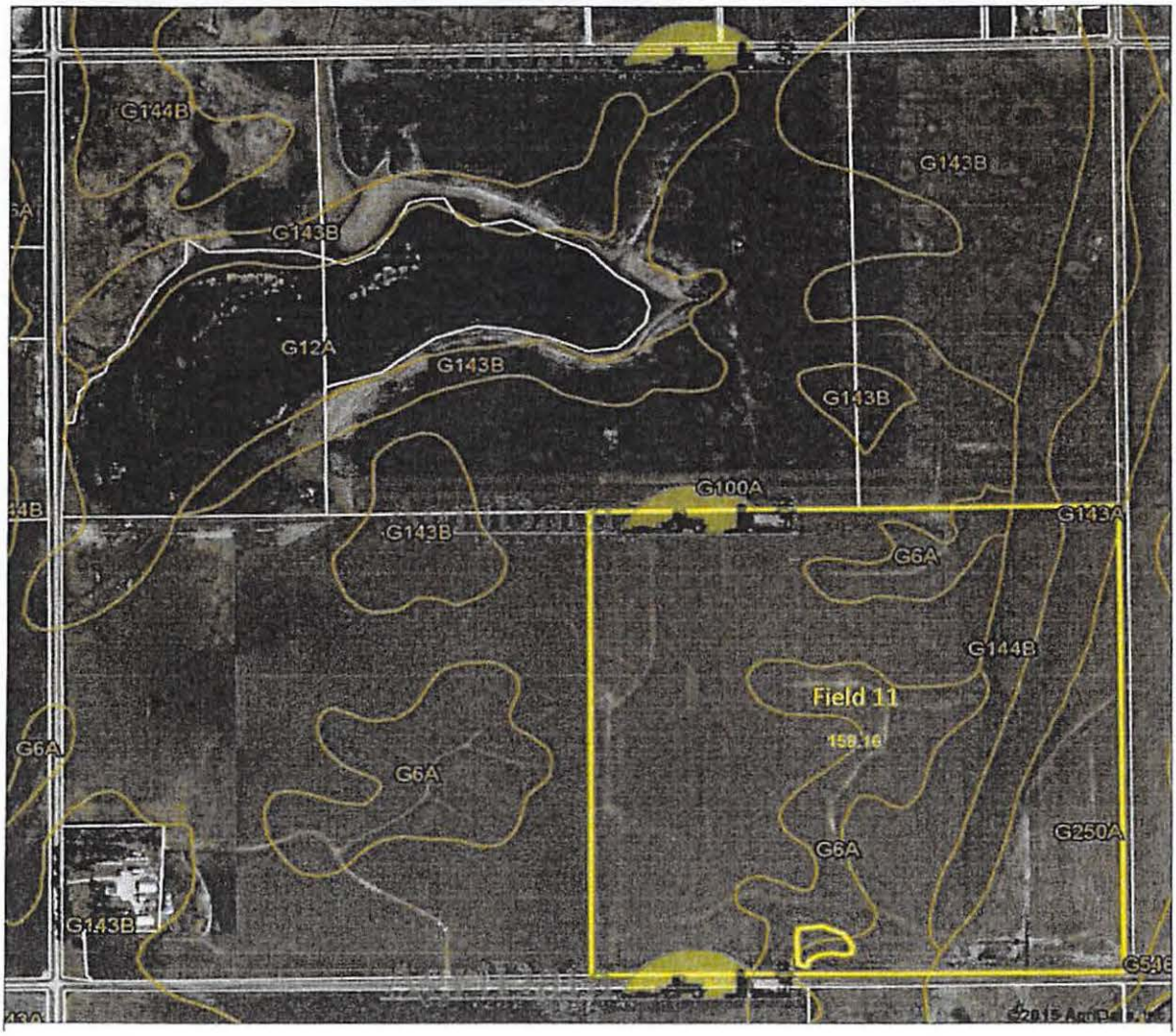
Soil Map

Name: Rolling Green Sow Farm

Landowner: Jonathan Melvin

Legal: SE ¼ S10-T140N-R55W, Cass County, ND

Acres: 158



Area Symbol: ND017, Soil Area Version: 14						
Code	Soil Description	Acres	Percent of field	PI Legend	Non-Irr Class *c	Productivity Index
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	75.29	47.6%		IIe	64
G6A	Vallers loam, 0 to 1 percent slopes	25.54	16.1%		IVw	46
G250A	Divide loam, 0 to 2 percent slopes	23.88	15.1%		IIs	58
G144B	Barnes-Buse loams, 3 to 6 percent slopes	19.78	12.5%		IIe	69
G143A	Barnes-Svea loams, 0 to 3 percent slopes	13.67	8.6%		IIc	85
					Weighted Average	62.6

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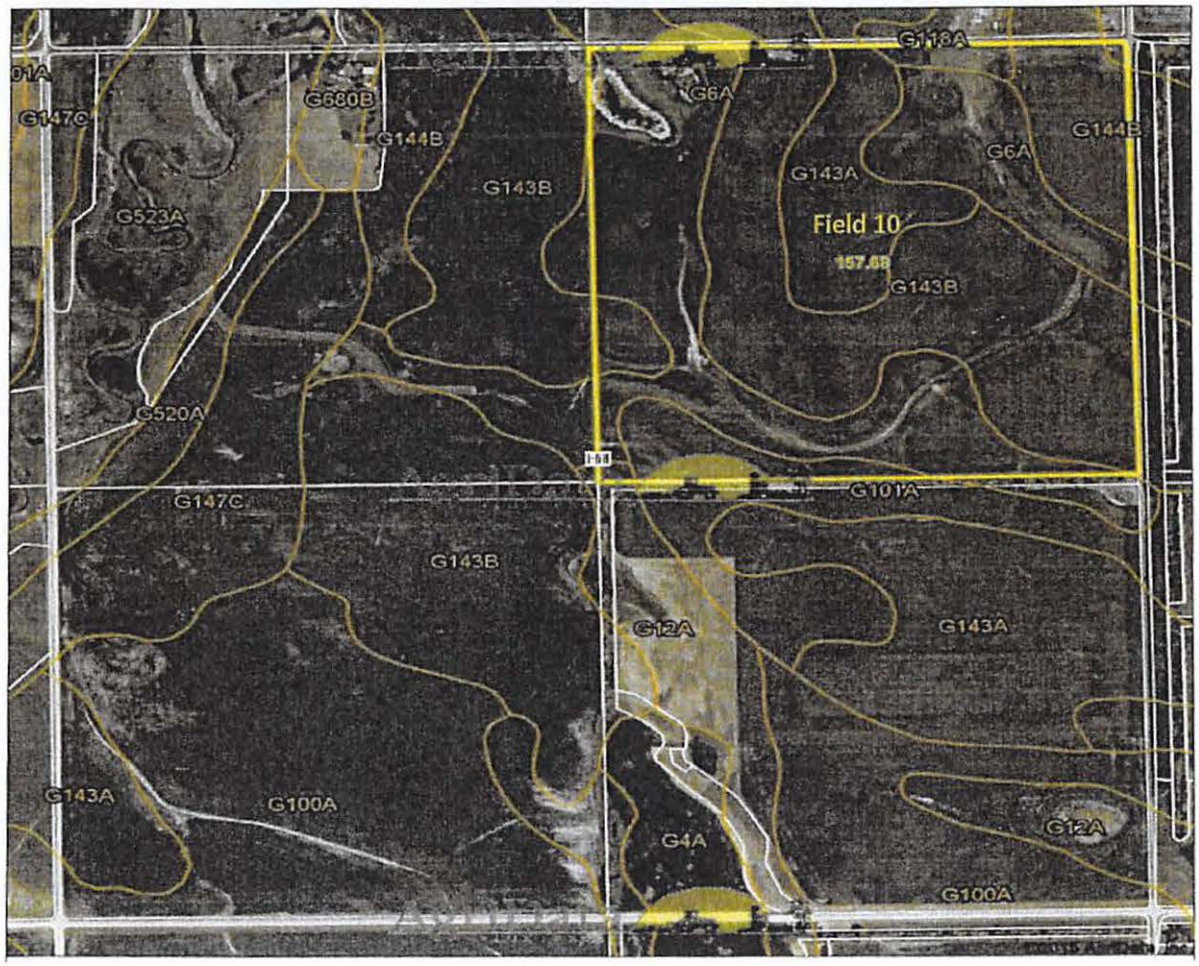
Soil Map

Name: Rolling Green Sow Farm

Landowner: Joseph Harbeke

Legal: NE ¼ S14-T139N-R55W, Cass County, ND

Acres: 140.2



Area Symbol: ND017, Soil Area Version: 14						
Code	Soil Description	Acres	Percent of field	PI Legend	Non-Irr Class *c	Productivity Index
G143B	Barnes-Svea loams, 3 to 6 percent slopes	59.37	37.7%		IIe	75
G6A	Vallers loam, 0 to 1 percent slopes	57.81	36.7%		IVw	46
G143A	Barnes-Svea loams, 0 to 3 percent slopes	18.37	11.7%		IIc	85
G144B	Barnes-Buse loams, 3 to 6 percent slopes	11.54	7.3%		IIe	69
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	7.57	4.8%		IIe	77
G118A	Vallers loam, saline, 0 to 1 percent slopes	2.58	1.6%		IVw	42
G12A	Vallers-saline Parnell complex, 0 to 1 percent slopes	0.41	0.3%		IVw	32
					Weighted Average	64.5

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PO Box 522 | Mandan, ND | 58554

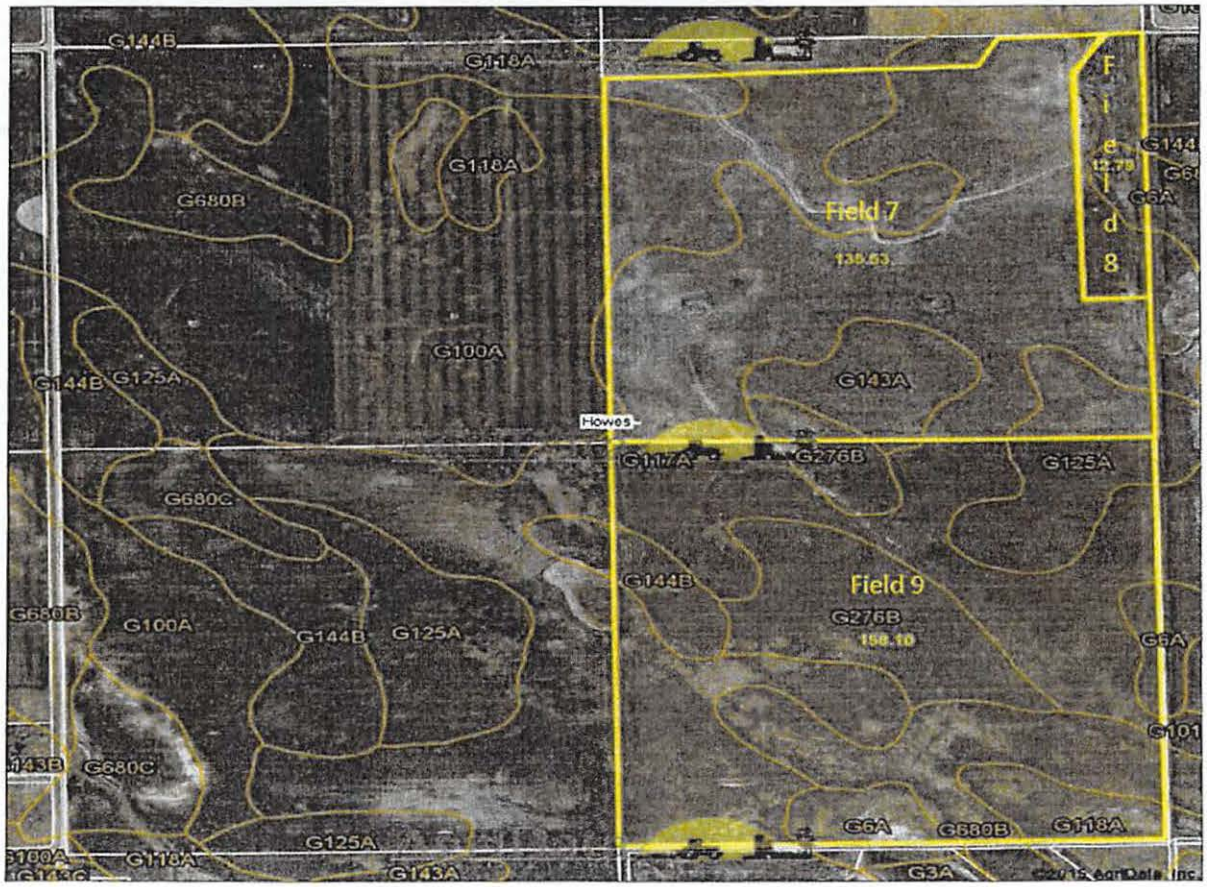
Soil Map

Name: Rolling Green Sow Farm

Landowner: Eldwyn Van Bruggen

Legal: E ½ S32-T139N-R54W, Cass County, ND

Acres: 291.3 Combined



Area Symbol: ND017, Soil Area Version: 14						
Code	Soil Description	Acres	Percent of field	PI Legend	Non-Irr Class *c	Productivity Index
G117A	Hamerly loam, saline, 0 to 3 percent slopes	164.09	53.6%		IIIs	56
G276B	Renshaw-Sioux complex, 2 to 6 percent slopes	30.83	10.1%		IVs	40
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	29.39	9.6%		IIe	64
G680B	Barnes-Sioux complex, 1 to 6 percent slopes	22.91	7.5%		IIe	63
G125A	Cavour-Crosby complex, 0 to 3 percent slopes	18.86	6.2%		IVs	50
G143A	Barnes-Svea loams, 0 to 3 percent slopes	12.73	4.2%		IIc	65
G6A	Vallers loam, 0 to 1 percent slopes	10.87	3.5%		IVw	46
G118A	Vallers loam, saline, 0 to 1 percent slopes	10.51	3.4%		IVw	42
G144B	Barnes-Buse loams, 3 to 6 percent slopes	6.11	2.0%		IIe	69
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	0.12	0.0%		IIe	77
					Weighted Average	55.9

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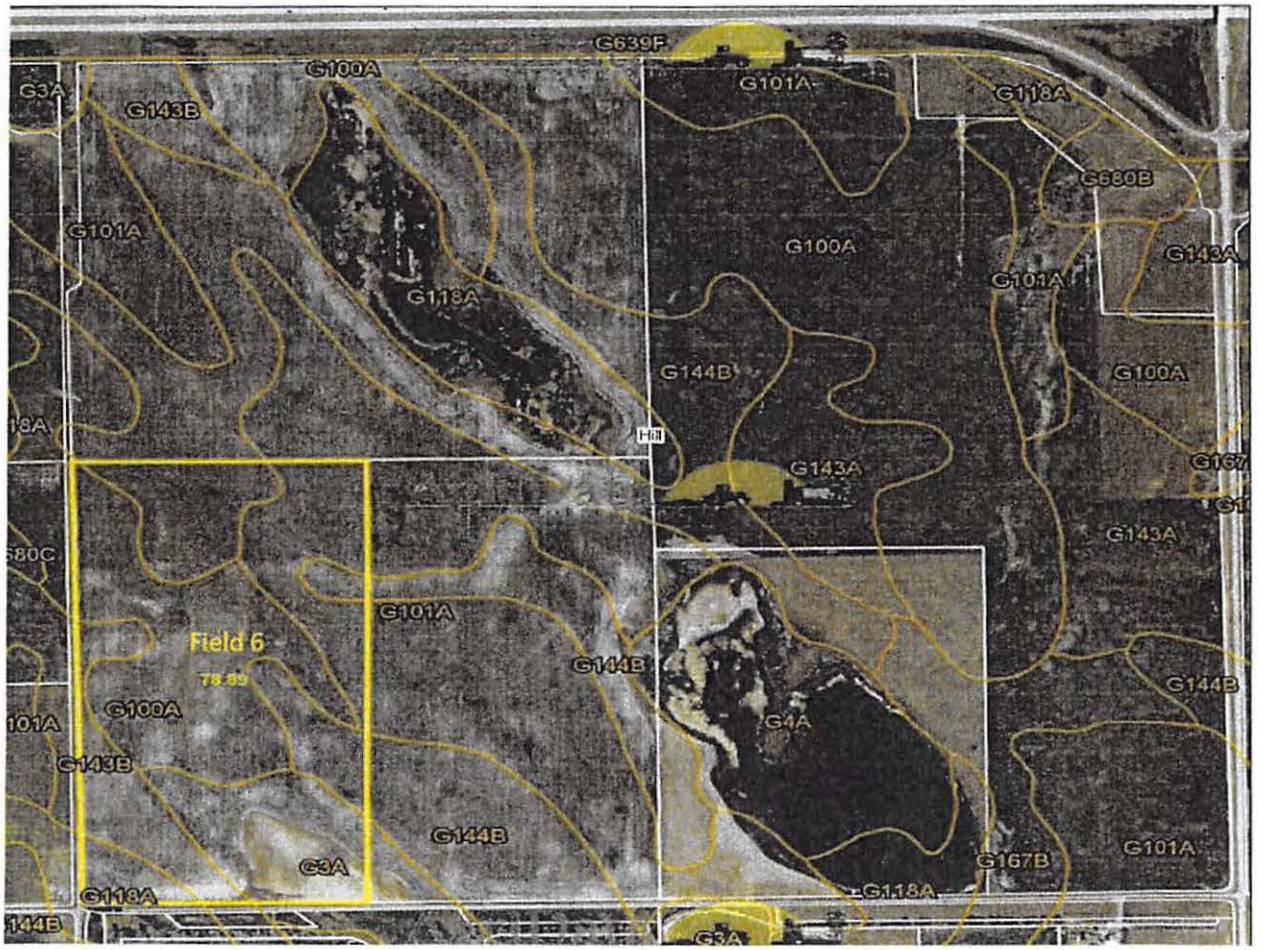
Soil Map

Name: Rolling Green Sow Farm

Landowner: Melvin Family RE LLLP

Legal: W ½ SW ¼ S12-T139N-R55W, Cass County, ND

Acres: 78



Area Symbol: ND017, Soil Area Version: 14						
Code	Soil Description	Acres	Percent of field	PI Legend	Non-Irr Class *c	Productivity Index
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	27.04	34.3%		IIe	64
G144B	Barnes-Buse loams, 3 to 6 percent slopes	14.97	19.0%		IIe	69
G3A	Parnell silty clay loam, 0 to 1 percent slopes	12.93	16.4%		Vw	25
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	11.95	15.1%		IIe	77
G143B	Barnes-Svea loams, 3 to 6 percent slopes	9.03	11.4%		IIe	75
G118A	Vallers loam, saline, 0 to 1 percent slopes	2.97	3.8%		IVw	42
					Weighted Average	61

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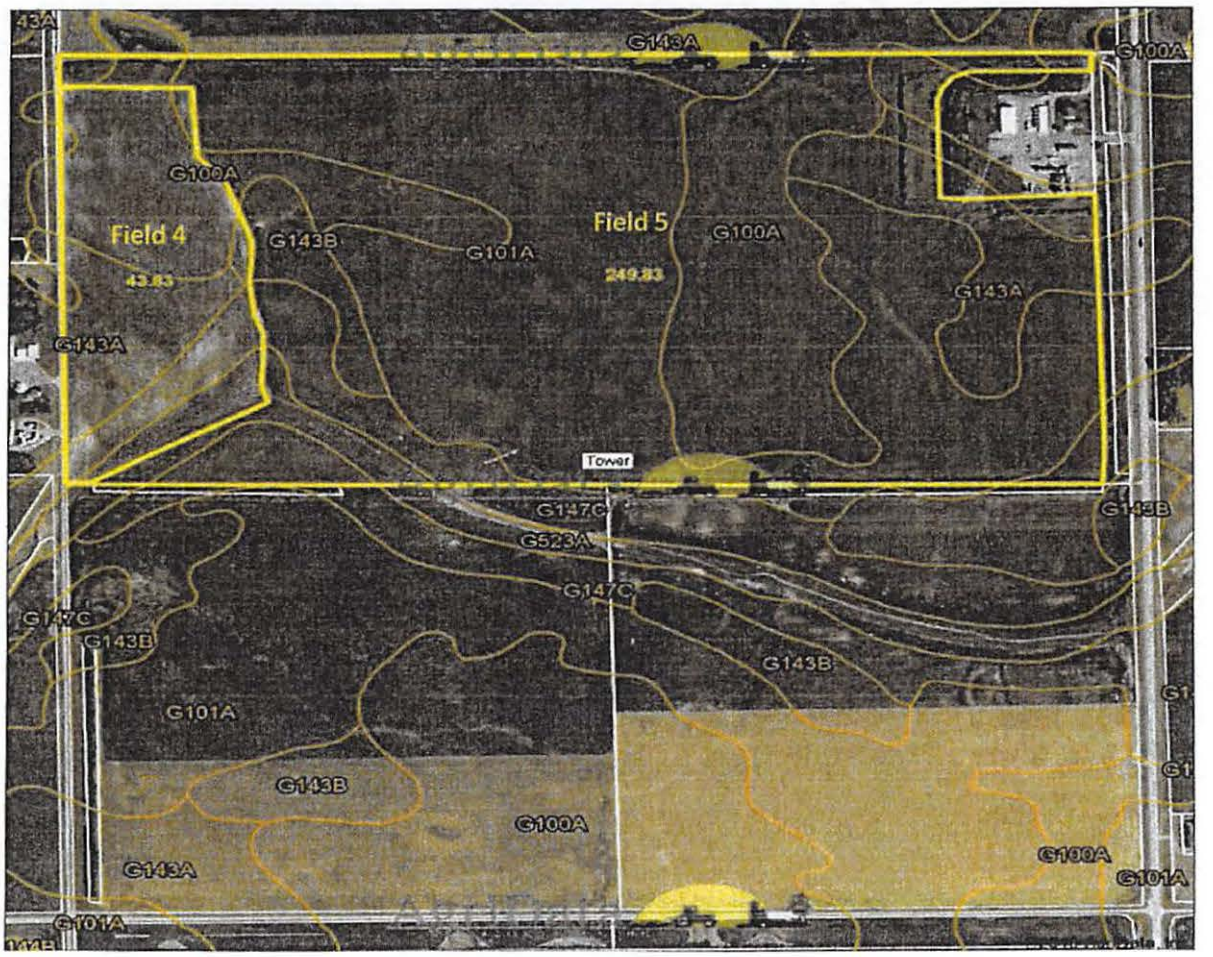
Soil Map

Name: Rolling Green Sow Farm

Landowner: Melvin Family RE LLLP

Legal: N ½ S36-T140N-R55W, Cass County, ND

Acres: 282.8 Combined



Area Symbol: ND017, Soil Area Version: 14						
Code	Soil Description	Acres	Percent of field	PI Legend	Non-Irr Class *c	Productivity Index
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	137.47	46.8%		IIe	77
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	74.08	25.2%		IIe	64
G143A	Barnes-Svea loams, 0 to 3 percent slopes	40.34	13.7%		IIc	85
G147C	Buse-Barnes-Darnen loams, 3 to 9 percent slopes	22.57	7.7%		IVe	60
G523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	10.65	3.6%		VIw	22
G143B	Barnes-Svea loams, 3 to 6 percent slopes	8.55	2.9%		IIe	75
					Weighted Average	71.5

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Consulting Engineers
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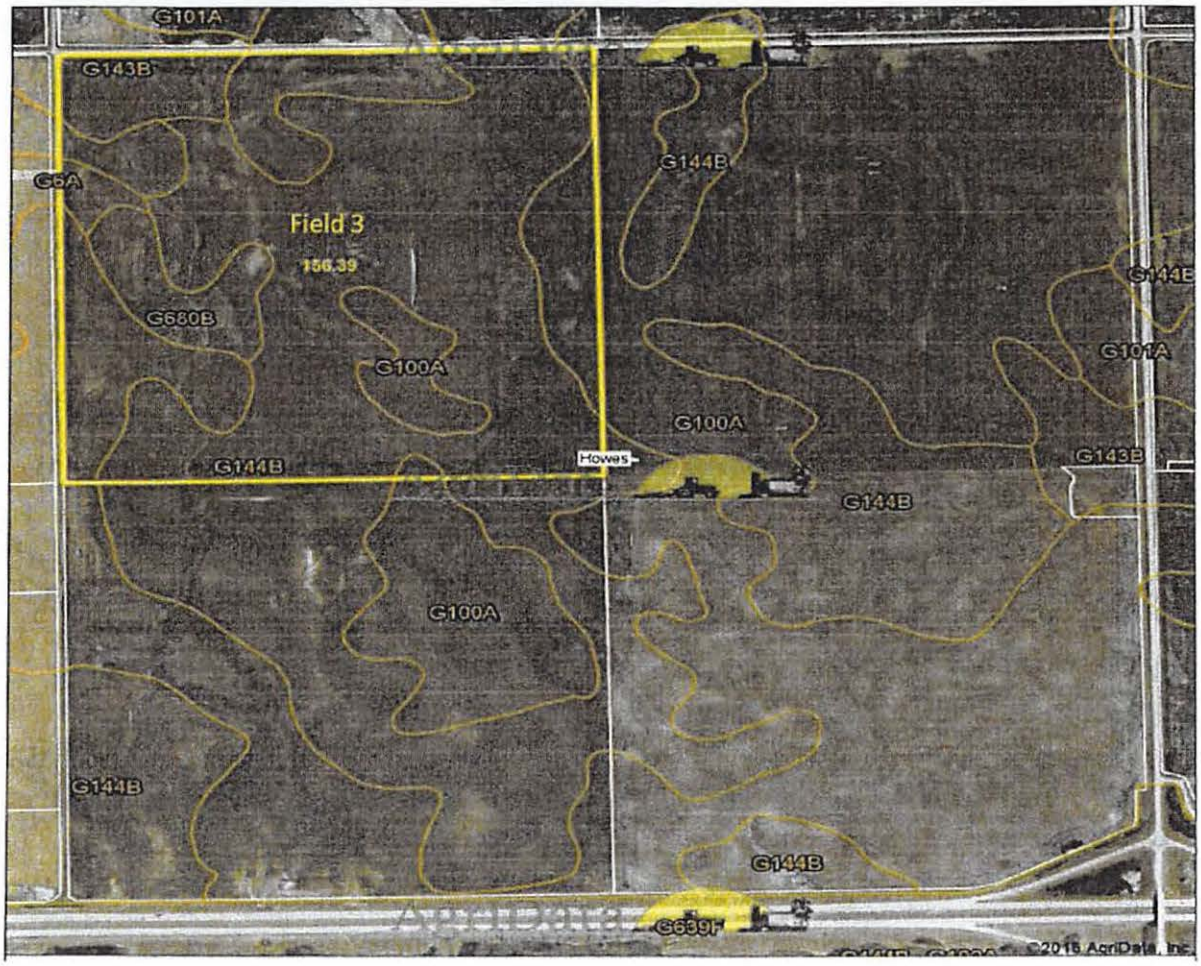
Soil Map

Name: Rolling Green Sow Farm

Landowner: Melvin Family RE LLLP

Legal: NW ¼ S4-T139N-R54W, Cass County, ND

Acres: 150



Area Symbol: ND017, Soil Area Version: 14						
Code	Soil Description	Acres	Percent of field	PI Legend	Non-Irr Class *c	Productivity Index
G144B	Barnes-Buse loams, 3 to 6 percent slopes	88.44	58.6%		IIe	69
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	47.25	30.2%		IIe	64
G680B	Barnes-Sioux complex, 1 to 6 percent slopes	9.87	6.3%		IIe	63
G143B	Barnes-Svea loams, 3 to 6 percent slopes	8.51	5.4%		IIe	75
G6A	Vallers loam, 0 to 1 percent slopes	2.32	1.5%		IVw	46
					Weighted Average	67.1

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Consulting Engineers
PO Box 522 | Mandan, ND | 58554

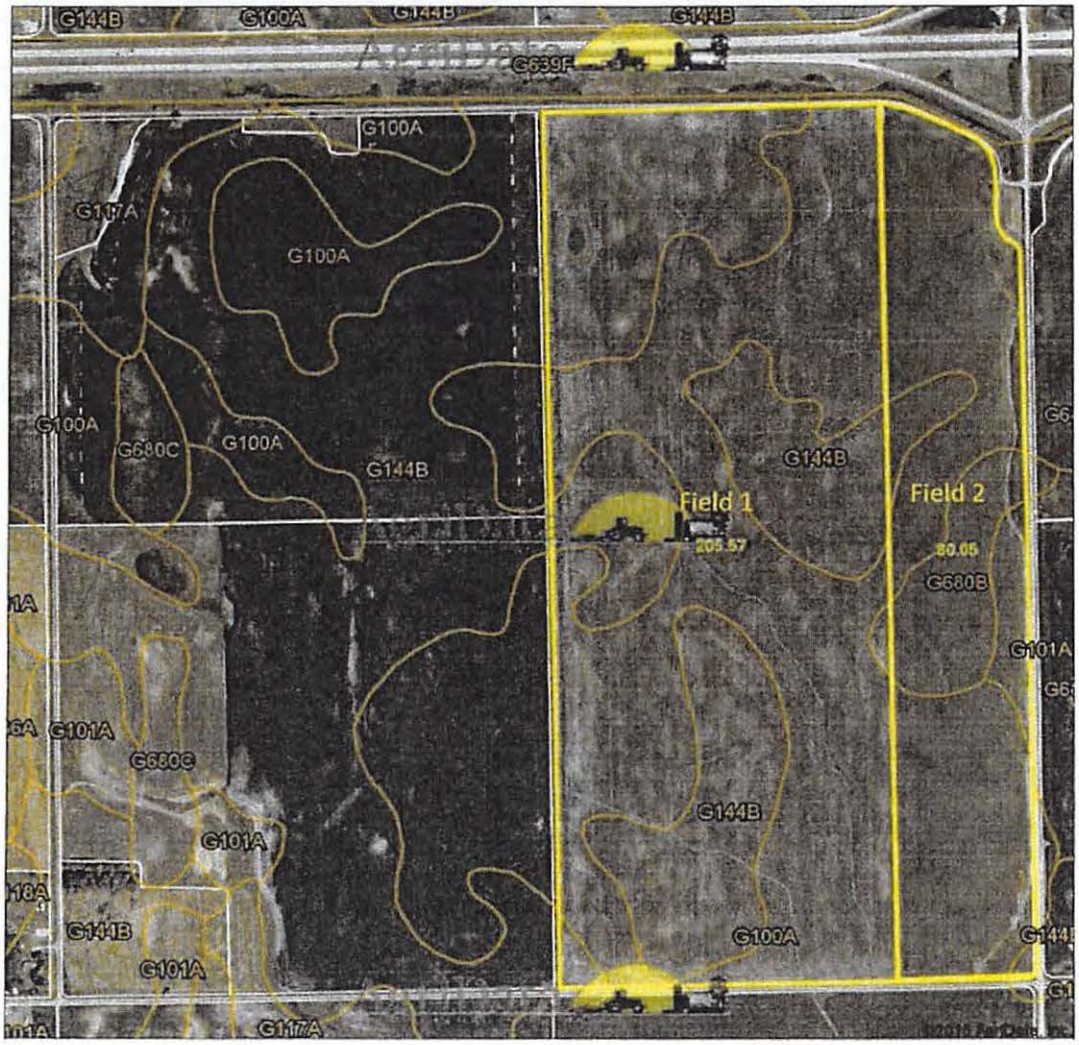
Soil Map

Name: Rolling Green Sow Farm

Landowner: Melvin Family RE LLLP

Legal: E ½ S9-T139N-R54W, Cass County, ND

Acres: 204.9 Combined



Area Symbol: ND017, Soil Area Version: 14						
Code	Soil Description	Acres	Percent of field	PI Legend	Non-Irr Class *c	Productivity Index
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	171.91	60.2%		IIe	64
G144B	Barnes-Buse loams, 3 to 6 percent slopes	94.80	33.2%		IIe	69
G680B	Barnes-Sioux complex, 1 to 6 percent slopes	13.89	4.9%		IIe	63
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	5.02	1.8%		IIe	77
					Weighted Average	65.8

10D. LAND APPLICATION EASEMENTS

Land application easements for nutrient application are attached.

MANURE SPREADING AGREEMENT

I, JOSEPH J. HARBEKE (Property Owner's Name) owning fields with the following legal descriptions and approximate acres:

- Legal Description NE ¼ 14-139-55 Approximate Acres: 157.68
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____

These fields located in Cass County do hereby give Rolling Green Sow Farm permission to apply effluent and/ or solids to the above listed acreage as fertilizer. The acreage will be used for raising _____. The application rate of effluent and/or solids from the Rolling Green Sow Farm will not exceed the crop's nutrient needs in a 12-month period and will be in accordance with good farming practices.

This agreement is for 15 years and shall be renewed automatically for the same amount of time specified above, unless written notification of said parties' intent to not renew the Agreement is received by Registered Mail at least one Hundred Eighty (180) days in advance of the expiration of this Agreement. If the above property is to be sold or disposed of by the Property Owner or his Estate, that his Easement be an attached Condition of Sale and Above terms will stay in effect with the new Property Owner.

SIGNED:

Property Owner Joseph J. Harbeke (Signature) JOSEPH J. HARBEKE (Print Name)

Facility Owner: _____ (Signature) _____ (Print Name)

MANURE SPREADING AGREEMENT

I, Randal Melvin (Property Owner's Name) owning fields with the following legal descriptions and approximate acres:

- Legal Description 11-140-55 Approximate Acres: 500
- Legal Description NE¼ 2-139-55 Approximate Acres: 150
- Legal Description E½ 4-139.54 Approximate Acres: 300.68
- Legal Description S½ SE¼ 11-139-55 Approximate Acres: 60
- Legal Description NW¼ 12-139-55 Approximate Acres: 120
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____

These fields located in Cass County do hereby give Rolling Green Sow Farm permission to apply effluent and/ or solids to the above listed acreage as fertilizer. The acreage will be used for raising _____. The application rate of effluent and/or solids from the Rolling Green Sow Farm will not exceed the crop's nutrient needs in a 12-month period and will be in accordance with good farming practices.

This agreement is for 15 years and shall be renewed automatically for the same amount of time specified above, unless written notification of said parties' intent to not renew the Agreement is received by Registered Mail at least one Hundred Eighty (180) days in advance of the expiration of this Agreement. If the above property is to be sold or disposed of by the Property Owner or his Estate, that his Easement be an attached Condition of Sale and Above terms will stay in effect with the new Property Owner.

SIGNED:

Property Owner _____ (Signature) Randal Melvin (Print Name)

Facility Owner: _____ (Signature) _____ (Print Name)

MANURE SPREADING AGREEMENT

I, Tim Berntson (Property Owner's Name) owning fields with the following legal descriptions and approximate acres:

- Legal Description section 29 140-54 Approximate Acres: 550
- Legal Description NE ¼ sec. 32 140-54 Approximate Acres: 155
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____

These fields located in Cass County do hereby give Rolling Green Sow Farm permission to apply effluent and/ or solids to the above listed acreage as fertilizer. The acreage will be used for raising Corn/soybean. The application rate of effluent and/or solids from the Rolling Green Sow Farm will not exceed the crop's nutrient needs in a 12-month period and will be in accordance with good farming practices.

This agreement is for 15 years and shall be renewed automatically for the same amount of time specified above, unless written notification of said parties' intent to not renew the Agreement is received by Registered Mail at least one Hundred Eighty (180) days in advance of the expiration of this Agreement. If the above property is to be sold or disposed of by the Property Owner or his Estate, that his Easement be an attached Condition of Sale and Above terms will stay in effect with the new Property Owner.

SIGNED:

Property Owner _____ Timothy M. Berntson
Signature Print Name

Facility Owner: _____ _____
Signature Print Name

MANURE SPREADING AGREEMENT

I, Melvin Family RE LLP (Property Owner's Name) owning fields with the following legal descriptions and approximate acres:

- Legal Description NW ¼ 4-139-54 Approximate Acres: 150
- Legal Description E ½ 9-139-54 Approximate Acres: 284.92
- Legal Description N ½ 36-140-55 Approximate Acres: 293
- Legal Description W ½ SW ¼ 12-139-55 Approximate Acres: 78
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____

These fields located in Cass County do hereby give Rolling Green Sow Farm permission to apply effluent and/ or solids to the above listed acreage as fertilizer. The acreage will be used for raising _____. The application rate of effluent and/or solids from the Rolling Green Sow Farm will not exceed the crop's nutrient needs in a 12-month period and will be in accordance with good farming practices.

This agreement is for 15 years and shall be renewed automatically for the same amount of time specified above, unless written notification of said parties' intent to not renew the Agreement is received by Registered Mail at least one Hundred Eighty (180) days in advance of the expiration of this Agreement. If the above property is to be sold or disposed of by the Property Owner or his Estate, that his Easement be an attached Condition of Sale and Above terms will stay in effect with the new Property Owner.

SIGNED:

Property Owner Gerald Melvin — Signature

Gerald Melvin — Print Name

Facility Owner: _____ — Signature

_____ — Print Name

MANURE SPREADING AGREEMENT

I, Jonathan Melvin (Property Owner's Name) owning fields with the following legal descriptions and approximate acres:

- Legal Description SE ¼ 10 - 140 - 55 Approximate Acres: 158
- Legal Description NW ¼ 14 - 140 - 55 Approximate Acres: 113.98
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____

These fields located in Cass County do hereby give Rolling Green Sow Farm permission to apply effluent and/ or solids to the above listed acreage as fertilizer. The acreage will be used for raising _____. The application rate of effluent and/or solids from the Rolling Green Sow Farm will not exceed the crop's nutrient needs in a 12-month period and will be in accordance with good farming practices.

This agreement is for 15 years and shall be renewed automatically for the same amount of time specified above, unless written notification of said parties' intent to not renew the Agreement is received by Registered Mail at least one Hundred Eighty (180) days in advance of the expiration of this Agreement. If the above property is to be sold or disposed of by the Property Owner or his Estate, that his Easement be an attached Condition of Sale and Above terms will stay in effect with the new Property Owner.

SIGNED:

Property Owner Jonathan Melvin / Jonathan Melvin
Signature / Print Name

Facility Owner: _____ / _____
Signature / Print Name

MANURE SPREADING AGREEMENT

I, Eldwyn Van Bruggen (Property Owner's Name) owning fields with the following legal descriptions and approximate acres:

- Legal Description E ½ 32 - 139 - 54 Approximate Acres: 308.84
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____

These fields located in Cass County do hereby give Rolling Green Sow Farm permission to apply effluent and/ or solids to the above listed acreage as fertilizer. The acreage will be used for raising _____. The application rate of effluent and/or solids from the Rolling Green Sow Farm will not exceed the crop's nutrient needs in a 12-month period and will be in accordance with good farming practices.

This agreement is for 15 years and shall be renewed automatically for the same amount of time specified above, unless written notification of said parties' intent to not renew the Agreement is received by Registered Mail at least one Hundred Eighty (180) days in advance of the expiration of this Agreement. If the above property is to be sold or disposed of by the Property Owner or his Estate, that his Easement be an attached Condition of Sale and Above terms will stay in effect with the new Property Owner.

SIGNED:

Property Owner Eldwyn Van Bruggen EldwyN VAN BRUGGEN
Signature Print Name

Facility Owner: _____ Barry R. Kirkeide
Signature Print Name

10.E. LAND APPLICATION SOIL TESTS AND SOIL TESTING PROCEDURES

1. Soil Testing Procedure, Bulletin SF-990

2. Land Application Soil Tests

1. Soil Testing Procedures

Soil samples shall be collected and prepared according to North Dakota State University Extension Service guidance contained in Publication SF 990, Soil Sampling for Fertilizer Recommendations as shown on the next page.

Avoid taking soil test sample within 9 months after a manure application.

Soil testing shall include analysis for any nutrients for which specific information is needed to develop the nutrient plan. Request analyses pertinent to monitoring or amending the annual nutrient budget, e.g. pH, electrical conductivity (EC), soil organic matter, nitrogen, phosphorus, and potassium.

The minimum analysis for North Dakota is to include: pH, electrical conductivity (EC), soil organic matter, nitrogen, phosphorus, and potassium.

Soil Sampling as a Basis for Fertilizer Application

SF-990 (Revised) August 1998

D.W. Franzen, Soil Specialist, NDSU Extension Service
L.J. Cihacek, Associate Professor, Soil Science, Director, NDSU Soil and Water Laboratory

Index

Importance of Soil Sampling
Depth of Sampling
Sampling Tools
Soil Sample Handling
Soil Sample Collecting, Where and How
Summary

The accuracy of a soil test result is influenced by the laboratory analysis but may be influenced even more by the quality of the soil sample.

Importance of Soil Sampling

Soil tests measure the relative nutrient status of soils and are used as a basis for profitable and environmentally responsible fertilizer application. The accuracy of a soil test result is influenced by the laboratory analysis but may be influenced even more by the quality of the soil sample. Sample collection is extremely important in the accuracy and repeatability of a soil test. Sample handling following collection is also important. A soil sample which does not represent the area being sampled will be misleading and result in over or under-application of fertilizer. It is therefore very important to collect and handle soil samples properly.

There have been several changes in field sampling methods since the last revision of this circular. This revision will help direct soil samplers in methods for determining a composite soil test, but will also introduce site-specific methods for revealing within-field nutrient levels. The challenge has been to provide meaningful information about field and within field nutrient levels with minimal costs to the producer.

When to sample

Soil samples to be analyzed for soil pH, salt content, zinc (Zn) and phosphorus (P) can be taken nearly any time of year. Potassium (K) values from samples taken in frozen soil may test high compared to other times of the year. Sulfur (S) and chloride (Cl) are mobile in the soil, so sampling in the fall or spring is recommended.

Most soil samples in North Dakota are taken for nitrate-nitrogen (NO_3-N) analysis. When samples are collected in the fall before September 15, a sampling date adjustment (SDA) should be used to compensate for additional N releases anticipated from soil organic matter and previous crop residue decomposition. Soil samples for NO_3-N may be taken without sampling date adjustment after September 15. After this date, most additional N releases from soil micro-biological activity are low. Soil samples may be taken for NO_3-N as early as August 1. The SDA adds one-half pound of NO_3-N to the soil test analysis for each day the sample is collected prior to September 15 (Table 1).

Table 1. Sampling date adjustments if soil samples are

taken in the fall prior to September 15.

Date of sampling	Sampling date adjustment
	lb NO_3-N/acre
August 1	23
August 15	15
August 30	8
September 5	5
September 15	0

Producers should not be reluctant to sample in early August following small grain harvest because of fear of greater N release from organic matter and residues compared to late fall sampling. If yields were relatively high, the SDA adjustment represents potential N release well. Sampling fields before tillage also increases the reliability of the 0-6 inch soil core depth because of more uniform soil conditions compared to tilled fields. Waiting to sample small grain fields until late fall increases the risk of N uptake by small grain regrowth, which may contain up to 100 lb N/acre. Sampling standing row crops for NO_3-N is not recommended.

Fall soil sampling results for NO_3-N and S are similar in most years to spring sampling. However, warmer than normal winters followed by an early spring combined with good soil moisture could increase NO_3-N and S levels through organic matter and residue mineralization. Green sugarbeet leaves or other crop residues with relatively high N content may also contribute to early mineralization and increase spring NO_3-N levels compared to a fall soil sampling. In sandy soils with high rainfall or snow-melt following a fall sampling, levels of NO_3-N and S in the spring compared to a fall sampling may decrease as nitrate and sulfate is leached out of the sampling zone. In most situations, however, fall sampling is a good guide to N and S application.

Depth of Sampling

Soil sampling and analysis assumes 2,000,000 lb/acre of soil from 0-6 inches in depth. This weight per unit volume (bulk density) assumes a medium soil texture with some compaction typically found following cropping and harvest. Bulk density differences can make a difference of 10% in soil test results. Bulk density is ignored in commercial soil sampling, but consistency in soil sampling techniques is important because of soil bulk density differences, especially in surface cores. The depth of sampling required depends mainly on the nutrient of interest, the crop to be fertilized, and in some cases, the tillage system in place (Figure 1).

Figure 1. Depth recommended generally for soil analysis of certain properties and nitrate analysis for crops.

Soil Surface	Soil Properties	Crops
0-6 inch	pH, P,K, OM, Cl, S, Ca, Mg, CEC, Zn, $NH4^+$-N, Fe, Mn, Cu, soluble salts, NA	Alfalfa, clovers (analyze only 0-6 inch depth, nitrate analysis at deeper depths not necessary).
6-24 inch	Soluble salts, NO_3-N, S, Cl (in addition to 0-6 inch depth)	Wheat, barley, oats, durum, corn, soybean, dry bean, potato, canola, crambe, mustard, sunflower, grass hay, pasture, millet, canary seed, flax, safflower, buckwheat, lentil, field pea,

		sorghum, sudangrass. (Separate 0-24 inch depth into a 0-6 inch and 6-24 inch depth.)
24-48 inch	NO_3-N, in addition to the 0-6 inch and 6-24 inch depths	Sugarbeet, malting barley. (Sunflower if greater than 30 lb N/acre are anticipated at the 24-48 inch depth.) (Separate cores into 0-6 inch, 6-24 inch and 24-48 inch depths.)

Nutrients

For soil pH, P, K, Zn, copper (Cu) and manganese (Mn), sampling the 0-6 inch depth is adequate. In long-term no-till fields, soil pH, P, and K may become stratified. Most studies for P and K suggest that stratification is not important as long as the fertilizer P and K rates based on a 0-6 inch value is followed. However, soil pH may be important in the surface 0-2 inch layer because of possible herbicide interaction with lower pH levels. The 0-6 inch depth is also important for soluble salts, in addition to the 6-24 inch depth.

To determine soil NO_3-N, S and Cl, samples are taken from at least the 0-24 inch depth. The 0-24 inch sample should be broken into a 0-6 inch depth and a 6-24 inch depth, so that the relative position of N in the soil can be determined. In some years, NO_3-N can be leached to lower depths so that large amounts are in the 6-24 inch layer but only a small amount may be left in the 0-6 inch layer. Depending on the crop, soil NO_3-N may need to be determined on the 24-48 inch depth (2-4 foot) also. A few areas within the Red River Valley have a history of poor sugarbeet quality due in part to the presence of especially high levels of soil NO_3-N at deep depths. In these special areas, deep N to 6 feet may also need to be checked.

Crop

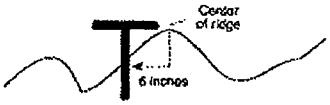
For most crops, NO_3-N should be determined on the 0-24 inch depth. For sugarbeet and malting barley, the 24-48 inch depth should also be sampled to fine-tune N rates necessary to improve beet and grain quality. Sunflower also may use deep N; however, deeper sampling is conducted not to improve quality, but to save money on N fertilizer when there is reason to suspect the presence of large quantities of N at deep depths, such as following years of growing shallow rooted crops, following fallow, and when previous crop yields have been low.

Tillage system

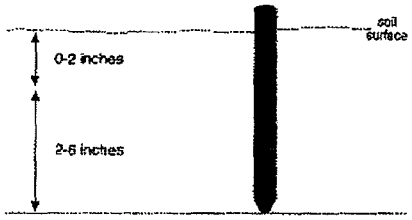
Under conventional tillage and conservation tillage, sampling 0-6 inch, 6-24 inch and the 24-48 inch depths described previously are appropriate. Under long-term no-till, stratification of soil non-mobile nutrients and soil pH will occur. Phosphate and soil pH stratification are common, with high P and lower pH levels at the surface 0-2 inch depth and lower P and higher pH levels at deeper depths. If the lower depths become depleted in P, application of more deeply placed P may be beneficial, especially in drier seasons. Soil pH tends to become acid at the surface, especially if N fertilizers are applied to the surface. Separating the 0-6 inch depth into a 0-2 inch depth and 2-6 inch depth would identify these trends (Figure 2).

Figure 2. Sampling under special tillage conditions.

Ridge till	No till for soil pH and P if stratification from long-term no till is suspected



Sample is obtained straight downwards, 6 inches from the ridge center



The 0-6 inch core is separated into a 0-2 inch and 2-6 inch depth for soil pH and P

Special sampling situations

Ridge-till is occasionally used in North Dakota, but it is a popular tillage system in some areas of the corn-soybean belt. In ridge till, ridges are built by deep cultivation during the growing season and remain in the field following harvest and through the winter. At planting, the top of the ridge is removed, exposing moist soil for seeding, and soil from the top of the ridge is moved into the row middles. Starter fertilizer is often used at planting, and sometimes deep-placed fertilizer is applied right under the ridge-top in the fall. Ridge-till should be sampled 6 inches to either side of the ridge-top and straight down into the ridge (Figure 2).

Fields with a history of large band applications of P and K are special problems, especially where within-field P and K levels are to be determined. When band rates greater than about 30 lb P_2O_5 or K_2O are used, there may be a residual effect of the fertilizer band for several years. If the bands can be located, they should be avoided when sampling. In North Dakota, high reproducibility of P levels has been achieved in grids or zones using eight to 10 soil cores where 20-30 lb P_2O_5 has been applied annually. For sampling whole fields, the 20 cores per field recommendation is appropriate.

| more |

SF-990 (Revised) August 1998

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INFORMATION ACADEMICS RESEARCH EXTENSION PUBLICATIONS CALENDAR WEATHER DIRECTORY

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North Dakota State University Agriculture and University Extension
Dept. 7070, Morrill 7, P.O. Box 6050, Fargo, ND 58108-6050

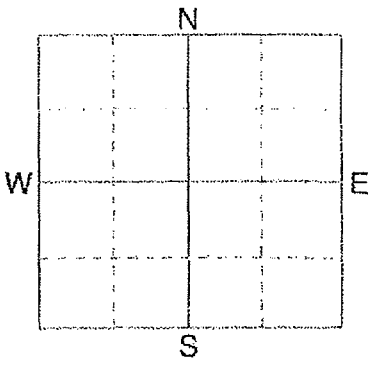
2. Land Application Soil Tests

CENTROL CROP CONSULTING

Soil Analysis by Agvise Laboratories
(http://www.agvise.com)
Northwood: (701) 587-6010
Benson: (320) 843-4109

SOIL TEST REPORT

FIELD ID **9-1**
SAMPLE ID **MGF-9-1**
FIELD NAME **Field 1**
COUNTY **CASS**
TWP **HOWES** RANGE
SECTION **9** QTR **NESE** ACRES **202**
PREV. CROP **Beans-Edible**



SUBMITTED FOR:
MELVIN GRAIN FARMS
3510 139TH AVE SE

BUFFALO, ND 58011

SUBMITTED BY: **OL0549**
MATT OLSON
1230 3RD AVE NW
VALLEY CITY, ND 58072-

REF # **978996** BOX # **0**
LAB # **NW78184**

Date Sampled | Date Received **10/01/2014** | Date Reported **5/12/2015**

Nutrient In The Soil		Interpretation	1st Crop Choice			2nd Crop Choice			3rd Crop Choice		
		Very Low Low Med High	Corn-Grain			Beans-Edible			Soybeans		
			YIELD GOAL			YIELD GOAL			YIELD GOAL		
			140 BU			2000 LBS			40 BU		
			SUGGESTED GUIDELINES			SUGGESTED GUIDELINES			SUGGESTED GUIDELINES		
			Centrol			Centrol			Centrol		
			LB/ACRE		APPLICATION	LB/ACRE		APPLICATION	LB/ACRE		APPLICATION
0-6"	9 lb/ac	*****	N	115		N	50		N	***	
6-24"	15 lb/ac										
0-24"	24 lb/ac		P_2O_5	90	Broadcast	P_2O_5	50	Broadcast	P_2O_5	70	Broadcast
Nitrate			K_2O	20	Broadcast	K_2O	0		K_2O	0	
Olsen	2 ppm	***	Cl			Cl			Cl		
Phosphorus			S	0		S	0		S	0	
Potassium	182 ppm	**********	B			B			B		
Chloride			Zn	4	Broadcast	Zn	4	Broadcast	Zn	1	Broadcast
0-6"	120 +lb/ac	**********	Fe			Fe			Fe		
6-24"	360 +lb/ac	**********	Mn			Mn			Mn		
Sulfur			Cu			Cu			Cu		
Boron			Mg			Mg			Mg		
Zinc	0.39 ppm	*******	Lime			Lime			Lime		
Iron											
Manganese											
Copper											
Magnesium											
Calcium											
Sodium											
Org Matter	3.1 %	*******									
Carbonate(C.C.E)											
0-6"	1.77 mmho/cm	**********									
6-24"	2.04 mmho/cm	**********									
Soil Salts											

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range)				
			% Ca	% Mg	% K	% Na	% H
0-6" 7.9							
6-24" 8.0							

Crop 1: Nitrogen is credited 37.5 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 56 K2O = 38

Crop 2: Nitrogen is credited 25.125 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 28 K2O = 28

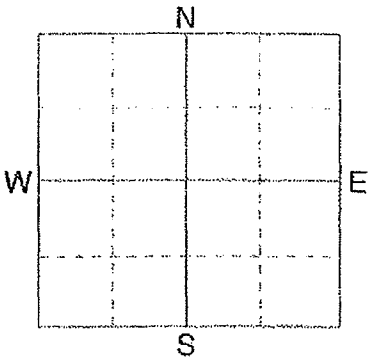
Crop 3: Nitrogen is credited 25.125 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 35 K2O = 60 Soybeans may respond to nitrogen on fields testing less than 60 lb/ac with a limited soybean history.

CENTROL CROP CONSULTING

Soil Analysis by Agvise Laboratories
(http://www.agvise.com)
Northwood: (701) 587-6010
Benson: (320) 843-4109

SOIL TEST REPORT

FIELD ID **9-2**
SAMPLE ID **MGF-9-2**
FIELD NAME **Field 2**
COUNTY **CASS**
TWP **HOWES** RANGE
SECTION **9** QTR **NESE** ACRES **80**
PREV. CROP **Corn-Grain**



SUBMITTED FOR:
MELVIN GRAIN FARMS
3510 139TH AVE SE
BUFFALO, ND 58011

SUBMITTED BY: **OL0549**
MATT OLSON
1230 3RD AVE NW
VALLEY CITY, ND 58072-

REF # **979047** BOX # **0**
LAB # **NW154910**

Date Sampled | Date Received **11/03/2014** | Date Reported **5/12/2015**

Nutrient In The Soil		Interpretation
		Very Low / Low / Med / High
Nitrate	0-6" 14 lb/ac 6-24" 27 lb/ac 0-24" 41 lb/ac	********
Phosphorus	Olsen 2 ppm	***
Potassium	150 ppm	**********
Chloride	0-24" 52 lb/ac	**********
Sulfur	0-6" 120 +lb/ac 6-24" 360 +lb/ac	**********
Boron	1.7 ppm	**********
Zinc	0.23 ppm	*****
Iron	8.4 ppm	**********
Manganese	2.0 ppm	**********
Copper	0.67 ppm	**********
Magnesium	970 ppm	**********
Calcium	10546 ppm	**********
Sodium	101 ppm	**********
Org Matter	3.5 %	**********
Carbonate(CCE)	5.9 %	**********
Soil Salts	0-6" 2.15 mmho/cm 6-24" 2.69 mmho/cm	**********

1st Crop Choice		
Corn-Grain		
YIELD GOAL		
140 BU		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	135	
P_2O_5	90	Broadcast
K_2O	50	Broadcast
Cl		Not Available
S	10	
B	0	
Zn	5	Broadcast
Fe	0	
Mn	0	
Cu	0	
Mg	0	
Lime		

2nd Crop Choice		
Beans-Edible		
YIELD GOAL		
2000 LBS		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	60	
P_2O_5	50	Broadcast
K_2O	30	Broadcast
Cl	0	
S	0	
B	0	
Zn	5	Broadcast
Fe	0	
Mn	0	
Cu	0	
Mg	0	
Lime		

3rd Crop Choice		
Soybeans		
YIELD GOAL		
40 BU		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	***	
P_2O_5	70	Broadcast
K_2O	0	
Cl	0	
S	0	
B	0	
Zn	2	Broadcast
Fe	0	
Mn	0	
Cu	0	
Mg	0	
Lime		

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range)				
			% Ca	% Mg	% K	% Na	% H
0-6" 7.9 6-24" 8.0		61.6 meq	(65-75) 85.5	(15-20) 13.1	(1-7) 0.6	(0-5) 0.7	(0-5)

General Comments: Texture is not estimated on high pH soils.

Crop 1: ** Chloride yield data is limited for this crop. Many crops may respond to a starter application of P & K even on high soil tests. High salt levels may decrease yields in portions of this field. Extra nitrogen is suggested. Crop Removal: P2O5 = 56 K2O = 38

Crop 2: Many crops may respond to a starter application of P & K even on high soil tests. High salt levels may decrease yields in portions of this field. Extra nitrogen is suggested. Crop Removal: P2O5 = 28 K2O = 28

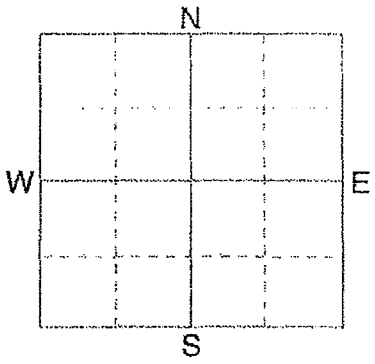
Crop 3: Many crops may respond to a starter application of P & K even on high soil tests. High salt levels may decrease yields in portions of this field. Extra nitrogen is suggested. The risk of the development of iron chlorosis on soybeans on this field is extreme based on the salt and carbonate levels. Crop Removal: P2O5 = 35 K2O = 60 Soybeans may respond to nitrogen on fields testing less than 60 lb/ac with a limited soybean history.

CENTROL CROP CONSULTING

Soil Analysis by Agvise Laboratories
(http://www.agvise.com)
Northwood: (701) 587-6010
Benson: (320) 843-4109

SOIL TEST REPORT

FIELD ID **4-1MGF**
SAMPLE ID **MGF-4-1**
FIELD NAME **Field 3**
COUNTY **CASS**
TWP **HOWES** RANGE
SECTION **4** QTR **NW** ACRES **146**
PREV. CROP **Corn-Grain**



SUBMITTED FOR:
MELVIN GRAIN FARMS
3510 139TH AVE SE
BUFFALO, ND 58011

SUBMITTED BY: **OL0549**
MATT OLSON
1230 3RD AVE NW
VALLEY CITY, ND 58072-

REF # **982498** BOX # **0**
LAB # **NW128184**

Date Sampled | Date Received **10/22/2014** | Date Reported **5/12/2015**

Nutrient In The Soil		Interpretation				1st Crop Choice			2nd Crop Choice			3rd Crop Choice		
		V.L.	Low	Med.	High	Corn-Grain			Beans-Edible			Soybeans		
						YIELD GOAL			YIELD GOAL			YIELD GOAL		
						140 BU			2000 LBS			40 BU		
						SUGGESTED GUIDELINES			SUGGESTED GUIDELINES			SUGGESTED GUIDELINES		
						Centrol			Centrol			Centrol		
						LB/ACRE	APPLICATION		LB/ACRE	APPLICATION		LB/ACRE	APPLICATION	
0-6"	8 lb/ac					N	140		N	65		N	***	
6-24"	27 lb/ac					P_2O_5	85	Broadcast	P_2O_5	50	Broadcast	P_2O_5	65	Broadcast
0-24"	35 lb/ac					K_2O	65	Broadcast	K_2O	35	Broadcast	K_2O	20	Broadcast
Nitrate						Cl			Cl			Cl		
Olsen	3 ppm					S	10		S	0		S	0	
Phosphorus						B			B			B		
Potassium	132 ppm					Zn	5	Broadcast	Zn	5	Broadcast	Zn	2	Broadcast
Chloride						Fe			Fe			Fe		
0-6"	120 +lb/ac					Mn			Mn			Mn		
6-24"	360 +lb/ac					Cu			Cu			Cu		
Sulfur						Mg			Mg			Mg		
Boron						Lime			Lime			Lime		
Zinc	0.30 ppm													
Iron														
Manganese														
Copper														
Magnesium														
Calcium														
Sodium														
Org-Matter	3.0 %													
Carbonate(CCE)														
0-6"	1.53 mmho/cm													
6-24"	2.23 mmho/cm													
Sol. Salts														

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range)				
			% Ca	% Mg	% K	% Na	% H
0-6" 8.0							
6-24 8.2							

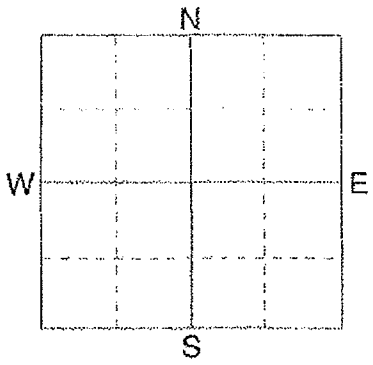
Crop 1: Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 56 K2O = 38
Crop 2: Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 28 K2O = 28
Crop 3: Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 35 K2O = 60 Soybeans may respond to nitrogen on fields testing less than 60 lb/ac with a limited soybean history.

CENTROL CROP CONSULTING

Soil Analysis by Agvise Laboratories
(http://www.agvise.com)
Northwood: (701) 587-6010
Benson: (320) 843-4109

SOIL TEST REPORT

FIELD ID **36-1**
SAMPLE ID **MGF-36-1**
FIELD NAME **Field 4**
COUNTY **CASS**
TWP **TOWER** RANGE
SECTION **36** QTR **NW** ACRES **35**
PREV. CROP **Beans-Edible**



SUBMITTED FOR:
MELVIN GRAIN FARMS
3510 139TH AVE SE
BUFFALO, ND 58011

SUBMITTED BY: **OL0549**
MATT OLSON
1230 3RD AVE NW
VALLEY CITY, ND 58072-

REF # **978994** BOX # **0**
LAB # **NW84685**

Date Sampled

Date Received **10/04/2014**

Date Reported **5/12/2015**

Nutrient In The Soil		Interpretation
		Very Low / Low / Med / High
Nitrate	0-6" 12 lb/ac 6-24" 15 lb/ac 0-24" 27 lb/ac	*****
Phosphorus	Olsen 6 ppm	**********
Potassium	176 ppm	**********
Chloride		
Sulfur	0-6" 120 +lb/ac 6-24" 360 +lb/ac	**********
Boron		
Zinc	0.49 ppm	**********
Iron		
Manganese		
Copper		
Magnesium		
Calcium		
Sodium		
Org.Matter	3.1 %	**********
Carbonate(CCE)		
Soil Salts	0-6" 0.66 mmho/cm 6-24" 0.92 mmho/cm	**********

1st Crop Choice		
Corn-Grain		
YIELD GOAL		
140 BU		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	110	
P_2O_5	70	Broadcast
K_2O	25	Broadcast
Cl		
S	0	
B		
Zn	4	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

2nd Crop Choice		
Beans-Edible		
YIELD GOAL		
2000 LBS		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	50	
P_2O_5	45	Broadcast
K_2O	0	
Cl		
S	0	
B		
Zn	4	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

3rd Crop Choice		
Soybeans		
YIELD GOAL		
40 BU		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	***	
P_2O_5	50	Broadcast
K_2O	0	
Cl		
S	0	
B		
Zn	1	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range)				
			% Ca	% Mg	% K	% Na	% H
0-6" 7.7 6-24" 8.0							

Crop 1: Nitrogen is credited 37.5 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 56 K2O = 38

Crop 2: Nitrogen is credited 25.125 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 28 K2O = 28

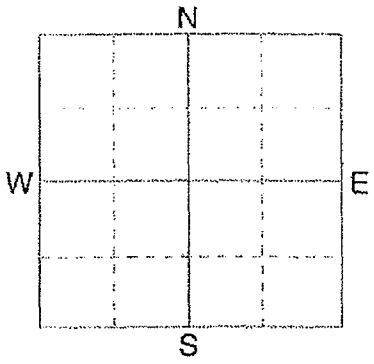
Crop 3: Nitrogen is credited 25.125 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 35 K2O = 60 Soybeans may respond to nitrogen on fields testing less than 60 lb/ac with a limited soybean history.

CENTROL CROP CONSULTING

Soil Analysis by Agvise Laboratories
(http://www.agvise.com)
Northwood: (701) 587-6010
Benson: (320) 843-4109

SOIL TEST REPORT

FIELD ID **36-2**
SAMPLE ID **MGF-36-2**
FIELD NAME **Field 5**
COUNTY **CASS**
TWP **TOWER** RANGE
SECTION **36** QTR **NW** ACRES **250.3**
PREV. CROP **Corn-Grain**



SUBMITTED FOR:
MELVIN GRAIN FARMS
3510 139TH AVE SE
BUFFALO, ND 58011

SUBMITTED BY: **OL0549**
MATT OLSON
1230 3RD AVE NW
VALLEY CITY, ND 58072-

REF # **979043** BOX # **0**
LAB # **NW150276**

Date Sampled | Date Received **10/31/2014** | Date Reported **5/12/2015**

Nutrient In The Soil		Interpretation (Very Low / Low / Med / High)
Nitrate	0-6" 12 lb/ac 6-24" 9 lb/ac 0-24" 21 lb/ac	****
Phosphorus	Olsen 7 ppm	**********
Potassium	221 ppm	**********
Chloride		
Sulfur	0-6" 120 +lb/ac 6-24" 360 +lb/ac	**********
Boron		
Zinc	0.63 ppm	**********
Iron		
Manganese		
Copper		
Magnesium		
Calcium		
Sodium		
Org Matter	3.2 %	**********
Carbonate(CCE)		
Soil Salts	0-6" 0.59 mmho/cm 6-24" 1.04 mmho/cm	**********

1st Crop Choice		
Corn-Grain		
YIELD GOAL		
140 BU		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	155	
P_2O_5	65	Broadcast
K_2O	0	
Cl		
S	10	
B		
Zn	3	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

2nd Crop Choice		
Beans-Edible		
YIELD GOAL		
2000 LBS		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	80	
P_2O_5	40	Broadcast
K_2O	0	
Cl		
S	0	
B		
Zn	3	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

3rd Crop Choice		
Soybeans		
YIELD GOAL		
40 BU		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	***	
P_2O_5	45	Broadcast
K_2O	0	
Cl		
S	0	
B		
Zn	1	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range)				
			% Ca	% Mg	% K	% Na	% H
0-6" 7.7 6-24" 8.1							

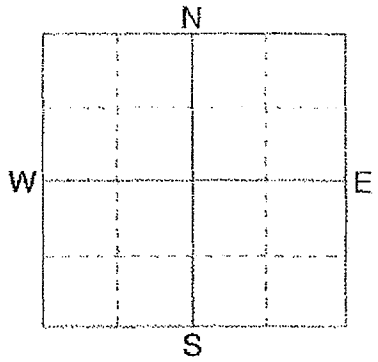
Crop 1: Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 56 K2O = 38
Crop 2: Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 28 K2O = 28
Crop 3: Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 35 K2O = 60 Soybeans may respond to nitrogen on fields testing less than 60 lb/ac with a limited soybean history.

CENTROL CROP CONSULTING

Soil Analysis by Agvise Laboratories
(http://www.agvise.com)
Northwood: (701) 587-6010
Benson: (320) 843-4109

SOIL TEST REPORT

FIELD ID **12-1MGF**
SAMPLE ID **MGF-12-1**
FIELD NAME **Field 6**
COUNTY **CASS**
TWP **HILL** RANGE
SECTION **12** QTR **SW** ACRES **139.8**
PREV. CROP **Beans-Edible**



SUBMITTED FOR:
MELVIN GRAIN FARMS
3510 139TH AVE SE
BUFFALO, ND 58011

SUBMITTED BY: **OL0549**
MATT OLSON
1230 3RD AVE NW
VALLEY CITY, ND 58072-

REF # **978995** BOX # **0**
LAB # **NW67290**

Date Sampled | Date Received **09/24/2014** | Date Reported **5/12/2015**

Nutrient In The Soil		Interpretation
		Very Low / Low / Med / High
Nitrate	0-6" 10 lb/ac 6-24" 18 lb/ac 0-24" 28 lb/ac	******
Phosphorus	Olsen 4 ppm	******
Potassium	166 ppm	**********
Chloride		
Sulfur	0-6" 120 +lb/ac 6-24" 360 +lb/ac	**********
Boron		
Zinc	0.35 ppm	******
Iron		
Manganese		
Copper		
Magnesium		
Calcium		
Sodium		
Org.Matter	2.3 %	********
Carbonate(CCE)		
Soil Salts	0-6" 0.81 mmho/cm 6-24" 1.54 mmho/cm	**********

1st Crop Choice		
Corn-Grain		
YIELD GOAL		
140 BU		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	110	
P_2O_5	80	Broadcast
K_2O	35	Broadcast
Cl		
S	0	
B		
Zn	4	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

2nd Crop Choice		
Beans-Edible		
YIELD GOAL		
2000 LBS		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	45	
P_2O_5	50	Broadcast
K_2O	20	Broadcast
Cl		
S	0	
B		
Zn	4	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

3rd Crop Choice		
Soybeans		
YIELD GOAL		
40 BU		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	***	
P_2O_5	60	Broadcast
K_2O	0	
Cl		
S	0	
B		
Zn	1	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range)				
			% Ca	% Mg	% K	% Na	% H
0-6" 7.9 6-24" 8.2							

Crop 1: Nitrogen is credited 37.5 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 56 K2O = 38

Crop 2: Nitrogen is credited 25.125 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 28 K2O = 28

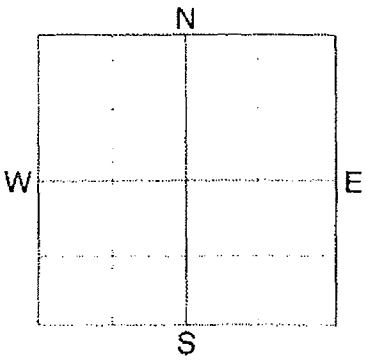
Crop 3: Nitrogen is credited 25.125 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 35 K2O = 60 Soybeans may respond to nitrogen on fields testing less than 60 lb/ac with a limited soybean history.

CENTROL CROP CONSULTING

Soil Analysis by Agvise Laboratories
(http://www.agvise.com)
Northwood: (701) 587-6010
Benson: (320) 843-4109

SOIL TEST REPORT

FIELD ID **32-1**
SAMPLE ID **MVB-32-1**
FIELD NAME **Fields 7&8**
COUNTY **CASS**
TWP **HOWES** RANGE
SECTION **32** QTR **NE** ACRES **154**
PREV. CROP **Beans-Edible**



SUBMITTED FOR:
MELVIN VAN BRUGGEN
3510 139TH AVE SE
BUFFALO, ND 58011

SUBMITTED BY: **OL0549**
MATT OLSON
1230 3RD AVE NW
VALLEY CITY, ND 58072-

REF # **978427** BOX # **0**
LAB # **NW62457**

Date Sampled | Date Received **09/20/2014** | Date Reported **5/12/2015**

Nutrient In The Soil		Interpretation
		Very Low / Low / Med / High
Nitrate 0-6"	16 lb/ac	
Nitrate 6-24"	21 lb/ac	
Nitrate 0-24"	37 lb/ac	
Phosphorus Olsen	6 ppm	
Potassium	278 ppm	
Chloride		
Sulfur 0-6"	120 +lb/ac	
Sulfur 6-24"	360 +lb/ac	
Boron		
Zinc	0.68 ppm	
Iron		
Manganese		
Copper		
Magnesium		
Calcium		
Sodium		
Org.Matter	4.4 %	
Carbonate(CCE)		
Sol. Salts 0-6"	0.8 mmho/cm	
Sol. Salts 6-24"	1.83 mmho/cm	

1st Crop Choice		
Corn-Grain		
YIELD GOAL		
140 BU		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	100	
P_2O_5	70	Broadcast
K_2O	0	
Cl		
S	0	
B		
Zn	3	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

2nd Crop Choice		
Wheat-Spring		
YIELD GOAL		
60 BU		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	85	
P_2O_5	55	Broadcast
K_2O	0	
Cl		
S	0	
B		
Zn	0	
Fe		
Mn		
Cu		
Mg		
Lime		

3rd Crop Choice		
Soybeans		
YIELD GOAL		
40 BU		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	***	
P_2O_5	50	Broadcast
K_2O	0	
Cl		
S	0	
B		
Zn	1	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range)				
			% Ca	% Mg	% K	% Na	% H
0-6" 8.0 6-24" 8.1							

Crop 1: Nitrogen is credited 37.5 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 56 K2O = 38

Crop 2: Nitrogen is credited 25,125 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 38 K2O = 23

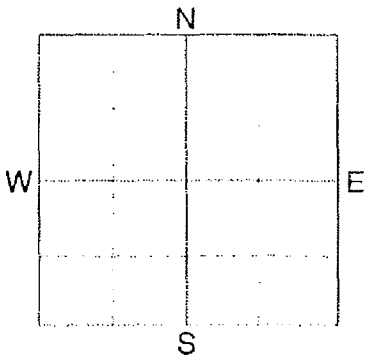
Crop 3: Nitrogen is credited 25,125 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 35 K2O = 60 Soybeans may respond to nitrogen on fields testing less than 60 lb/ac with a limited soybean history.

CENTROL CROP CONSULTING

Soil Analysis by Agvise Laboratories
(http://www.agvise.com)
Northwood: (701) 587-6010
Benson: (320) 843-4109

SOIL TEST REPORT

FIELD ID **32-2**
SAMPLE ID **MVB-32-2**
FIELD NAME **Field 9**
COUNTY **CASS**
TWP **HOWES** RANGE
SECTION **32** QTR **NW** ACRES **157.1**
PREV. CROP **Corn-Grain**



SUBMITTED FOR:
MELVIN VAN BRUGGEN
3510 139TH AVE SE
BUFFALO, ND 58011

SUBMITTED BY: **OL0549**
MATT OLSON
1230 3RD AVE NW
VALLEY CITY, ND 58072-

REF # **982508** BOX # **0**
LAB # **NW122937**

Date Sampled | Date Received **10/20/2014** | Date Reported **5/12/2015**

Nutrient In The Soil		Interpretation (Low / Med / High)
Nitrate 0-6"	12 lb/ac	
Nitrate 6-24"	33 lb/ac	
Nitrate 0-24"	45 lb/ac	
Phosphorus Olsen	5 ppm	
Potassium	238 ppm	
Chloride		
Sulfur 0-6"	120 +lb/ac	
Sulfur 6-24"	360 +lb/ac	
Boron		
Zinc	0.36 ppm	
Iron		
Manganese		
Copper		
Magnesium		
Calcium		
Sodium		
Org.Matter	3.3 %	
Carbonate(CCE)		
Sol. Salts 0-6"	2.12 mmho/cm	
Sol. Salts 6-24"	2.56 mmho/cm	

1st Crop Choice		
Corn-Grain		
YIELD GOAL		
140 BU		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	130	
P_2O_5	75	Broadcast
K_2O	0	
Cl		
S	10	
B		
Zn	4	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

2nd Crop Choice		
Beans-Edible		
YIELD GOAL		
2000 LBS		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	55	
P_2O_5	45	Broadcast
K_2O	0	
Cl		
S	0	
B		
Zn	4	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

3rd Crop Choice		
Soybeans		
YIELD GOAL		
40 BU		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	***	
P_2O_5	55	Broadcast
K_2O	0	
Cl		
S	0	
B		
Zn	1	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range)				
			% Ca	% Mg	% K	% Na	% H
0-6" 7.9 6-24" 8.1							

Crop 1: Many crops may respond to a starter application of P & K even on high soil tests. High salt levels may decrease yields in portions of this field. Extra nitrogen is suggested. Crop Removal: P2O5 = 56 K2O = 38

Crop 2: Many crops may respond to a starter application of P & K even on high soil tests. High salt levels may decrease yields in portions of this field. Extra nitrogen is suggested. Crop Removal: P2O5 = 28 K2O = 28

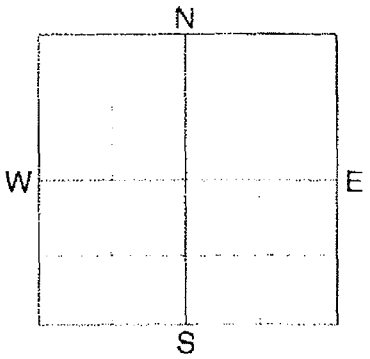
Crop 3: Many crops may respond to a starter application of P & K even on high soil tests. High salt levels may decrease yields in portions of this field. Extra nitrogen is suggested. Crop Removal: P2O5 = 35 K2O = 60 Soybeans may respond to nitrogen on fields testing less than 60 lb/ac with a limited soybean history.

CENTROL CROP CONSULTING

Soil Analysis by Agvise Laboratories
(http://www.agvise.com)
Northwood: (701) 587-6010
Benson: (320) 843-4109

SOIL TEST REPORT

FIELD ID **14-1**
SAMPLE ID **RAM-14-1**
FIELD NAME **Field 10**
COUNTY **CASS**
TWP **HILL** RANGE
SECTION **14** QTR **NE** ACRES **94.8**
PREV. CROP **Corn-Grain**



SUBMITTED FOR:
RANDY MELVIN
3510 135TH AVE SE
BUFFALO, ND 58011

SUBMITTED BY: **OL0549**
MATT OLSON
1230 3RD AVE NW
VALLEY CITY, ND 58072-

REF # **979059** BOX # **0**
LAB # **NW162307**

Date Sampled | Date Received **11/06/2014** | Date Reported **5/12/2015**

Nutrient In The Soil		Interpretation (Low / Med / High)
Nitrate	0-6" 19 lb/ac 6-24" 9 lb/ac 0-24" 28 lb/ac	
Phosphorus	Olsen 6 ppm	
Potassium	195 ppm	
Chloride		
Sulfur	0-6" 120 +lb/ac 6-24" 360 +lb/ac	
Boron		
Zinc	0.52 ppm	
Iron		
Manganese		
Copper		
Magnesium		
Calcium		
Sodium		
Org.Matter	4.1 %	
Carbonate(CCE)		
Sol. Salts	0-6" 0.83 mmho/cm 6-24" 1.36 mmho/cm	

1st Crop Choice		
Corn-Grain		
YIELD GOAL		
140 BU		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	145	
P_2O_5	70	Broadcast
K_2O	20	Broadcast
Cl		
S	10	
B		
Zn	4	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

2nd Crop Choice		
Beans-Edible		
YIELD GOAL		
2000 LBS		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	70	
P_2O_5	45	Broadcast
K_2O	0	
Cl		
S	0	
B		
Zn	4	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

3rd Crop Choice		
Soybeans		
YIELD GOAL		
40 BU		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	***	
P_2O_5	50	Broadcast
K_2O	0	
Cl		
S	0	
B		
Zn	1	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range)				
			% Ca	% Mg	% K	% Na	% H
0-6" 7.9 6-24" 8.0							

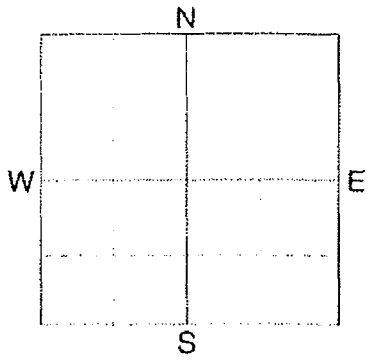
Crop 1: Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 56 K2O = 38
Crop 2: Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 28 K2O = 28
Crop 3: Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 35 K2O = 60 Soybeans may respond to nitrogen on fields testing less than 60 lb/ac with a limited soybean history.

CENTROL CROP CONSULTING

Soil Analysis by Agvise Laboratories
(http://www.agvise.com)
Northwood: (701) 587-6010
Benson: (320) 843-4109

SOIL TEST REPORT

FIELD ID **14-2**
SAMPLE ID **RAM-14-2**
FIELD NAME **Field 10**
COUNTY **CASS**
TWP **HILL** RANGE
SECTION **14** QTR **NE** ACRES **49.2**
PREV. CROP **Corn-Grain**



SUBMITTED FOR:
RANDY MELVIN
3510 135TH AVE SE
BUFFALO, ND 58011

SUBMITTED BY: **OL0549**
MATT OLSON
1230 3RD AVE NW
VALLEY CITY, ND 58072-

REF # **979060** BOX # **0**
LAB # **NW162293**

Date Sampled | Date Received **11/06/2014** | Date Reported **5/12/2015**

Nutrient In The Soil		Interpretation (Low / Med / High)
Nitrate 0-6"	11 lb/ac	
Nitrate 6-24"	9 lb/ac	
Nitrate 0-24"	20 lb/ac	
Phosphorus Olsen	7 ppm	
Potassium	180 ppm	
Chloride		
Sulfur 0-6"	120 +lb/ac	
Sulfur 6-24"	360 +lb/ac	
Boron		
Zinc	0.53 ppm	
Iron		
Manganese		
Copper		
Magnesium		
Calcium		
Sodium		
Org.Matter	4.1 %	
Carbonate(CCE)		
Soil Salts 0-6"	0.58 mmho/cm	
Soil Salts 6-24"	1.22 mmho/cm	

1st Crop Choice		
Corn-Grain		
YIELD GOAL		
140 BU		
SUGGESTED GUIDELINES		
Central		
LB/ACRE		APPLICATION
N	155	
P_2O_5	65	Broadcast
K_2O	25	Broadcast
Cl		
S	10	
B		
Zn	4	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

2nd Crop Choice		
Beans-Edible		
YIELD GOAL		
2000 LBS		
SUGGESTED GUIDELINES		
Central		
LB/ACRE		APPLICATION
N	80	
P_2O_5	40	Broadcast
K_2O	0	
Cl		
S	0	
B		
Zn	4	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

3rd Crop Choice		
Soybeans		
YIELD GOAL		
40 BU		
SUGGESTED GUIDELINES		
Central		
LB/ACRE		APPLICATION
N	***	
P_2O_5	45	Broadcast
K_2O	0	
Cl		
S	0	
B		
Zn	1	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range)				
			% Ca	% Mg	% K	% Na	% H
0-6" 8.0 6-24" 8.1							

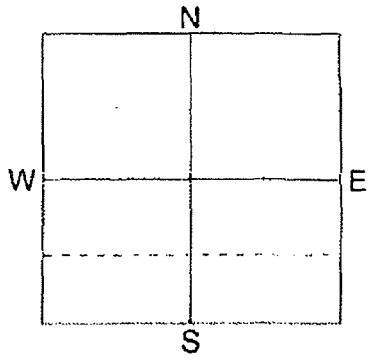
Crop 1: Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 56 K2O = 38
Crop 2: Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 28 K2O = 28
Crop 3: Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 35 K2O = 60 Soybeans may respond to nitrogen on fields testing less than 60 lb/ac with a limited soybean history.

CENTROL
CROP CONSULTING

Soil Analysis by Agvise Laboratories
(http://www.agvise.com)
Northwood: (701) 587-6010
Benson: (320) 843-4109

SOIL TEST REPORT

FIELD ID 10-1
SAMPLE ID MGF-10-1
FIELD NAME Field 11
COUNTY CASS
TWP TOWER RANGE
SECTION 10 QTR SE ACRES 107
PREV. CROP Corn-Grain



SUBMITTED FOR:
MELVIN GRAIN FARMS
3510 139TH AVE SE
BUFFALO, ND 58011

SUBMITTED BY: OL0549
MATT OLSON
1230 3RD AVE NW
VALLEY CITY, ND 58072-

REF # 979016 BOX # 0
LAB # NW148725

Date Sampled | Date Received 10/30/2014 | Date Reported 11/11/2014

Nutrient In The Soil		Interpretation
Nitrate	0-6" 6 lb/ac 6-24" 6 lb/ac 0-24" 12 lb/ac	
Phosphorus	Olsen 19 ppm	
Potassium	383 ppm	
Chloride		
Sulfur	0-6" 120 +lb/ac 6-24" 360 +lb/ac	
Boron		
Zinc	0.67 ppm	
Iron		
Manganese		
Copper		
Magnesium		
Calcium		
Sodium		
Org.Matter	4.0 %	
Carbonate(CCE)		
Sol. Salts	0-6" 0.87 mmho/cm 6-24" 2.07 mmho/cm	

1st Crop Choice		
Corn-Grain		
YIELD GOAL		
140 BU		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	165	
P_2O_5	20	Broadcast
K_2O	0	
Cl		
S	10	
B		
Zn	3	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

2nd Crop Choice		
Beans-Edible		
YIELD GOAL		
2000 LBS		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	90	
P_2O_5	0	
K_2O	0	
Cl		
S	0	
B		
Zn	3	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

3rd Crop Choice		
Soybeans		
YIELD GOAL		
40 BU		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	***	
P_2O_5	0	
K_2O	0	
Cl		
S	0	
B		
Zn	1	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range)				
			% Ca	% Mg	% K	% Na	% H
0-6" 7.9 6-24" 8.2							

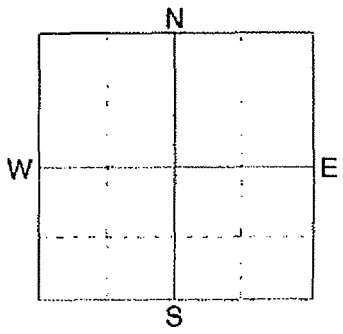
Crop 1: Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 56 K2O = 38
Crop 2: Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 28 K2O = 28
Crop 3: Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 35 K2O = 60 Soybeans may respond to nitrogen on fields testing less than 60 lb/ac with a limited soybean history.

CENTROL
CROP CONSULTING

Soil Analysis by Agvise Laboratories
(http://www.agvise.com)
Northwood: (701) 587-6010
Benson: (320) 843-4109

SOIL TEST REPORT

FIELD ID 14-1MGF
SAMPLE ID MGF-14-1
FIELD NAME Field 12
COUNTY CASS
TWP TOWER RANGE
SECTION 14 QTR NW ACRES 118
PREV. CROP Corn-Grain



SUBMITTED FOR:
MELVIN GRAIN FARMS
3510 139TH AVE SE

BUFFALO, ND 58011

SUBMITTED BY: OL0549
MATT OLSON
1230 3RD AVE NW
VALLEY CITY, ND 58072-

REF # 982497 BOX # 0
LAB # NW140300

Date Sampled
Date Received 10/27/2014
Date Reported 10/27/2014

Nutrient In The Soil		Interpretation			
		Low	Low	Med	High
Nitrate 0-6"	23 lb/ac				
Nitrate 6-24"	21 lb/ac				
Nitrate 0-24"	44 lb/ac				
Phosphorus Olsen	6 ppm				
Potassium	242 ppm				
Chloride					
Sulfur 0-6"	120 +lb/ac				
Sulfur 6-24"	360 +lb/ac				
Boron					
Zinc	0.81 ppm				
Iron					
Manganese					
Copper					
Magnesium					
Calcium					
Sodium					
Org.Matter	4.4 %				
Carbonate(CCE)					
Sol. Salts 0-6"	0.54 mmho/cm				
Sol. Salts 6-24"	1.64 mmho/cm				

1st Crop Choice		
Corn-Grain		
YIELD GOAL		
140 BU		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	130	
P_2O_5	70	Broadcast
K_2O	0	
Cl		
S	10	
B		
Zn	3	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime	0	

2nd Crop Choice		
Beans-Edible		
YIELD GOAL		
2000 LBS		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	55	
P_2O_5	45	Broadcast
K_2O	0	
Cl		
S	0	
B		
Zn	3	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime	0	

3rd Crop Choice		
Soybeans		
YIELD GOAL		
40 BU		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	***	
P_2O_5	50	Broadcast
K_2O	0	
Cl		
S	0	
B		
Zn	1	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime	0	

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range)				
			% Ca	% Mg	% K	% Na	% H
0-6" 6.8 6-24" 7.7							

Crop 1: Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 56 K2O = 38
Crop 2: Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 28 K2O = 28
Crop 3: Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 35 K2O = 60 Soybeans may respond to nitrogen on fields testing less than 60 lb/ac with a limited soybean history.

CENTROL CROP CONSULTING

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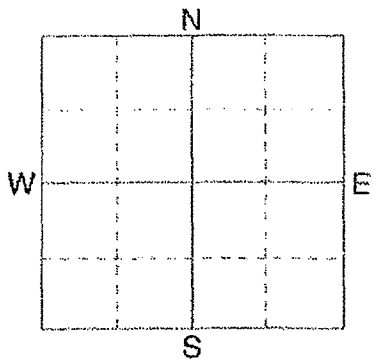
Northwood: (701) 587-6010
Benson: (320) 843-4109

SOIL TEST REPORT

FIELD ID **11-4**
SAMPLE ID **MGF-11-4**
FIELD NAME **Field 13**
COUNTY **CASS**
TWP **TOWER** RANGE
SECTION **11** QTR **SE** ACRES **183.6**
PREV. CROP **Beans-Edible**



SUBMITTED FOR:
MELVIN GRAIN FARMS
3510 139TH AVE SE
BUFFALO, ND 58011

SUBMITTED BY: **OL0549**
MATT OLSON
1230 3RD AVE NW
VALLEY CITY, ND 58072-

REF # **978990** BOX # **0**
LAB # **NW72887**

Date Sampled | Date Received **09/27/2014** | Date Reported **5/12/2015**

Nutrient In The Soil		Interpretation				1st Crop Choice			2nd Crop Choice			3rd Crop Choice		
		Very Low	Low	Med	High	Corn-Grain			Beans-Edible			Soybeans		
						YIELD GOAL			YIELD GOAL			YIELD GOAL		
						140 BU			2000 LBS			40 BU		
						SUGGESTED GUIDELINES			SUGGESTED GUIDELINES			SUGGESTED GUIDELINES		
						Centrol			Centrol			Centrol		
						LB/ACRE	APPLICATION		LB/ACRE	APPLICATION		LB/ACRE	APPLICATION	
0-6"	13 lb/ac					N 105			N 40			N ***		
6-24"	21 lb/ac					P_2O_5 80	Broadcast		P_2O_5 50	Broadcast		P_2O_5 60	Broadcast	
0-24"	34 lb/ac					K_2O 20	Broadcast		K_2O 0			K_2O 0		
Nitrate						Cl			Cl			Cl		
Olsen	4 ppm					S 0			S 0			S 0		
Phosphorus						B			B			B		
Potassium	194 ppm					Zn 3	Broadcast		Zn 3	Broadcast		Zn 1	Broadcast	
Chloride						Fe			Fe			Fe		
0-6"	120 +lb/ac					Mn			Mn			Mn		
6-24"	360 +lb/ac					Cu			Cu			Cu		
Sulfur						Mg			Mg			Mg		
Boron						Lime			Lime			Lime		
Zinc	0.65 ppm													
Iron														
Manganese														
Copper														
Magnesium														
Calcium														
Sodium														
Org.Matter	3.7 %													
Carbonate(CCE)														
0-6"	1.12 mmho/cm													
6-24"	1.81 mmho/cm													
Sol.Salts														

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range)				
			% Ca	% Mg	% K	% Na	% H
0-6" 7.4							
6-24" 8.1							

Crop 1: Nitrogen is credited 37.5 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 56 K2O = 38

Crop 2: Nitrogen is credited 25.125 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 28 K2O = 28

Crop 3: Nitrogen is credited 25.125 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 35 K2O = 60 Soybeans may respond to nitrogen on fields testing less than 60 lb/ac with a limited soybean history.

CENTROL CROP CONSULTING

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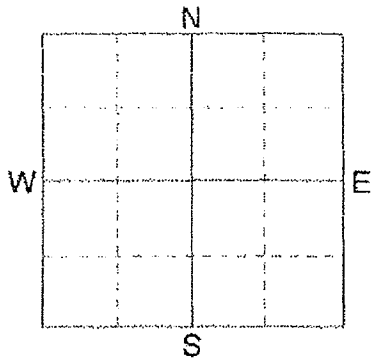
Northwood: (701) 587-6010
Benson: (320) 843-4109

SOIL TEST REPORT

FIELD ID **11-5**
SAMPLE ID **MGF-11-5**
FIELD NAME: **Field 13**
COUNTY **CASS**
TWP **TOWER** RANGE
SECTION **11** QTR **NE** ACRES **202.3**
PREV. CROP **Beans-Edible**



SUBMITTED FOR:
MELVIN GRAIN FARMS
3510 139TH AVE SE

BUFFALO, ND 58011

SUBMITTED BY: **OL0549**
MATT OLSON
1230 3RD AVE NW
VALLEY CITY, ND 58072-

REF # **978989** BOX # **0**
LAB # **NW72910**

Date Sampled | Date Received **09/27/2014** | Date Reported **5/12/2015**

Nutrient In The Soil		Interpretation				1st Crop Choice			2nd Crop Choice			3rd Crop Choice		
		Very Low	Low	Med	High	Corn-Grain			Beans-Edible			Soybeans		
						YIELD GOAL			YIELD GOAL			YIELD GOAL		
						140 BU			2000 LBS			40 BU		
						SUGGESTED GUIDELINES			SUGGESTED GUIDELINES			SUGGESTED GUIDELINES		
						Central			Central			Central		
						LB/ACRE	APPLICATION		LB/ACRE	APPLICATION		LB/ACRE	APPLICATION	
0-6"	16 lb/ac					N 100			N 35			N ***		
6-24"	24 lb/ac					P_2O_5 75	Broadcast		P_2O_5 45	Broadcast		P_2O_5 55	Broadcast	
0-24"	40 lb/ac					K_2O 0			K_2O 0			K_2O 0		
Nitrate						Cl			Cl			Cl		
Olsen	5 ppm					S 0			S 0			S 0		
Phosphorus						B			B			B		
Potassium	218 ppm					Zn 4	Broadcast		Zn 4	Broadcast		Zn 1	Broadcast	
Chloride						Fe			Fe			Fe		
0-6"	120 +lb/ac					Mn			Mn			Mn		
6-24"	360 +lb/ac					Cu			Cu			Cu		
Sulfur						Mg			Mg			Mg		
Boron						Lime			Lime			Lime		
Zinc	0.58 ppm													
Iron														
Manganese														
Copper														
Magnesium														
Calcium														
Sodium														
Org Matter	3.5 %													
Carbonate(COE)														
0-6"	1.12 mmho/cm													
6-24"	1.91 mmho/cm													
Soil Salts														

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range)				
			% Ca	% Mg	% K	% Na	% H
0-6" 7.5							
6-24" 7.9							

Crop 1: Nitrogen is credited 37.5 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 56 K2O = 38

Crop 2: Nitrogen is credited 25.125 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 28 K2O = 28

Crop 3: Nitrogen is credited 25.125 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 35 K2O = 60 Soybeans may respond to nitrogen on fields testing less than 60 lb/ac with a limited soybean history.

CENTROL CROP CONSULTING

Soil Analysis by Agvise Laboratories
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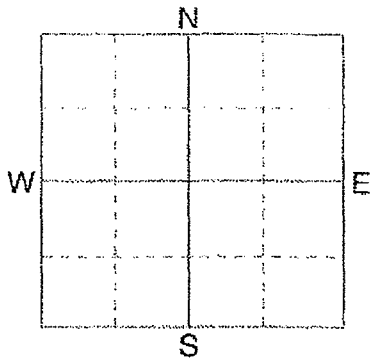
Northwood: (701) 587-6010
Benson: (320) 843-4109

SOIL TEST REPORT

FIELD ID **11-2**
SAMPLE ID **MGF-11-2**
FIELD NAME **Field 14**
COUNTY **CASS**
TWP **TOWER** RANGE
SECTION **11** QTR **SW** ACRES **72.5**
PREV. CROP **Corn-Grain**



SUBMITTED FOR:
MELVIN GRAIN FARMS
3510 139TH AVE SE

BUFFALO, ND 58011

SUBMITTED BY: **OL0549**
MATT OLSON
1230 3RD AVE NW
VALLEY CITY, ND 58072-

REF # **979029** BOX # **0**
LAB # **NW140453**

Date Sampled | Date Received **10/27/2014** | Date Reported **5/12/2015**

Nutrient In The Soil		Interpretation (Very Low / Low / Med / High)
Nitrate	0-6" 16 lb/ac 6-24" 57 lb/ac 0-24" 73 lb/ac	**********
Phosphorus (Olsen)	5 ppm	********
Potassium	174 ppm	**********
Chloride		
Sulfur	0-6" 74 lb/ac 6-24" 360 +lb/ac	**********
Boron		
Zinc	0.49 ppm	**********
Iron		
Manganese		
Copper		
Magnesium		
Calcium		
Sodium		
Org Matter	3.4 %	**********
Carbonate(CCE)		
Soil Salts	0-6" 0.39 mmho/cm 6-24" 1.37 mmho/cm	******** **********

1st Crop Choice		
Corn-Grain		
YIELD GOAL		
140 BU		
SUGGESTED GUIDELINES		
Control		
LB/ACRE		APPLICATION
N	100	
P_2O_5	75	Broadcast
K_2O	30	Broadcast
Cl		
S	10	
B		
Zn	4	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

2nd Crop Choice		
Beans-Edible		
YIELD GOAL		
2000 LBS		
SUGGESTED GUIDELINES		
Control		
LB/ACRE		APPLICATION
N	25	
P_2O_5	45	Broadcast
K_2O	0	
Cl		
S	0	
B		
Zn	4	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

3rd Crop Choice		
Soybeans		
YIELD GOAL		
40 BU		
SUGGESTED GUIDELINES		
Control		
LB/ACRE		APPLICATION
N	***	
P_2O_5	55	Broadcast
K_2O	0	
Cl		
S	0	
B		
Zn	1	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range)				
			% Ca	% Mg	% K	% Na	% H
0-6" 7.5 6-24" 8.1							

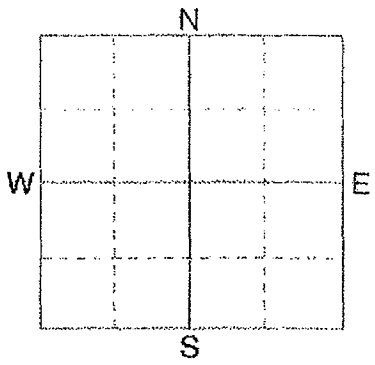
Crop 1: Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 56 K2O = 38
Crop 2: Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 28 K2O = 28
Crop 3: Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 35 K2O = 60

CENTROL
CROP CONSULTING

Soil Analysis by Agvise Laboratories
(http://www.agvise.com)
Northwood: (701) 587-6010
Benson: (320) 843-4109

SOIL TEST REPORT

FIELD ID **11-1MGF**
SAMPLE ID MGF-11-1
Field Name **Field 15**
COUNTY **CASS**
TWP **TOWER** RANGE **W**
SECTION **11** QTR **HALF W** ACRES **85**



SUBMITTED FOR:
MELVIN GRAIN FARMS
3510 139TH AVE SE
BUFFALO, ND 58011

SUBMITTED BY: **OL0549**
MATT OLSON
1230 3RD AVE NW
VALLEY CITY, ND 58072-

REF # **982496** BOX # **0**
LAB # **NW148884**

Date Sampled | Date Received **10/30/2014** | Date Reported **5/12/2015**

Nutrient In The Soil		Interpretation			
		Very L	L-M	Med	High
Nitrate	0-6" 24 lb/ac 6-24" 57 lb/ac 0-24" 81 lb/ac				
Phosphorus	Olsen 8 ppm				
Potassium	239 ppm				
Chloride					
Sulfur	0-6" 120 +lb/ac 6-24" 360 +lb/ac				
Boron					
Zinc	0.84 ppm				
Iron					
Manganese					
Copper					
Magnesium					
Calcium					
Sodium					
Org. Matter	4.6 %				
Carbonate(CCE)					
Sol. Salts	0-6" 1.73 mmho/cm 6-24" 3.17 mmho/cm				

1st Crop Choice			2nd Crop Choice			3rd Crop Choice		
Corn-Grain			Beans-Edible			Soybeans		
YIELD GOAL			YIELD GOAL			YIELD GOAL		
140 BU			2000 LBS			40 BU		
SUGGESTED GUIDELINES			SUGGESTED GUIDELINES			SUGGESTED GUIDELINES		
Centrol			Centrol			Centrol		
	LB/ACRE	APPLICATION		LB/ACRE	APPLICATION		LB/ACRE	APPLICATION
N	95		N	20		N	***	
P_2O_5	60	Broadcast	P_2O_5	40	Broadcast	P_2O_5	40	Broadcast
K_2O	0		K_2O	0		K_2O	0	
Cl			Cl			Cl		
S	10		S	0		S	0	
B			B			B		
Zn	3	Broadcast	Zn	3	Broadcast	Zn	1	Broadcast
Fe			Fe			Fe		
Mn			Mn			Mn		
Cu			Cu			Cu		
Mg			Mg			Mg		
Lime			Lime			Lime		

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range)				
			% Ca	% Mg	% K	% Na	% H
0-6" 7.9 6-24" 8.0							

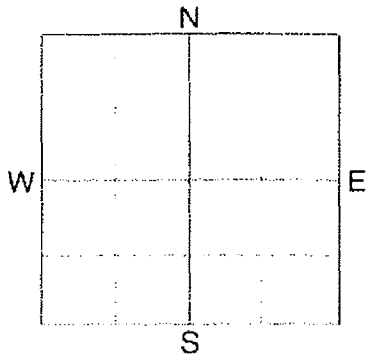
Crop 1: Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 56 K2O = 38
Crop 2: Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 28 K2O = 28
Crop 3: Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 35 K2O = 60

CENTROL CROP CONSULTING

Soil Analysis by Agvise Laboratories
(http://www.agvise.com)
Northwood: (701) 587-6010
Benson: (320) 843-4109

SOIL TEST REPORT

FIELD ID **2-1**
SAMPLE ID **RAM-2-1**
FIELD NAME **Field 16**
COUNTY **CASS**
TWP **HILL** RANGE
SECTION **2** QTR **NE** ACRES **63.7**
PREV. CROP **Corn-Grain**



SUBMITTED FOR:
RANDY MELVIN
3510 135TH AVE SE
BUFFALO, ND 58011

SUBMITTED BY: **OL0549**
MATT OLSON
1230 3RD AVE NW
VALLEY CITY, ND 58072-

REF # **979054** BOX # **0**
LAB # **NW146258**

Date Sampled | Date Received **10/29/2014** | Date Reported **5/12/2015**

Nutrient In The Soil		Interpretation (Low / Med / High)
Nitrate	0-6" 9 lb/ac 6-24" 6 lb/ac 0-24" 15 lb/ac	***
Phosphorus	Olsen 4 ppm	**
Potassium	199 ppm	**
Chloride		
Sulfur	0-6" 106 lb/ac 6-24" 360 +lb/ac	**
Boron		
Zinc	0.38 ppm	*
Iron		
Manganese		
Copper		
Magnesium		
Calcium		
Sodium		
Org.Matter	2.6 %	**
Carbonate(CCE)		
Sol. Salts	0-6" 0.4 mmho/cm 6-24" 1.2 mmho/cm	**

1st Crop Choice		
Corn-Grain		
YIELD GOAL		
140 BU		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	160	
P_2O_5	80	Broadcast
K_2O	20	Broadcast
Cl		
S	10	
B		
Zn	4	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

2nd Crop Choice		
Beans-Edible		
YIELD GOAL		
2000 LBS		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	85	
P_2O_5	50	Broadcast
K_2O	0	
Cl		
S	0	
B		
Zn	4	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

3rd Crop Choice		
Soybeans		
YIELD GOAL		
40 BU		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	***	
P_2O_5	60	Broadcast
K_2O	0	
Cl		
S	0	
B		
Zn	1	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range)				
			% Ca	% Mg	% K	% Na	% H
0-6" 7.8 6-24" 8.2							

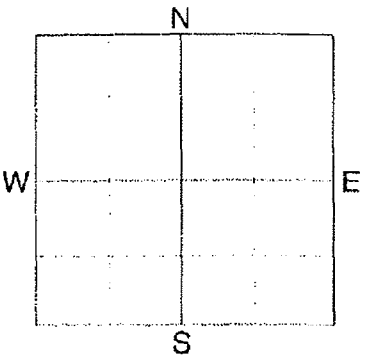
Crop 1: Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 56 K2O = 38
Crop 2: Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 28 K2O = 28
Crop 3: Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 35 K2O = 60 Soybeans may respond to nitrogen on fields testing less than 60 lb/ac with a limited soybean history.

CENTROL CROP CONSULTING

Soil Analysis by Agvise Laboratories
(http://www.agvise.com)
Northwood: (701) 587-6010
Benson: (320) 843-4109

SOIL TEST REPORT

FIELD ID **2-2**
SAMPLE ID **RAM-2-2**
FIELD NAME **Field 17**
COUNTY **CASS**
TWP **HILL** RANGE
SECTION **2** QTR **NE** ACRES **84.6**
PREV. CROP **Beans-Edible**



SUBMITTED FOR:
RANDY MELVIN
3510 135TH AVE SE
BUFFALO, ND 58011

SUBMITTED BY: **OL0549**
MATT OLSON
1230 3RD AVE NW
VALLEY CITY, ND 58072-

REF # **979049** BOX # **0**
LAB # **NW84540**

Date Sampled | Date Received **10/04/2014** | Date Reported **5/12/2015**

Nutrient In The Soil		Interpretation (Low / Med / High)
Nitrate	0-6" 21 lb/ac 6-24" 21 lb/ac 0-24" 42 lb/ac	
Phosphorus	Olsen 8 ppm	
Potassium	239 ppm	
Chloride		
Sulfur	0-6" 84 lb/ac 6-24" 360 +lb/ac	
Boron		
Zinc	0.55 ppm	
Iron		
Manganese		
Copper		
Magnesium		
Calcium		
Sodium		
Org.Matter	3.0 %	
Carbonate(CCE)		
Sol. Salts	0-6" 0.44 mmho/cm 6-24" 1.09 mmho/cm	

1st Crop Choice		
Corn-Grain		
YIELD GOAL		
140 BU		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	95	
P_2O_5	60	Broadcast
K_2O	0	
Cl		
S	0	
B		
Zn	4	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

2nd Crop Choice		
Beans-Edible		
YIELD GOAL		
2000 LBS		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	35	
P_2O_5	40	Broadcast
K_2O	0	
Cl		
S	0	
B		
Zn	4	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

3rd Crop Choice		
Soybeans		
YIELD GOAL		
40 BU		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	***	
P_2O_5	40	Broadcast
K_2O	0	
Cl		
S	0	
B		
Zn	1	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range)				
			% Ca	% Mg	% K	% Na	% H
0-6" 7.6 6-24" 7.8							

Crop 1: Nitrogen is credited 37.5 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 56 K2O = 38

Crop 2: Nitrogen is credited 25.125 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 28 K2O = 28

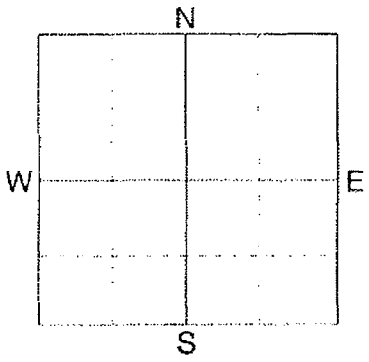
Crop 3: Nitrogen is credited 25.125 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 35 K2O = 60 Soybeans may respond to nitrogen on fields testing less than 60 lb/ac with a limited soybean history.

CENTROL CROP CONSULTING

Soil Analysis by Agvise Laboratories
(http://www.agvise.com)
Northwood: (701) 587-6010
Benson: (320) 843-4109

SOIL TEST REPORT

FIELD ID **4-1**
SAMPLE ID **RAM-4-1**
FIELD NAME **Field 18**
COUNTY **CASS**
TWP **HOWES** RANGE
SECTION **4** QTR **NE** ACRES **155.8**
PREV. CROP **Corn-Grain**



SUBMITTED FOR:
RANDY MELVIN
3510 135TH AVE SE
BUFFALO, ND 58011

SUBMITTED BY: **OL0549**
MATT OLSON
1230 3RD AVE NW
VALLEY CITY, ND 58072-

REF # **979055** BOX # **0**
LAB # **NW155180**

Date Sampled | Date Received **11/03/2014** | Date Reported **5/12/2015**

Nutrient In The Soil		Interpretation (Low / Med / High)
Nitrate	0-6" 16 lb/ac 6-24" 30 lb/ac 0-24" 46 lb/ac	
Phosphorus (Olsen)	4 ppm	
Potassium	196 ppm	
Chloride		
Sulfur	0-6" 120 +lb/ac 6-24" 360 +lb/ac	
Boron		
Zinc	0.37 ppm	
Iron		
Manganese		
Copper		
Magnesium		
Calcium		
Sodium		
Org.Matter	3.7 %	
Carbonate(CCE)		
Sol. Salts	0-6" 1.66 mmho/cm 6-24" 2.32 mmho/cm	

1st Crop Choice		
Corn-Grain		
YIELD GOAL		
140 BU		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	130	
P_2O_5	80	Broadcast
K_2O	20	Broadcast
Cl		
S	10	
B		
Zn	4	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

2nd Crop Choice		
Beans-Edible		
YIELD GOAL		
2000 LBS		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	55	
P_2O_5	50	Broadcast
K_2O	0	
Cl		
S	0	
B		
Zn	4	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

3rd Crop Choice		
Soybeans		
YIELD GOAL		
40 BU		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	***	
P_2O_5	60	Broadcast
K_2O	0	
Cl		
S	0	
B		
Zn	1	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range)				
			% Ca	% Mg	% K	% Na	% H
0-6" 7.9 6-24" 8.1							

Crop 1: Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 56 K2O = 38
Crop 2: Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 28 K2O = 28
Crop 3: Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 35 K2O = 60 Soybeans may respond to nitrogen on fields testing less than 60 lb/ac with a limited soybean history.

CENTROL CROP CONSULTING

Soil Analysis by Agvise Laboratories
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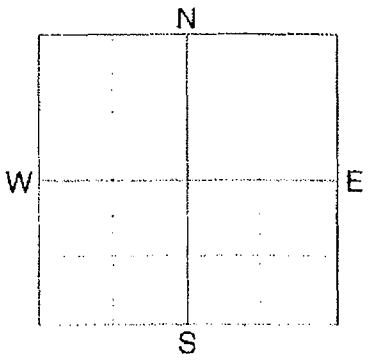
Northwood: (701) 587-6010
Benson: (320) 843-4109

SOIL TEST REPORT

FIELD ID **4-2**
SAMPLE ID **RAM-4-2**
FIELD NAME **Field 19**
COUNTY **CASS**
TWP **HOWES** RANGE
SECTION **4** QTR **EHALF** ACRES **144.8**
PREV. CROP **Beans-Edible**



SUBMITTED FOR:
RANDY MELVIN
3510 135TH AVE SE
BUFFALO, ND 58011

SUBMITTED BY: **OL0549**
MATT OLSON
1230 3RD AVE NW
VALLEY CITY, ND 58072-

REF # **979051** BOX # **0**
LAB # **NW77882**

Date Sampled | Date Received **10/01/2014** | Date Reported **5/12/2015**

Nutrient In The Soil		Interpretation (Low / Med / High)
Nitrate	0-6" 15 lb/ac 6-24" 21 lb/ac 0-24" 36 lb/ac	
Phosphorus	Olsen 10 ppm	
Potassium	231 ppm	
Chloride		
Sulfur	0-6" 120 +lb/ac 6-24" 360 +lb/ac	
Boron		
Zinc	0.75 ppm	
Iron		
Manganese		
Copper		
Magnesium		
Calcium		
Sodium		
Org Matter	3.9 %	
Carbonate(CCE)		
Soil Salts	0-6" 1.74 mmho/cm 6-24" 2.0 mmho/cm	

1st Crop Choice		
Corn-Grain		
YIELD GOAL		
140 BU		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	100	
P_2O_5	50	Broadcast
K_2O	0	
Cl		
S	0	
B		
Zn	3	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

2nd Crop Choice		
Beans-Edible		
YIELD GOAL		
2000 LBS		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	40	
P_2O_5	35	Broadcast
K_2O	0	
Cl		
S	0	
B		
Zn	3	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

3rd Crop Choice		
Soybeans		
YIELD GOAL		
40 BU		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	***	
P_2O_5	30	Broadcast
K_2O	0	
Cl		
S	0	
B		
Zn	1	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range)				
			% Ca	% Mg	% K	% Na	% H
0-6" 7.9 6-24" 8.0							

Crop 1: Nitrogen is credited 37.5 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 56 K2O = 38

Crop 2: Nitrogen is credited 25.125 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 28 K2O = 28

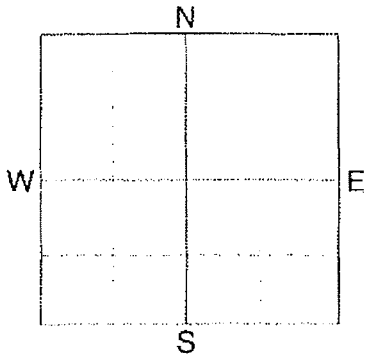
Crop 3: Nitrogen is credited 25.125 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 35 K2O = 60 Soybeans may respond to nitrogen on fields testing less than 60 lb/ac with a limited soybean history.

CENTROL CROP CONSULTING

Soil Analysis by Agvise Laboratories
(http://www.agvise.com)
Northwood: (701) 587-6010
Benson: (320) 843-4109

SOIL TEST REPORT

FIELD ID **11-1**
SAMPLE ID **RAM-11-1**
FIELD NAME **Field 20**
COUNTY **CASS**
TWP **HILL** RANGE
SECTION **11** QTR **SE** ACRES **60.7**
PREV. CROP **Corn-Grain**



SUBMITTED FOR:
RANDY MELVIN
3510 135TH AVE SE
BUFFALO, ND 58011

SUBMITTED BY: **OL0549**
MATT OLSON
1230 3RD AVE NW
VALLEY CITY, ND 58072-

REF # **979057** BOX # **0**
LAB # **NW165338**

Date Sampled | Date Received **11/07/2014** | Date Reported **5/12/2015**

Nutrient In The Soil		Interpretation (Very Low / Low / Med / High)
Nitrate	0-6" 7 lb/ac 6-24" 3 lb/ac 0-24" 10 lb/ac	
Phosphorus	Olsen 3 ppm	
Potassium	170 ppm	
Chloride		
Sulfur	0-6" 120 +lb/ac 6-24" 360 +lb/ac	
Boron		
Zinc	0.50 ppm	
Iron		
Manganese		
Copper		
Magnesium		
Calcium		
Sodium		
Org.Matter	2.7 %	
Carbonate(CCE)		
Sol. Salts	0-6" 1.5 mmho/cm 6-24" 1.82 mmho/cm	

1st Crop Choice		
Corn-Grain		
YIELD GOAL		
140 BU		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	165	
P_2O_5	85	Broadcast
K_2O	30	Broadcast
Cl		
S	10	
B		
Zn	4	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

2nd Crop Choice		
Beans-Edible		
YIELD GOAL		
2000 LBS		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	90	
P_2O_5	50	Broadcast
K_2O	0	
Cl		
S	0	
B		
Zn	4	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

3rd Crop Choice		
Soybeans		
YIELD GOAL		
40 BU		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	***	
P_2O_5	65	Broadcast
K_2O	0	
Cl		
S	0	
B		
Zn	1	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range)				
			% Ca	% Mg	% K	% Na	% H
0-6" 7.8 6-24" 8.1							

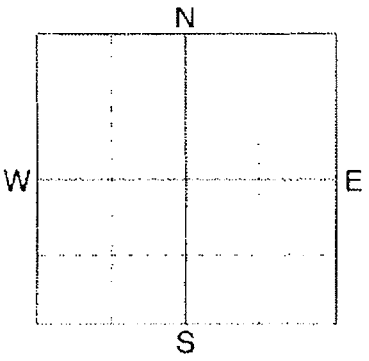
Crop 1: Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 56 K2O = 38
Crop 2: Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 28 K2O = 28
Crop 3: Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 35 K2O = 60 Soybeans may respond to nitrogen on fields testing less than 60 lb/ac with a limited soybean history.

CENTROL CROP CONSULTING

Soil Analysis by Agvise Laboratories
(http://www.agvise.com)
Northwood: (701) 587-6010
Benson: (320) 843-4109

SOIL TEST REPORT

FIELD ID **12-1**
SAMPLE ID **RAM-12-1**
FIELD NAME **Field 21**
COUNTY **CASS**
TWP **HILL** RANGE
SECTION **12** QTR **NW** ACRES **100.1**
PREV. CROP **Beans-Edible**



SUBMITTED FOR:
RANDY MELVIN
3510 135TH AVE SE
BUFFALO, ND 58011

SUBMITTED BY: **OL0549**
MATT OLSON
1230 3RD AVE NW
VALLEY CITY, ND 58072-

REF # **979052** BOX # **0**
LAB # **NW67556**

Date Sampled | Date Received **09/24/2014** | Date Reported **5/12/2015**

Nutrient In The Soil		Interpretation
		Very Low / Low / Med. / High
Nitrate	0-6" 13 lb/ac 6-24" 15 lb/ac 0-24" 28 lb/ac	
Phosphorus	Olsen 4 ppm	
Potassium	166 ppm	
Chloride		
Sulfur	0-6" 120 +lb/ac 6-24" 360 +lb/ac	
Boron		
Zinc	0.23 ppm	
Iron		
Manganese		
Copper		
Magnesium		
Calcium		
Sodium		
Org.Matter	2.2 %	
Carbonate(CCE)		
Sol. Salts	0-6" 2.15 mmho/cm 6-24" 0.81 mmho/cm	

1st Crop Choice		
Corn-Grain		
YIELD GOAL		
140 BU		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	110	
P_2O_5	80	Broadcast
K_2O	35	Broadcast
Cl		
S	0	
B		
Zn	5	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

2nd Crop Choice		
Beans-Edible		
YIELD GOAL		
2000 LBS		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	45	
P_2O_5	50	Broadcast
K_2O	20	Broadcast
Cl		
S	0	
B		
Zn	5	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

3rd Crop Choice		
Soybeans		
YIELD GOAL		
40 BU		
SUGGESTED GUIDELINES		
Centrol		
LB/ACRE		APPLICATION
N	***	
P_2O_5	60	Broadcast
K_2O	0	
Cl		
S	0	
B		
Zn	2	Broadcast
Fe		
Mn		
Cu		
Mg		
Lime		

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range)				
			% Ca	% Mg	% K	% Na	% H
0-6" 7.7 6-24" 8.0							

Crop 1: Nitrogen is credited 37.5 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. High salt levels may decrease yields in portions of this field. Extra nitrogen is suggested. Crop Removal: P2O5 = 56 K2O = 38

Crop 2: Nitrogen is credited 25.125 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. High salt levels may decrease yields in portions of this field. Extra nitrogen is suggested. Crop Removal: P2O5 = 28 K2O = 28

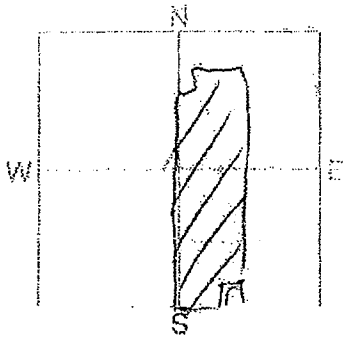
Crop 3: Nitrogen is credited 25.125 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. High salt levels may decrease yields in portions of this field. Extra nitrogen is suggested. Crop Removal: P2O5 = 35 K2O = 60 Soybeans may respond to nitrogen on fields testing less than 60 lb/ac with a limited soybean history.

CENTROL CROP CONSULTING

Soil Analysis by Agvise Laboratories
(http://www.agvise.com)
Northwood: (701) 587-6010
Benson: (320) 843-4109

SOIL TEST REPORT

FIELD ID VINCE W OF FARM
SAMPLE ID TIB-B 29-1
FIELD NAME Field 22
COUNTY CASS
TWP BUFFALO RANGE
SECTION 29 QTR ACRES 278
PREV. CROP Corn-Grain



SUBMITTED FOR:
TIM BERNTSON
3311 142ND AVE SE
BUFFALO, ND 58011

SUBMITTED BY: OL0549
MATT OLSON
1230 3RD AVE NW
VALLEY CITY, ND 58072-

REF # 981729 BOX # 0
LAB # NW128541

Date Sampled | Date Received 10/22/2014 | Date Reported 5/15/2015

[illegible]		[illegible]
	0-6"	18 lb/ac
	6-24"	24 lb/ac
	0-24"	42 lb/ac
[illegible]		
	Olsen	10 ppm
[illegible]		125 ppm
	0-24"	32 lb/ac
[illegible]		
	0-6"	120 +lb/ac
	6-24"	360 +lb/ac
[illegible]		
Boron		1.1 ppm
[illegible]		0.56 ppm
[illegible]		13.1 ppm
[illegible]		4.5 ppm
Copper		0.43 ppm
[illegible]		592 ppm
[illegible]		3994 ppm
[illegible]		37 ppm
[illegible]		3.8 %
[illegible]		1.1 %
	0-6"	0.48 mmho/cm
	6-24"	1.95 mmho/cm
[illegible]		

[illegible] Interpretation

1st Crop Choice			2nd Crop Choice			3rd Crop Choice		
Corn-Grain			Corn-Grain			Soybeans		
YIELD GOAL			YIELD GOAL			YIELD GOAL		
150 BU			170 BU			40 BU		
SUGGESTED GUIDELINES			SUGGESTED GUIDELINES			SUGGESTED GUIDELINES		
Control			Control			Control		
LB/ACRE		APPLICATION	LB/ACRE		APPLICATION	LB/ACRE		APPLICATION
[illegible]	140		[illegible]	155		[illegible]	***	
[illegible]	50	B roadcast	[illegible]	60	B road	[illegible]	30	B roadcast
K_2O	80	B roadcast	K_2O	90	B roadcast	K_2O	25	B roadcast
Cl		Not Available	Cl		Not Available	Cl	0	
S	10		S	10		S	0	
B	0		B	0		B	0	
Zn	4	B roadcast	Zn	5	Broadcast	Zn	1	B roadcast
[illegible]	0		[illegible]	0		[illegible]	0	
[illegible]	0		[illegible]	0		[illegible]	0	
[illegible]	0		[illegible]	0		[illegible]	0	
[illegible]	0		[illegible]	0		[illegible]	0	
[illegible]			[illegible]			[illegible]		

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range)				
			% Ca	% Mg	% K	% Na	% H
0-6" 7.7		25.4 meq	(65-75) 78.7	(15-20) 19.4	(1-7) 1.3	(0-5) 0.6	(0-5)
6-24" 7.9							

General Comments: Texture is not estimated on high pH soils.

Crop 1: * Chloride yield data is limited for this crop. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 60 K2O = 41

Crop 2: ** Chloride yield data is limited for this crop. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 68 K2O = 46

Crop 3: Many crops may respond to a starter application of P & K even on high soil tests. The risk of the development of iron chlorosis on soybeans on this field is low based on the salt and carbonate levels. Crop Removal: P2O5 = 35 K2O = 60 Soybeans may respond to nitrogen on fields testing less than 60 lb/ac with a limited soybean history.

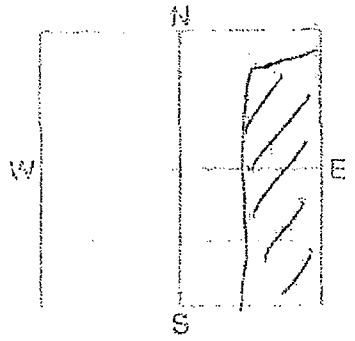
Pasture Ground

CENTROL CROP CONSULTING

Soil Analysis by Agvise Laboratories
(http://www.agvise.com)
Northwood: (701) 587-6010
Benson: (320) 843-4109

SOIL TEST REPORT

FIELD ID **VINCE E OF FARM**
SAMPLE ID **GREENS**
FIELD NAME Fe pl 23
COUNTY **CASS**
TWP **BUFFALO** RANGE
SECTION **29** QTR ACRES **220.6**
PREV. CROP **Soybeans**



SUBMITTED FOR:
TIM BERNTSON
3311 142ND AVE SE
BUFFALO, ND 58011

SUBMITTED BY: **OL0549**
MATT OLSON
1230 3RD AVE NW
VALLEY CITY, ND 58072-

REF # **984859** BOX # **0**
LAB # **NW97073**

Date Sampled | Date Received **10/09/2014** | Date Reported **5/15/2015**

Nutrients In The Soil		Interpretation
		Very Low
0-6"	8 lb/ac	
6-24"	12 lb/ac	
0-24"	20 lb/ac	
Olsen	9 ppm	
Potassium	148 ppm	
Chloride		
0-6"	120 +lb/ac	
6-24"	360 +lb/ac	
Zinc	0.64 ppm	
Organic Matter	4.0 %	
Saturation(CCE)		
0-6"	1.36 mmho/cm	
6-24"	1.33 mmho/cm	

1st Crop Choice			2nd Crop Choice			3rd Crop Choice		
Corn-Grain			Corn-Grain			Corn-Grain		
YIELD GOAL			YIELD GOAL			YIELD GOAL		
130 BU			150 BU			170 BU		
SUGGESTED GUIDELINES			SUGGESTED GUIDELINES			SUGGESTED GUIDELINES		
Centrol			Centrol			Centrol		
LB/ACRE		APPLICATION	LB/ACRE		APPLICATION	LB/ACRE		APPLICATION
N	115		N	130		N	145	
P_2O_5	50	Broadcast	P_2O_5	55	Broadcast	P_2O_5	65	Broadcast
K_2O	50	Broadcast	K_2O	55	Broadcast	K_2O	65	Broadcast
Cl			Cl			Cl		
S	0		S	0		S	0	
B			B			B		
Zn	3	Broadcast	Zn	3	Broadcast	Zn	4	Broadcast
Fe			Fe			Fe		
Mn			Mn			Mn		
Cu			Cu			Cu		
Mg			Mg			Mg		
Lime			Lime			Lime		

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range)				
			% Ca	% Mg	% K	% Na	% H
0-6" 7.6							
6-24" 8.0							

Crop 1: Nitrogen is credited 30 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 52 K2O = 35

Crop 2: Nitrogen is credited 30 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 60 K2O = 41

Crop 3: Nitrogen is credited 30 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 68 K2O = 46

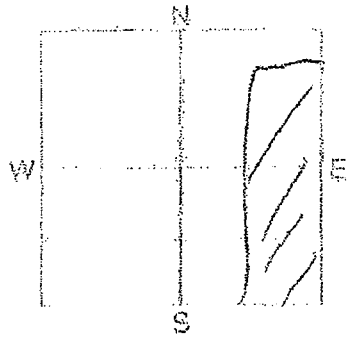
Land Grant

CENTROL
CROP CONSULTING

Soil Analysis by Agvise Laboratories
(http://www.agvise.com)
Northwood: (701) 587-6010
Benson: (320) 843-4109

SOIL TEST REPORT

FIELD ID VINCE E OF FARM
SAMPLE ID RED-ORG LOW5
FIELD NAME Field 23
COUNTY CASS
TWP BUFFALO RANGE
SECTION 29 QTR ACRES 220.6
PREV. CROP Soybeans



SUBMITTED FOR:
TIM BERNTSON
3311 142ND AVE SE
BUFFALO, ND 58011

SUBMITTED BY: OL0549
MATT OLSON
1230 3RD AVE NW
VALLEY CITY, ND 58072-

REF # 984857 BOX # 0
LAB # NW97141

Date Sampled | Date Received 10/09/2014 | Date Reported 5/15/2015

Interpretation for Untested Soil		Interpretation
	0-6" 9 lb/ac 6-24" 18 lb/ac	*****
	0-24" 27 lb/ac	
Olsen	8 ppm	**********
	112 ppm	**********
	0-6" 120 +lb/ac 6-24" 360 +lb/ac	**********
Zinc	0.58 ppm	**********
Organic Matter	3.3 %	**********
	0-6" 1.78 mmho/cm 6-24" 2.12 mmho/cm	**********

1st Crop Choice			2nd Crop Choice			3rd Crop Choice		
Corn-Grain			Corn Grain			Corn Grain		
YIELD GOAL			YIELD GOAL			YIELD GOAL		
130 BU			150 BU			170 BU		
SUGGESTED GUIDELINES			SUGGESTED GUIDELINES			SUGGESTED GUIDELINES		
Centrol			Centrol			Centrol		
LB/ACRE		APPLICATION	LB/ACRE		APPLICATION	LB/ACRE		APPLICATION
N	105		N	125		N	140	
P2O5	55	Broadcast	P2O5	60	Broadcast	P2O5	70	Broadcast
K2O	80	Broadcast	K2O	90	Broadcast	K2O	90	Broadcast
Cl			Cl			Cl		
S	0		S	0		S	0	
B			B			B		
Zn	4	Broadcast	Zn	4	Broadcast	Zn	5	Broadcast
Fe			Fe			Fe		
Mn			Mn			Mn		
Cu			Cu			Mo		
Mo			Mo			Mg		
Mg			Mg			Ca		

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range)				
			% Ca	% Mg	% K	% Na	% H
0-6" 7.9 6-24" 8.0							

Crop 1: Nitrogen is credited 30 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 52 K2O = 35

Crop 2: Nitrogen is credited 30 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 60 K2O = 41

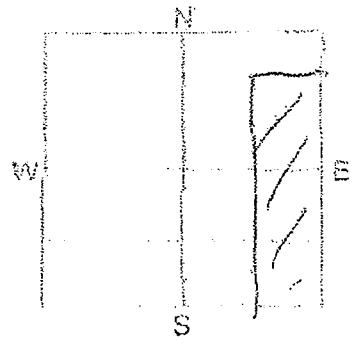
Crop 3: Nitrogen is credited 30 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 68 K2O = 46

CENTROL
CROP CONSULTING

Soil Analysis by Agvise Laboratories
(http://www.agvise.com)
Northwood: (701) 587-6010
Benson: (320) 843-4109

SOIL TEST REPORT

FIELD ID VINCE E OF FARM
SAMPLE ID YLW-ORG RIDGES
FIELD NAME Field 23
COUNTY CASS
TWP BUFFALO RANGE
SECTION 29 QTR ACRES 220.6
PREV. CROP Soybeans



SUBMITTED FOR:
TIM BERNTSON
3311 142ND AVE SE

BUFFALO, ND 58011

SUBMITTED BY: OL0549
MATT OLSON
1230 3RD AVE NW
VALLEY CITY, ND 58072-

REF # 984858 BOX # 0
LAB # NW97107

Date Sampled | Date Received 10/09/2014 | Date Reported 5/15/2015

Nutrient in the Soil		Interpretation
	0-6" 3 lb/ac	
	6-24" 6 lb/ac	
	0-24" 9 lb/ac	
	4 ppm	
	164 ppm	
	0-6" 36 lb/ac	
	6-24" 132 lb/ac	
	0.27 ppm	
	2.2 %	
	0-6" 0.27 mmho/cm	
	6-24" 0.3 mmho/cm	

1st Crop Choice			2nd Crop Choice			3rd Crop Choice		
Corn Grain			Corn-Grain			Corn-Grain		
YIELD GOAL			YIELD GOAL			YIELD GOAL		
130 BU			150 BU			170 BU		
SUGGESTED GUIDELINES			SUGGESTED GUIDELINES			SUGGESTED GUIDELINES		
Centrol			Centrol			Centrol		
LB/ACRE		APPLICATION	LB/ACRE		APPLICATION	LB/ACRE		APPLICATION
N	125		N	145		N	155	
P_2O_5	70	Broadcast	P_2O_5	85	Broadcast	P_2O_5	95	Broadcast
K_2O	35	Broadcast	K_2O	40	Broadcast	K_2O	45	Broadcast
Cl			Cl			Cl		
S	5	Broadcast	S	5	Broadcast	S	5	Broadcast
B			B			B		
Zn	5	Broadcast	Zn	5	Broadcast	Zn	6	Broadcast
Fe			Fe			Fe		
Mn			Mn			Mn		
Cu			Cu			Cu		
Mg			Mg			Mg		
Lime			Lime			Lime		

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range)				
			% Ca	% Mg	% K	% Na	% H
0-6" 8.1							
6-24" 8.3							

Crop 1: Nitrogen is credited 30 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 52 K2O = 35

Crop 2: Nitrogen is credited 30 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 60 K2O = 41

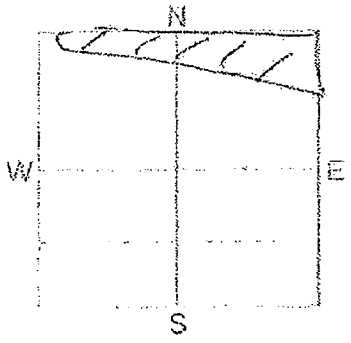
Crop 3: Nitrogen is credited 30 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 68 K2O = 46

CENTROL CROP CONSULTING

Soil Analysis by Agvise Laboratories
(http://www.agvise.com)
Northwood: (701) 587-6010
Benson: (320) 843-4109

SOIL TEST REPORT

FIELD ID N OF TRACKS
SAMPLE ID TIB-B 29-3
FIELD NAME Field 24
COUNTY CASS
TWP BUFFALO RANGE
SECTION 29 QTR ACRES 37.7
PREV. CROP Soybeans



SUBMITTED FOR:
TIM BERNTSON
3311 142ND AVE SE
BUFFALO, ND 58011

SUBMITTED BY: OL0549
MATT OLSON
1230 3RD AVE NW
VALLEY CITY, ND 58072-

REF # 981716 BOX # 0
LAB # NW80374

Date Sampled | Date Received 10/02/2014 | Date Reported 5/15/2015

Nutrient in the Soil		Interpretation
0-6"	9 lb/ac	
6-24"	21 lb/ac	
0-24"	30 lb/ac	
Olsen	10 ppm	
	144 ppm	
0-24"	96 lb/ac	
0-6"	120 +lb/ac	
6-24"	360 +lb/ac	
	1.3 ppm	
	0.52 ppm	
	10.3 ppm	
	2.4 ppm	
	0.65 ppm	
	812 ppm	
	6055 ppm	
	45 ppm	
	3.0 %	
	3.7 %	
0-6"	1.02 mmho/cm	
6-24"	1.64 mmho/cm	

1st Crop Choice		
Corn-Grain		
YIELD GOAL		
150 BU		
SUGGESTED GUIDELINES		
Control		
LB/ACRE		APPLICATION
N	120	
P2O5	50	Broadcast
K2O	60	Broadcast
Cl		Not Available
S	0	
B	0	
Zn	4	Broadcast
Mn	0	
Fe	0	
Cu	0	
Mg	0	
Lime		

2nd Crop Choice		
Corn-Grain		
YIELD GOAL		
170 BU		
SUGGESTED GUIDELINES		
Control		
LB/ACRE		APPLICATION
N	135	
P2O5	60	Broadcast
K2O	70	Broadcast
Cl		Not Available
S	0	
B	0	
Zn	5	Broadcast
Mn	0	
Fe	0	
Cu	0	
Mg	0	
Lime		

3rd Crop Choice		
Soybeans		
YIELD GOAL		
40 BU		
SUGGESTED GUIDELINES		
Control		
LB/ACRE		APPLICATION
N	***	
P2O5	30	Broadcast
K2O	0	
Cl	0	
S	0	
B	0	
Zn	1	Broadcast
Mn	0	
Fe	0	
Mg	0	
Lime		

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range)				
			% Ca	% Mg	% K	% Na	% H
0-6" 7.9 6-24" 8.0		37.6 meq	(65-75) 80.5	(15-20) 18.0	(1-7) 1.0	(0-5) 0.5	(0-5)

General Comments: Texture is not estimated on high pH soils.

Crop 1: ** Chloride yield data is limited for this crop. Nitrogen is credited 30 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 60 K2O = 41

Crop 2: ** Chloride yield data is limited for this crop. Nitrogen is credited 30 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 68 K2O = 46

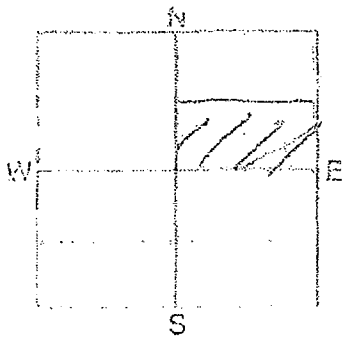
Crop 3: Nitrogen is credited 20.1 lbs for the previous crop. Nitrogen credits may need to be adjusted based on local conditions. Many crops may respond to a starter application of P & K even on high soil tests. The risk of the development of iron chlorosis on soybeans on this field is very high based on the salt and carbonate levels. Crop Removal: P2O5 = 35 K2O = 60 Soybeans may respond to nitrogen on fields testing less than 60 lb/ac with a limited soybean history.

CENTROL
CROP CONSULTING

Soil Analysis by Agvise Laboratories
(http://www.agvise.com)
Northwood: (701) 587-6010
Benson: (320) 843-4109

SOIL TEST REPORT

FIELD ID VINCE 32 S
SAMPLE ID TIB-B 32-3
FIELD NAME Field 25
COUNTY CASS
TWP BUFFALO RANGE
SECTION 32 QTR ACRES 77
PREV. CROP Corn-Grain



SUBMITTED FOR:
TIM BERNTSON
3311 142ND AVE SE
BUFFALO, ND 58011

SUBMITTED BY: OL0549
MATT OLSON
1230 3RD AVE NW
VALLEY CITY, ND 58072-

REF # 981732 BOX # 0
LAB # NW146274

Date Sampled | Date Received 10/29/2014 | Date Reported 5/15/2015

Nutrient In The Soil		Interpretation
	0-6" 20 lb/ac 6-24" 24 lb/ac	
	0-24" 44 lb/ac	
Olsen	6 ppm	
	154 ppm	
	0-24" 48 lb/ac	
	0-6" 120 +lb/ac 6-24" 360 +lb/ac	
	1.0 ppm	
	0.38 ppm	
	6.5 ppm	
	1.3 ppm	
	0.63 ppm	
	789 ppm	
	6484 ppm	
	45 ppm	
	3.1 %	
	5.3 %	
	0-6" 1.09 mmho/cm 6-24" 2.03 mmho/cm	

1st Crop Choice		
Corn-Grain		
YIELD GOAL		
150 BU		
SUGGESTED GUIDELINES		
Control		
LB/ACRE		APPLICATION
N	140	
P_2O_5	75	Broadcast
K_2O	50	Broadcast
Cl		Not Available
S	10	
B	0	
Zn	4	Broadcast
Fe	0	
Mn	0	
Cu	0	
Mg	0	

2nd Crop Choice		
Corn-Grain		
YIELD GOAL		
170 BU		
SUGGESTED GUIDELINES		
Control		
LB/ACRE		APPLICATION
N	150	
P_2O_5	80	Broadcast
K_2O	55	Broadcast
Cl		Not Available
S	10	
B	0	
Zn	5	Broadcast
Fe	0	
Mn	0	
Cu	0	
Mg	0	

3rd Crop Choice		
Soybeans		
YIELD GOAL		
40 BU		
SUGGESTED GUIDELINES		
Control		
LB/ACRE		APPLICATION
N	0	
P_2O_5	50	Broadcast
K_2O	0	
Cl	0	
S	0	
B	0	
Zn	1	Broadcast
Fe	0	
Mn	0	
Cu	0	
Mg	0	

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range)				
			% Ca	% Mg	% K	% Na	% H
0-6" 7.9 6-24" 8.1		39.6 meq	(65-75) 81.9	(15-20) 16.6	(1-7) 1.0	(0-5) 0.5	(0-5)

General Comments: Texture is not estimated on high pH soils.

Crop 1: ** Chloride yield data is limited for this crop. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 60 K2O = 41

Crop 2: ** Chloride yield data is limited for this crop. Many crops may respond to a starter application of P & K even on high soil tests. Crop Removal: P2O5 = 68 K2O = 46

Crop 3: Many crops may respond to a starter application of P & K even on high soil tests. The risk of the development of iron chlorosis on soybeans on this field is extreme based on the salt and carbonate levels. Crop Removal: P2O5 = 35 K2O = 60 Soybeans may respond to nitrogen on fields testing less than 60 lb/ac with a limited soybean history.

10. F. MANURE TESTS AND MANURE ANALYSIS PROCEDURES

1. Manure Analysis Gathering Procedure for Solid Manure
2. Manure Analysis Gathering Procedure for Liquid Manure
3. Sample Identification and Delivery
4. Recommended Testing Lab
5. Nutrient Tests

1. Solid Manure

Collect a composite sample by following one of the procedures listed below. A method for mixing a composite sample is to pile the manure and then shovel from the outside to the inside of the pile until well mixed. Fill a one-gallon plastic heavy-duty zip lock bag approximately one-half full with the composite sample, squeeze out excess air, close and seal. Store sample in freezer if not delivered to the laboratory immediately.

Procedure 1. Sampling while loading - *Recommended method for sampling from a stack or bedded pack.* Take at least ten samples while loading several spreader loads and combine to form one composite sample. Thoroughly mix the composite sample and take an approximately one pound sub sample using a one-gallon plastic bag. *Sampling directly from a stack or bedded pack is not recommended.*

Procedure 2. Sampling during spreading - Spread a tarp in field and catch the manure from one pass. Sample from several locations and create a composite sample. Thoroughly mix the composite sample together and take a one-pound sub sample using a one-gallon plastic bag.

Procedure 3. Sampling daily haul - Place a five-gallon bucket under the barn cleaner 4-5 times while loading a spreader. Thoroughly mix the composite sample together and take a one-pound sub sample using a one-gallon plastic bag. Repeat sampling 2-3 times over a period of time and test separately to determine variability.

Procedure 4

. Sampling stockpiled manure - Take ten – fifteen sub samples from different locations around the pile at least 18 inches below the surface. Mix in a five-gallon pail and place a one-pound composite sample in a gallon zip lock bag.

2. Liquid Manure - Dairy, Beef, Swine

Obtain a composite following one of the procedures listed below and thoroughly mix. Using a plunger, an up-and-down action works well for mixing liquid manure in a five-gallon bucket. Fill a one-quart plastic bottle not more than three-quarters full with the composite sample. Store sample in freezer if not delivered to the lab immediately.

Procedure 1. Sampling from storage- Agitate storage facility thoroughly before sampling. Collect at least five samples from the storage facility or during loading using a five-gallon bucket. Place a sub sample of the composite sample in a one-quart plastic container. Sampling a liquid manure storage facility without proper agitation (2-4 hrs. minimum) is not recommended due to nutrient stratification, which occurs in liquid systems. If manure is sampled from a lagoon that was not properly agitated, typically the nitrogen and potassium will be more concentrated in the top liquid, while the phosphorus will be more concentrated in the bottom solids.

Procedure 2. Sampling during application- Place buckets around field to catch manure from spreader or irrigation equipment. Combine and mix samples into one composite sub sample in a one-quart plastic container.

3. Sample Identification and Delivery

Identify the sample container with information regarding the farm, animal species and date. This information should also be included on the sample information sheet along with application method, which is important in determining first year availability of nitrogen.

Manure should be analyzed for Total nitrogen, inorganic N, phosphorus as P_2O_5 and potassium as K_2O

Keep all manure samples frozen until shipped or delivered to a laboratory. Ship early in the week (Mon.-Wed.) and avoid holidays and weekends.

4. Recommended Testing Lab:

Stearns DHIA Central Lab
PO Box 227
825 12th Street South
Sauk Centre, MN 56378

5. Nutrient Tests

No tests have been taken at this point, however before commercial fertilizer is applied the manure should be tested to limit over application. For this plan a tests from an existing operation is used.

10. G. LIVESTOCK MORTALITY MANAGEMENT PLAN

Mortalities will not be disposed of in the LWCF. The primary method of carcass disposal is composting and burial will be the secondary method.

The following is an Excerpt from Draft ND Dept. of Health Guidelines for Approval of Livestock Waste Systems:
Dead animals shall be disposed of in a manner acceptable to the board of animal health, and in accordance with NDCC section 36-14-19. Dead animals shall be disposed of in a manner that will not cause a detrimental impact to waters of the state.

NDCC Section 36-14-19: ***Disposition of carcass of animal dying from contagious or infectious disease.***
Any animal which is found dead must be presumed to have died from a contagious or infectious disease until the contrary is shown unless another cause of death is apparent. The owner or person in charge of any domestic animal or nontraditional livestock which dies within this state from or on account of any contagious or infectious disease shall dispose of the carcass of such animal as follows:

1. If the animal died of anthrax, as determined by a licensed veterinarian, the carcass must be completely burned at the place where it died if possible. If the carcass must be moved, it may not be dragged over the ground but must be moved only on a suitable conveyor and all body openings in the carcass must be plugged with cotton saturated with a strong antiseptic solution.

2. If the carcass is of a hog which died from hog cholera or swine erysipelas, the same, with hide intact, must be burned within thirty-six hours or given to a licensed rendering plant within such time.

3. If the carcass is of an animal which has died of a disease other than is specified in subsections 1 and 2, or from any other cause, it must be burned, buried, composted, or given to a licensed rendering plant within thirty-six hours, or must be disposed of by a method approved by the state veterinarian. If the carcass is buried, it must be buried not less than four feet [1.22 meters] below the surface of the ground and covered with dirt to that depth. No carcass may be disposed of along any public highway or along any stream, lake, or river nor be buried near or adjoining any such place.

10. H. RECORDKEEPING FORMS

1. Nutrient Application Log
2. Manure Transfer Form
3. Discharge Report for Production Area

Field ID Number	1	Nutrient Application Log						Page 1		Weather data					
										24 hours before		During		After	
Date Applied	Acres Applied	Number of Loads Applied	Application Method	Spreader Capacity (tons/gal)	Rate tons/acre or gal/acre	Manure Sample #	Total N from manure test lbs/ton or lbs/gal	Total P from manure test lbs/ton or lbs/gal	Total N Applied lbs/acre	Total P Applied lbs/acre	Wind direction and speed	Temp.	Wind direction and speed	Temp.	Wind direction and speed	Temp.

Field ID Number	2	Nutrient Application Log							Page 2		Weather data					
											24 hours before		During		After	
Date Applied	Acres Applied	Number of Loads Applied	Application Method	Spreader Capacity (tons/gal)	Rate tons/acre or gal/acre	Manure Sample #	Total N from manure test lbs/ton or lbs/gal	Total P from manure test lbs/ton or lbs/gal	Total N Applied lbs/acre	Total P Applied lbs/acre	Wind direction and speed	Temp.	Wind direction and speed	Temp.	Wind direction and speed	Temp.

Field ID Number		3	Nutrient Application Log						Page 3		Weather data					
											24 hours before		During		After	
Date Applied	Acres Applied	Number of Loads Applied	Application Method	Spreader Capacity (tons/gal)	Rate tons/acre or gal/acre	Manure Sample #	Total N from manure test lbs/ton or lbs/gal	Total P from manure test lbs/ton or lbs/gal	Total N Applied lbs/acre	Total P Applied lbs/acre	Wind direction and speed	Temp.	Wind direction and speed	Temp.	Wind direction and speed	Temp.

Field ID Number	4	Nutrient Application Log						Page 4		Weather data					
										24 hours before		During		After	
Date Applied	Acres Applied	Number of Loads Applied	Application Method	Spreader Capacity (tons/gal)	Rate tons/acre or gal/acre	Manure Sample #	Total N from manure test lbs/ton or lbs/gal	Total P from manure test lbs/ton or lbs/gal	Total N Applied lbs/acre	Total P Applied lbs/acre	Wind direction and speed	Temp.	Wind direction and speed	Temp.	Wind direction and speed	Temp.

Field ID Number	5	Nutrient Application Log							Page 5		Weather data					
											24 hours before		During		After	
Date Applied	Acres Applied	Number of Loads Applied	Application Method	Spreader Capacity (tons/gal)	Rate tons/acre or gal/acre	Manure Sample #	Total N from manure test lbs/ton or lbs/gal	Total P from manure test lbs/ton or lbs/gal	Total N Applied lbs/acre	Total P Applied lbs/acre	Wind direction and speed	Temp.	Wind direction and speed	Temp.	Wind direction and speed	Temp.

Field ID Number	6	Nutrient Application Log							Page 6		Weather data					
											24 hours before		During		After	
Date Applied	Acres Applied	Number of Loads Applied	Application Method	Spreader Capacity (tons/gal)	Rate tons/acre or gal/acre	Manure Sample #	Total N from manure test lbs/ton or lbs/gal	Total P from manure test lbs/ton or lbs/gal	Total N Applied lbs/acre	Total P Applied lbs/acre	Wind direction and speed	Temp.	Wind direction and speed	Temp.	Wind direction and speed	Temp.

Field ID Number	7	Nutrient Application Log						Page 7		Weather data					
										24 hours before		During		After	
Date Applied	Acres Applied	Number of Loads Applied	Application Method	Spreader Capacity (tons/gal)	Rate tons/acre or gal/acre	Manure Sample #	Total N from manure test lbs/ton or lbs/gal	Total P from manure test lbs/ton or lbs/gal	Total N Applied lbs/acre	Total P Applied lbs/acre	Wind direction and speed	Temp.	Wind direction and speed	Temp.	Wind direction and speed	Temp.

Field ID Number	8	Nutrient Application Log							Page 8		Weather data					
											24 hours before		During		After	
Date Applied	Acres Applied	Number of Loads Applied	Application Method	Spreader Capacity (tons/gal)	Rate tons/acre or gal/acre	Manure Sample #	Total N from manure test lbs/ton or lbs/gal	Total P from manure test lbs/ton or lbs/gal	Total N Applied lbs/acre	Total P Applied lbs/acre	Wind direction and speed	Temp.	Wind direction and speed	Temp.	Wind direction and speed	Temp.

Field ID Number		9	Nutrient Application Log						Page 9		Weather data					
											24 hours before		During		After	
Date Applied	Acres Applied	Number of Loads Applied	Application Method	Spreader Capacity (tons/gal)	Rate tons/acre or gal/acre	Manure Sample #	Total N from manure test lbs/ton or lbs/gal	Total P from manure test lbs/ton or lbs/gal	Total N Applied lbs/acre	Total P Applied lbs/acre	Wind direction and speed	Temp.	Wind direction and speed	Temp.	Wind direction and speed	Temp.

Field ID Number	10	Nutrient Application Log						Page 10		Weather data					
										24 hours before		During		After	
Date Applied	Acres Applied	Number of Loads Applied	Application Method	Spreader Capacity (tons/gal)	Rate tons/acre or gal/acre	Manure Sample #	Total N from manure test lbs/ton or lbs/gal	Total P from manure test lbs/ton or lbs/gal	Total N Applied lbs/acre	Total P Applied lbs/acre	Wind direction and speed	Temp.	Wind direction and speed	Temp.	Wind direction and speed	Temp.

Field ID Number	11	Nutrient Application Log							Page 11		Weather data					
											24 hours before		During		After	
Date Applied	Acres Applied	Number of Loads Applied	Application Method	Spreader Capacity (tons/gal)	Rate tons/acre or gal/acre	Manure Sample #	Total N from manure test lbs/ton or lbs/gal	Total P from manure test lbs/ton or lbs/gal	Total N Applied lbs/acre	Total P Applied lbs/acre	Wind direction and speed	Temp.	Wind direction and speed	Temp.	Wind direction and speed	Temp.

Field ID Number			Nutrient Application Log						Page 12		Weather data					
											24 hours before		During		After	
Date Applied	Acres Applied	Number of Loads Applied	Application Method	Spreader Capacity (tons/gal)	Rate tons/acre or gal/acre	Manure Sample #	Total N from manure test lbs/ton or lbs/gal	Total P from manure test lbs/ton or lbs/gal	Total N Applied lbs/acre	Total P Applied lbs/acre	Wind direction and speed	Temp.	Wind direction and speed	Temp.	Wind direction and speed	Temp.

Manure Source Info			Manure Transfer Log					
Sample Date	Manure Analysis (lbs/ton or gal.)		Date	Recipients Name	Address	Amount (tons or gals.)	Type (liquid or solid)	Was a copy of the most recent nutrient analysis provided to the recipient?
	Total N	P205						

Discharge Report for Production Area

Date	TIme	Location	Description (What was the cause and effect?)	Estimated Volume Corrective (tons or gals.)	Actions Taken	Date Corrected

DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers

ROLLING GREEN FAMILY FARMS RE, LLP

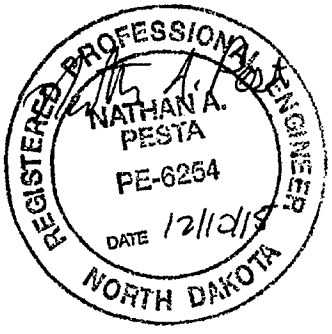
ENGINEERING PORTION OF

NORTH DAKOTA DEPARTMENT

OF HEALTH

APPLICATION FOR PERMIT TO CONTRUCT A CONCENTRATED

ANIMAL FEEDING OPERATIONS



LAST PAGE

1. Medical Information

JOHNS HOPKINS
CENTER *for* A LIVABLE FUTURE

The Johns Hopkins Center for a Livable Future
Bloomberg School of Public Health
615 North Wolfe Street, W7010
Baltimore, MD 21205

March 14, 2016

Dr. Terry Dwelle
State Health Officer
North Dakota Department of Health
600 East Boulevard Ave
Bismarck, ND 58505-0200

Disclaimer: The opinions expressed herein are our own and do not necessarily reflect the views of The Johns Hopkins University.

Re: Rolling Green Family Farms RE LLP proposed 9,000-head capacity sow facility

Dear Dr. Dwelle,

We are researchers at The Johns Hopkins Center for a Livable Future, based at the Bloomberg School of Public Health. The Center engages in research, policy analysis, education, and other activities guided by an ecologic perspective that diet, food production, the environment, and public health are interwoven elements of a complex system. We recognize the prominent role that food animal production plays regarding a wide range of public health issues within and associated with that system.

We have been contacted by Buffalo, North Dakota residents concerning the proposed 9,000-head capacity sow operation, Rolling Green Family Farms. We understand that the North Dakota Department of Health is preparing to review a Confined Animal Feeding Operation permit application for this operation, and we are writing to express our concerns regarding the potential public health impacts of this operation. Based on evidence from numerous scientific studies of similar facilities, the proposed operation, if constructed and put into operation, may present a range of health risks to members of the surrounding community.

Our concerns regarding the proposed swine operation include the following:

1. Antibiotic resistance and the spread of infectious diseases to communities
2. Groundwater and surface water pollution, and associated health impacts
3. Air pollution, odors, and associated health and social impacts

These are detailed below, with supporting evidence from the peer-reviewed scientific literature. Thank you for the opportunity to comment on this important issue—we appreciate you taking these concerns into consideration.

1. Industrial swine production has been linked to the spread of antibiotic-resistant pathogens to surrounding communities.

Crowded conditions in intensive livestock operations present frequent opportunities for the transmission of viral and bacterial pathogens among animals, and between animals and humans. Many of these pathogens live in the digestive tracts of animals and are passed in their waste (1–3).

The severity of disease risks stemming from intensive livestock production is heightened by the potential for infection with antibiotic-resistant bacteria. The non-medicinal use of antibiotic drugs as a means for growth promotion[1] in animals has become commonplace—an estimated 80 percent of antibiotics sold for human and animal uses in the U.S. are sold for use in food-producing animals (4). Administering antibiotics to animals at doses too low to treat disease fosters the proliferation of antibiotic-resistant pathogens. Resistant infections in humans are more difficult and expensive to treat (5) and more often fatal (6) than infections with non-resistant strains. The continued misuse of antibiotics in food animal production thereby threatens the effectiveness of these lifesaving resources for combating disease.

A growing body of evidence points to the potential pathways by which pathogens (antibiotic-resistant or otherwise) might spread from intensive livestock operations into communities. Studies suggest, for example, that antibiotic-resistant pathogens may be transmitted by workers into their homes and communities (7–10), conveyed by runoff into ground and surface waters (3), blown out of barns by ventilation systems (11–13), and spread to consumers via contaminated meat (14,15). Pathogens may also be transported by flies (16), wild birds (17,18), and animal transport vehicles (19).

[1]U.S. Food and Drug Administration (FDA) voluntary industry guidelines continue to endorse the use of antibiotics in livestock production for "disease prevention", which allows for dosing that is largely indistinguishable from growth promotion, thus tolerating business as usual (45).

Further evidence for disease transmission risks was documented in a 2013 study of nearly 450,000 Pennsylvania residents, in which living near larger swine operations or cropland where swine manure is spread was significantly associated with elevated rates of infection with methicillin-resistant *Staphylococcus aureus* (MRSA) and skin and soft tissue infections (20). MRSA is an antibiotic-resistant pathogen that can be challenging and expensive to treat. In a similar study in Iowa, persons living closer to swine operations had a greater risk of colonization with MRSA (21).

Industrial swine operations also present opportunities for the replication, mutation, and recombination of viruses—including novel influenza viruses—that may facilitate human-to-human transmission (22). Workers in swine operations face a greater risk of infection and may also increase the risk of influenza virus transmission to their surrounding communities (23,24).

2. Industrial swine operations can contaminate ground and surface waters, potentially leading to health impacts

Confining large numbers of animals indoors presents the challenge of how to collect, store, and dispose of the massive quantities of manure they generate. When such quantities are applied to nearby fields (the usual method of disposal), the amounts often exceed what surrounding land can absorb. When manure is over-applied, the excess—along with chemical and bacterial contaminants—is transported by runoff into surface waters and may leach into groundwater. A 2015 study traced fecal microbes specific to swine in surface water upstream and downstream of swine operations and found that swine specific microbes were nearly 2.5 times as prevalent in surface water downstream than upstream of swine operations, indicating poor sanitary quality of surface waters near industrial swine operations (25).

A 440 lb gestating sow generates an average of 11 lbs of wet manure daily[2], or roughly three times the mass of excreta generated by a person (26). With a projected inventory of over 9,000 sows, a conservative estimate indicates that Rolling Green Family Farms would be comparable, in terms of waste generated, to the addition of over 30,000 humans—more than 150 times the population of Buffalo, ND—without the benefit of a wastewater treatment plant to treat microbial and chemical pathogens.

Communities living near or downstream from confinement operations may be exposed to a range of waterborne contaminants, including nitrates, bacterial and viral pathogens, heavy metals, and veterinary pharmaceuticals (27). People may be exposed to these contaminants from drinking contaminated groundwater, placing them at greater risk for adverse health

[2] Lactating sows generate an average of 25 lbs of wet manure per day (26).

outcomes. Chronic exposure to nitrates (naturally occurring in animal waste), for example, has been associated with increased risks for thyroid conditions (28,29), birth defects and other reproductive problems (28,30), diabetes (28), various cancers (28,31), and methemoglobinemia (blue baby syndrome), a potentially fatal condition among infants (32).

3. **Industrial swine operations release air pollutants and odors, which are associated health and social impacts**

Animal confinement operations have been linked to a range of airborne pollutants, including ammonia, hydrogen sulfide, and other gases emitted from animal waste; and airborne particulates, which may be comprised of dried feces, animal dander, fungal spores, and bacterial toxins (33).

Much of the research on the health effects associated with exposure to airborne pollutants from confinement operations has focused on workers. At least one in four workers in these operations are estimated to suffer from respiratory illness (34).

A growing body of evidence suggests residents living near animal confinement operations may also be at greater risk of respiratory illness. One study detected high concentrations of particulate matter downwind from swine confinement operations, which was linked to wheezing, breathing difficulties, and eye, skin, and nasal irritation among residents of downwind communities (35). Indicators of air pollution (e.g., odors) from swine confinement operations have also been linked to asthma symptoms among students at nearby schools (36).

Odors associated with air pollutants from confinement operations have been found to interfere with daily activities, quality of life, social gatherings, and community cohesion (34,37). In addition to the stigma and social disruption they often generate, odors from swine confinement operations have been associated with physiological and psychological effects, including high blood pressure, depression, anxiety, and sleep disturbances (38–40).

Residents in Buffalo, ND and surrounding areas have relayed concerns to us regarding community members' various chronic health conditions, including asthma, chronic obstructive pulmonary disease (COPD), high blood pressure, cancer, and other ailments. There is evidence that some of these conditions—primarily asthma—may be exacerbated by living near industrial food animal production facilities (41,42), which raises concerns about whether these residents could be particularly vulnerable to the health risks described above.

We hope our letter is helpful in describing some of the potential public health harms associated with large-scale swine confinement operations. We strongly advise the North Dakota Department

of Health to take these concerns into consideration when deciding whether or not to approve the construction of Rolling Green Family Farms. Through our research, we know that health departments face many barriers addressing issues surrounding industrial food animal production (43,44), and we are prepared to serve as a resource to your office. Please do not hesitate to contact us if you have any questions.

Sincerely,

Anthony So, MD, MPA
Robert S. Lawrence Professor, Department of Environmental Health Sciences
Johns Hopkins Bloomberg School of Public Health
Director, Johns Hopkins Center for a Livable Future
Johns Hopkins University

Robert S. Lawrence, MD
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March 8, 2016

To Whom It May Concern:

My name is Judith Von Bank and my husband's name is Robert. We live a little over a mile from the proposed large scale corporate hog operation.

My husband and I are very concerned about what the hydrogen sulfate and methane gas will do to our health. My husband has severe asthma and he won't be able to enjoy the outdoor activities and the lifestyle that he has enjoyed on our farm for the past seventy-seven years.

Robert needs to exercise because of his fibromyalgia, and it will be impossible to walk on our country roads. We are very concerned that our quality of life will be completely destroyed.

I wish to read and submit a letter from my husband's physician.

Sincerely,

Judith Von Bank

Judith Von Bank

Signed by Stoy, Patrick J, MD on 02/09/16 at 1453

02/09/2016

ROBERT VONBANK
3610 140TH AVE SE

BUFFALO, ND 58011

MR#: E2572904

Dear Robert:

In discussion with your wife, I have learned that there are plans to construct a large hog operation near your home. This to me raises significant concerns with regard to your severe, difficult to manage asthma. I would anticipate that the fumes that would include ammonia and methane gas generated by this kind of an operation would lead to considerable difficulties managing and dealing with your asthma and a great deal of breathing difficulties for you. I think this plan of construction is certainly not in your interest whatsoever, and if there were a way to relocate that operation at a great distance from you, it would be highly advised.

Sincerely yours,

Patrick Stoy, M.D., Pulmonology

13435482/nec
5268680

Health Summary

Current Health Issues

Health Issue	Date Noted
Fibromyalgia	12/15/2003
Lumbar spondylosis	01/27/2004
Generalized anxiety disorder	
Cervicalgia	05/30/2007
Degeneration of cervical intervertebral disc	05/30/2007
Personal history of other malignant neoplasm of skin	05/04/2009
Hiatal hernia with gastroesophageal reflux	12/17/2007
Actinic keratosis	06/23/2010
Chronic constipation	07/21/2010
Fasting hyperglycemia	01/24/2011
History of testicular mass	06/08/2011
Osteoarthritis of wrist	05/13/2011
Hypogonadism male	07/20/2011
Migraine	
Hydronephrosis	03/09/2012
Tonsil stone	03/25/2013
Osteoarthritis, multiple sites	01/20/2014
Chronic pain	08/12/2015
Hyperlipidemia	08/12/2015
Screening for prostate cancer	08/12/2015
Asthma	08/12/2015
Pain medication agreement	11/12/2015

Medications

montelukast 10 mg tablet
Commonly known as: SINGULAIR

Instructions: Take 1 tablet (10 mg total) by mouth 1 time per day

Approved by Patrick Stoy, MD
Prescribed on 2/23/2016
Prescribed quantity: 90 tablets

albuterol HFA 108 (90 BASE) MCG/ACT inhaler
Commonly known as: PROVENTIL,PROAIR,VENTOLIN

Instructions: Inhale 1-2 puffs orally every 4 to 6 hours as needed for shortness of breath shake well before using.

Approved by Patrick Stoy, MD
Prescribed on 2/23/2016
Prescribed quantity: 1 Inhaler

oxyCODONE 10 mg ER (12 hr) tablet
Commonly known as: oxyCONTIN

You should not start taking this medication until 3/4/2016.

Instructions: Take 1 tablet (10 mg total) by mouth 2 times a day earliest fill date: 3/4/16.

Approved by Rebecca A Kiecker, APRN-CNP
Prescribed on 12/31/2015
Prescribed quantity: 60 tablets

gabapentin 300 mg capsule
Commonly known as: NEURONTIN

Instructions: Take 3 capsules (900 mg total) by mouth 3 times a day.

Approved by Rebecca A Kiecker, APRN-CNP
Prescribed on 11/12/2015
Prescribed quantity: 270 capsules

Request a renewal

lubiprostone 8 mcg capsule
Commonly known as: AMITIZA

Instructions: Take 1 daily or two times a day as needed for constipation

Approved by Nina Sjoquist, APRN-CNP
Prescribed on 8/12/2015

Prescribed quantity: 180 capsules

Request a renewal

fluticasone 50 mcg/spray nasal spray
Commonly known as: FLONASE

Instructions: Spray 2 sprays into each nostril as needed for other (specify) (seasonal allergies).

Approved by Nina Sjoquist, APRN-CNP
Prescribed on 8/12/2015
Prescribed quantity: 1 Bottle

Request a renewal

polyethylene glycol powder
Commonly known as: MIRALAX

Instructions: Take 1 tablespoonful by mouth 2 times a day as needed. in 8 oz of water for constipation.

Documented by Abstract Provider

SENNA PLUS PO

Instructions: Take 4 tablets by mouth 1 time a day as needed. for bowels.

Documented by Abstract Provider

catheter Misc

Instructions: 3 times a day. 14 fr straight cath 3x daily

Documented by Abstract Provider

Allergies

Allergen	Reaction
Aspirin	Wheezing/Bronchospasm (High)
Duloxetine Hcl	Nausea and Vomiting, Diarrhea
Pregabalin	Confusion
Penicillin	Hives (High), Rash, Angioedema (High)

Immunizations

Immunization	Date
Influenza High Dose (65+)	9/23/2013
Influenza High Dose Vaccine (65+)	10/22/2015, 10/3/2012
Influenza Trivalent w/preserv	9/24/2010, 9/30/2009
Influenza Vaccine	10/15/2008, 10/16/2007
Pneumococcal Polysaccharide PPSV23	11/30/2007
Td (adult) preservative free (Tenivac)	11/23/2005
Zoster	10/12/2009

Preventive Care

Name	Status	Last Done
Pneumococcal Adult	Overdue since 11/30/2008	11/30/2007
Asthma Control Test	Overdue since 5/27/2015	5/27/2014
Asthma Action Plan & Environmental Control	Overdue since 5/27/2015	5/27/2014
Tetanus Vaccine	Overdue since 11/23/2015	11/23/2005
Colonoscopy	Not due until 5/24/2016	5/24/2013
Zostavax Vaccine	Completed on 10/12/2009	10/12/2009
Flu Vaccine	Completed on 10/22/2015	10/22/2015

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Health Summary

Current Health Issues

Health Issue	Date Noted
Allergic rhinitis	07/17/2008
Esophageal reflux	07/17/2008
Hyperlipidemia	
Hypertension	04/29/2009
Arthritis of left knee	06/08/2009
Osteopenia	07/20/2009
S/P total knee replacement	09/01/2009
Chronic kidney disease, stage III (moderate)	01/24/2011

Medications

pravastatin 20 mg tablet
Commonly known as: PRAVACHOL

Instructions: Take 1 tablet daily

Approved by Nina Sjoquist, APRN-CNP
Prescribed on 12/8/2015
Prescribed quantity: 90 tablets

Request a renewal

amLODIPine 2.5 mg tablet
Commonly known as: NORVASC

Instructions: Take 1 tablet (2.5 mg total) by mouth 1 time per day.

Approved by Nina Sjoquist, APRN-CNP
Prescribed on 10/5/2015
Prescribed quantity: 90 tablets

Request a renewal

omeprazole 20 mg capsule
Commonly known as: priLOSEC

Instructions: Take 1 capsule by mouth 1 time a day in the morning.

Approved by Nina Sjoquist, APRN-CNP
Prescribed on 8/12/2015
Prescribed quantity: 90 capsules

Request a renewal

fluticasone 50 mcg/spray nasal spray
Commonly known as: FLONASE

Instructions: Spray 2 sprays into each nostril 1 time a day as needed for other (specify) (allergies).

Approved by Nina Sjoquist, APRN-CNP
Prescribed on 8/12/2015
Prescribed quantity: 3 Bottles

Request a renewal

clobetasol propionate 0.05 % cream
Commonly known as: TEMOVATE

Instructions: Apply to affected area 2 times a day as needed for itching or rash.

Approved by Nina Sjoquist, APRN-CNP
Prescribed on 8/12/2015
Prescribed quantity: 1 Tube

Request a renewal

COQ10 PO

Instructions: Take by mouth 1 time per day.

Documented by Abstract Provider

omega-3 fatty acids 1000 mg capsule
Commonly known as: FISH OIL

Instructions: Take 1,000 mg by mouth 1 time per day.

Documented by Abstract Provider

CINNAMON PO

Instructions: Take by mouth. per patient sprinkles on breakfast food qd

Documented by Abstract Provider

psyllium 50 % Powd
Commonly known as: METAMUCIL ORANGE

Instructions: Take 1 tablespoonful by mouth 1 time a day as needed.

Documented by Abstract Provider

calcium carbonate-vitamin D 600 mg-200 unit tablet
Generic name: calcium carbonate-vitamin D
Instructions: Take 1 tablet by mouth 2 times a day.
Documented by Abstract Provider

multi-vitamin tablet
Instructions: Take 1 tablet by mouth 1 time per day.
Documented by Abstract Provider

vitamin D (cholecalciferol) 1000 UNITS Caps
Instructions: Take 2,000 units by mouth 1 time per day.
Documented by Abstract Provider

Allergies

Allergen	Reaction
Penicillin	Hives (High), Rash
Other: See Comments	Hives (High), Rash

Immunizations

Immunization	Date
H1N1 Injectable Vaccine	12/14/2009
Influenza High Dose Vaccine (65+)	10/22/2015, 9/23/2013, 10/3/2012
Influenza Trivalent w/preserv	9/24/2010, 10/7/2009
Influenza Vaccine	10/15/2008, 10/16/2007, 10/17/2003
Pneumococcal Polysaccharide PPSV23	10/16/2007
Tetanus Toxoid,not adsorbed	7/17/2008, 1/1/2007
Zoster	10/12/2009

Preventive Care

Name	Status	Last Done
Pneumococcal Adult	Overdue since 10/16/2008	10/16/2007
Screening Mammogram	Not due until 10/22/2016	10/22/2015
Colonoscopy	Not due until 11/22/2016	11/22/2006
Tetanus Vaccine	Not due until 7/17/2018	7/17/2008
Lipid Screening	Not due until 8/12/2020	8/12/2015
Dexa/heel Scan	Not due until 10/3/2027	10/3/2012
Zostavax Vaccine	Completed on 10/12/2009	10/12/2009
Flu Vaccine	Completed on 10/22/2015	10/22/2015

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As a concerned citizen of Buffalo,

We are here to express our concerns to the Dept. of Health about a proposed corporate hog operation that will be located 1.5 miles from our dream home.

We are very concerned about the effects of hydrogen sulfide, methane gas and ammonia gases and any particulate matter to our health and those of our family members. We have two grandsons with asthma, my mother who has terminal small cell lung cancer and myself with anxiety and stage four kidney failure.

We walk our country roads not just for pleasure but also for health reason. We look forward to being outside using every 10 acres of space after a long North Dakota winter.

Sincerely,
Arnetta Frueh

My name is Vicki Wendt. I am Arnetta's neighbor. Because she was not able to attend, I am submitting her letter and her documents of concern on her behalf.

Concerned Citizen of Buffalo,

I am here to express my concerns to the Dept of Health on the possibility of Rolling Green Farms, managed by Pipestone Systems of putting up a hog factory. Rolling Green Farms are looking to put up a facility of 9000 hogs on 35 acres 1.5 miles from our home, with a yield of 177,000 hogs passing through by the end of their fiscal year.

At the meeting that Pipestone held on Monday, Jan 18th, we were told that our fears are unfounded, that the air will carry slight odor or no disease because there hogs are healthy, that they will have rodents and other inhabitants including the house fly, that it's an economic boost for our Community and that hogs and there 6 million gallons of slurry will not stink.

As far as **fear** in this situation it is well founded. When we heard about this facility and the possibilities of 14 to 20 employees coming in we were excited. Our family is a self- employed plumbing contractor. We also didn't know what a CAFO was. When we looked it up we were not looking for anything but good things. We were shocked!! We looked up Pipestone System and their site was awesome. Well presented with all positive research, charts and working opportunities. Then we saw all those other articles. Those were really bad. Everyone; no matter from what state; from lay people, to mayors to Health Organizations to Farm Associations. It made the hair stand up on the back of our necks, and our anxiety was great. Now we did look up these articles on the internet, we did call some of the people who live by the facilities, some up to 5 miles away. Fear was setting in and setting in fast. Now I understand that you need to use common sense in what to believe or not believe. I also know that some people complain because their ice cream is cold. Now even if 1% of all this has some truth to it, that's too much of a risk.

Now as far as **air**, the definition of air is that it's an invisible odorless tasteless gases. Pipestone systems claim that the wind isn't going to carry dust or gases. Now we all know that the ashes from Mt. St. Helen came this far, carried by the wind. We know that the Canadian wild fires smoke smell and haze were carried here by the wind. Now we are only talking 1.5 miles away from the hog farm, but wind won't carry anything. If there is an odor in the air; that means that there is some additional gases that are mixing with the air and that is called pollution. Those gases such as methane gas, hydrogen sulfide, ammonia, carbon dioxide can cause serious respiratory

distress.
Now Pipestone and its farmers state the hogs and there by product doesn't stink, that is a totally irresponsible commit with no merit!!! That's saying that our POO doesn't stink and we all know that not to be true. We all love that fact of when the sewer backs up into our homes, right. I'll tell you, I have been the other end of those calls and they can be very distressing, which by the way I never fully repeat to my husband, mostly because those are words that I never say! Now all waste has bacteria and in that bacteria are germs that can be spread from your shoes, clothes, hair. They state that the particles live in your nose for months and we know that coughing and sneezing doesn't spread germs. Wrong! So for any one of us that has a suppressed immune system it will be seriously compromised.

Now for **flies, rodents and other inhabitants.** First Pipestone Systems state that they will have traps around for rodent capture, which is good. They do not state weather there would be any type of fencing going around the property to keep stray dogs, fox, coyotes etc. out. We have small children and house pets that will be threatened if these inhabitants are moving about. Flies! We were told that flies don't fly any further than 50 ft from their feeding source. Pipestone Systems also stated that they will not have any thing in place to control the house flies. Now research states that a house fly produces every eight days with many generations during a typical season. Each house fly is shown to "easily carry over one million bacteria on its body." They also transmit disease pathogens such as e-coli, salmonella, cholera, dysentery. The University of Kentucky's Entomologist states that "if a large number of flies develop at a site, competition among their breeding sites causes them to move." The University also states that flies can easily move up to two miles on their own. No wind involved. The University also states the 60 to 80% of the flies that they marked and released were captured within 1 mile of the release point. Most of the rest, 85 to 95 % of the total were caught within 2 miles of the release in the first 4 days from where they were turned loose. At this time NDSU's study shows that in our area we do not have house flies, with testing spots in Casselton, Harmony Township and Kindred, Normanna Township as of May 27th,2015 to July 6th, 2015.

Economic Boost and Community. Now if this was such a wonderful thing to be happening to our community, then the land sellers, applicants and Economic Development should have been working on a plan for housing for these families. There was more than enough time to not only put a plan together, but to implement it with time to spare. We should have been

gearing the school for an increase in students. We could have been working with locums for all that is needed to put this together and make these families feel welcome. So now instead of our community profiting from this, as Pipestone state "there is Valley City, Casselton and Fargo." They are not our community, they are our neighbors.

Quality of Life, that's a funny phrase because the definition means something different for each of us. So the quality of life is up to what the individual and what makes them happy. For my family it's the quality of time that we share together on the farm. We have four generations living out here with us and each moment is treasured. We have three grand babies that we wear on our chests. We make snow banks, help Papa move snow in his truck sipping hot chocolate and eating a treat that we snuck out, we ride our go carts, bicycles, climb up the tress, spend time in uncles tree house, ride the green tractor with Papa, help grandma with the garden watching those little plants grow big so we can eat the fruits of the plant, we watch the monarchs hatch and fly around us, watch the silly antics of the squirrels – don't know why they don't fall off that twig! We pick apples and test taste them. Every day we have one or two grandchild in our home, never all three without a parent. Now two of these grandchild have asthma. One is growing out of it and the other one is still doctoring. If just a fraction of the air quality is negative we are putting these children at risk of respiratory failure. Without my babies, I would be crushed. I have an anxiety disorder and at this point I have had to double my medication. I also have stage four kidney failure. If I catch any disease it will have serious effects that could be deadly. My body at this time is weakened and will not be able to fight off any harm. My mom has terminal small cell lung cancer. She has finished her chemo and radiation.

I can choose not to believe anything that I've heard from Pipestone Systems, from community members, the people that we have spoke to and believe none of my research. I can choose to believe everything that Pipestone Systems had to say, everything that community members say, the people we spoke to and believe all of my research. Or I can weigh all this information with a pro and con column using common sense. I am not against hog farming or any other farming. I love pork chops, nothing better than a tender ham and crispy bacon. What I oppose is the amount of hogs and by product in such a small area and so close to a community and farms within the proposed area.

If there is a smidgen of truth to any of this, that is too big a price to pay for our family. And we are not willing to take any risk at this time. Can this

community afford the prospect of losing 4 families and a prominent business? Thank you!

Grand Forks Herald

Barbara Bentz: Make no mistake, methane is hazardous to your health

By Barbara Bentz Today at 5:00 a.m.

FARGO—I had the chance to attend the public hearing for the federal Bureau of Land Management's methane rule. The bureau is proposing to update 30-year-old regulations in order to reduce the release of natural gas into the atmosphere from oil and gas operations on public and American Indian lands.

The proposed rule is meant to harness the energy that's lost when the methane escapes or is flared, and to decrease lost royalties and the effect methane has on global warming. The global

warming effects and immediate health risks of methane recently have made headlines as a result of the uncontained methane gas leak in California.

As a pediatrician, I am concerned about how our environment affects the health and safety of North Dakota's children and families. At the hearing in Dickinson, representatives of the oil industry presented their position; and part of the industry's concern, they said, was the need to have more evidence about health complications from methane.

This claim was part of their attempt to refute the need for the BLM's guidelines.

As I mentioned in my own presentation, when methane is sold commercially, it contains mercaptan. This is a foul-smelling chemical that makes detection of leaks obvious. It has a sulfur smell, like rotten eggs.

The chemical was put into natural gas in the aftermath of a school explosion in New London, Texas, in 1937. Some 300 students and faculty members lost their lives when the school exploded and was leveled because of the ignition of trapped natural gas.

The school was being fueled by gas directly from the nearby oil wells. After that disaster, mercaptan was introduced by the gas companies for safety and health reasons, in order to make the presence of leaks obvious.

Perhaps the people representing the oil companies in Dickinson were unaware of their own companies' concerns about safety.

These are the facts, facts the oil industry works with every day:

■ Methane is slightly soluble, so it can enter in the groundwater. Then when it seeps into basements

or leaks and is exposed to air, it becomes a vapor.

■ It also is odorless in its natural state.

■ From a respiratory point of view, very high levels of methane can displace the oxygen in the air and cause suffocation, resulting in symptoms such as headaches, dizziness, weakness, nausea, vomiting, rapid breathing, loss of coordination, loss of consciousness and possible death.

■ As an odorless, colorless and tasteless gas, its health effects as well as its explosively flammable potential may not be suspected by children or adults.

The oil companies understand methane is dangerous, but the people who represented them at the hearing wanted more evidence, more proof. I recommended that the oil companies and the Bureau of Land Management include an experienced federal public health agency such as

Arnetta K Frueh

Continuity of Care Document, as of Feb. 26, 2016

Patient Demographics - Female, born Jul. 01, 1965

Patient Address	Communication	Language	Race / Ethnicity
14006 37th St SE BUFFALO, ND 58011	701-633-5620 (Home) 777-777-7777 (Work) 777-777-7777 (Mobile) 5bsybvrs@ictc.com	1 (Preferred)	Caucasian or White / Non-Hispanic

Note from Essentia Health

This document contains information that was shared with ARNETTA K Frueh. It may not contain the entire record from Essentia Health.

Reason for Visit

Reason
Recheck

Encounter Details

Date	Type	Department	Care Team
08/24/2011	Office Visit	32 AVE CLINIC NEPHROLOGY 3000 32nd Avenue South Fargo, ND 58103 701-364-8900	**Qarni, Ahmer, MD** 3000 32ND AVENUE SOUTH FARGO, ND 58103 701-364-8000 701-364-4628 (Fax)

Active Allergies and Adverse Reactions - as of 02/26/2016

Allergen	Noted Date	Severity	Reactions	Comments
Valine			Other	Nightmares

Current Medications - as of 02/26/2016

Prescription	Sig	Disp.	Start Date	End Date	Status
meclizine (ANTIVERT) 25 MG tablet	Take 1 Tab by mouth as needed for Dizziness.		04/05/2012		Active
busPIRone (BUSPAR) 10 MG tablet	Take 2 Tabs by mouth three times a day.	540 Tab	01/12/2015		Active
calcitRIOL (ROCALTROL) 0.25 MCG capsule	Take 1 Cap by mouth every 48 hours.	15 Cap	08/18/2015		Active
irbesartan (AVAPRO) 300 MG tablet	TAKE 1 TABLET BY MOUTH EVERY DAY NEEDS TO BE SEEN	90 Tab	09/13/2015		Active
escitalopram (LEXAPRO) 20 MG tablet	TAKE 1 TABLET BY MOUTH EVERY DAY	30 Tab	10/14/2015		Active
ALPRAZolam (XANAX) 0.25 MG tablet	Take 1 Tab by mouth one time a day as needed for Anxiety.	30 Tab	10/21/2015		Active
simvastatin (ZOCOR) 20 MG tablet	TAKE 1 TABLET EVERY DAY AT BEDTIME	30 Tab	10/23/2015		Active
hydrochlorothiazide 25 MG tablet	TAKE 1 TABLET BY MOUTH EVERY DAY	90 Tab	10/21/2015		Active
metoprolol succinate (TOPROL-XL) 100 MG 24 hour extended-release tablet	TAKE 1 AND 1/2 TABLET BY MOUTH AT BEDTIME	135 Tab	10/31/2015		Active

Active Problems - as of 02/26/2016

Problem	Noted Date
Lipid disorder	08/28/2015
Hyperparathyroidism due to renal insufficiency (HCC)	08/28/2015
CKD (chronic kidney disease) stage 4, GFR 15-29 ml/min (HCC)	11/15/2013
Depression with anxiety	04/05/2012
IgA nephropathy	04/05/2012
Benign essential hypertension	09/17/2009

Resolved Problems - as of 02/26/2016

Problem	Noted Date	Resolved Date
Essential hypertension	08/04/2010	04/05/2012
Anxiety	07/22/2010	04/05/2012
Chronic kidney disease, stage III (moderate)	09/21/2009	11/15/2013
Unspecified hypertensive kidney disease with chronic kidney disease stage I through stage IV, or unspecified	09/21/2009	12/19/2011
Pure hypercholesterolemia	09/17/2009	08/28/2015
Dysthymic disorder	09/17/2009	04/05/2012
Chronic kidney disease, unspecified	09/17/2009	12/19/2011

mmunizations - as of 02/26/2016

Name	Dates Previously Given	Next Due
Influenza (+3 Years) Quad NPF Vial	10/29/2015	
Pneumococcal Conjugate, (Prevnar)13-valent	10/29/2015	
Tdap >7 years	08/19/2014	

ocial History

Tobacco Use	Types	Packs/Day	Years Used	Date
Never Smoker				

ast Filed Vital Signs (In this Visit)

Vital Sign	Reading	Time Taken
Blood Pressure	151/85	08/24/2011 3:19 PM CDT
Pulse	72	08/24/2011 3:19 PM CDT
Temperature	-	-
Respiratory Rate	-	-
Oxygen Saturation	-	-
Weight	73 kg (161 lb 0.6 oz)	08/24/2011 3:19 PM CDT
Height	149.9 cm (4' 11")	08/24/2011 3:19 PM CDT
Body Mass Index	33.33	08/24/2011 3:19 PM CDT

rescriptions Ordered During Visit

Prescription	Sig.	Disp.	Start Date	End Date
irbesartan-hydrochlorothiazide (AVALIDE) 300-25 MG per tablet	Take 1 Tab by mouth one time a day.	30 Tab	08/24/2011	10/24/2011

lan of Care

Not on file

esults

Not on file

isit Diagnoses

CKD (chronic kidney disease) stage 3, GFR 30-59 ml/min - Primary

ocument Information

Primary Care Provider
Thomas Kempf (Aug. 19, 2011 - Present)
701-364-3300 (Work)
701-364-8740 (Fax)
1702 SOUTH UNIVERSITY DRIVE
FARGO, ND 58103

Custodian Organization
Essentia Health
218-786-2964 (Work)
400 East 3rd Street
Duluth, MN 55805

Encounter Providers
Ahmer Qarni (Attending)
701-364-8000 (Work)
701-364-4628 (Fax)
3000 32ND AVENUE SOUTH
FARGO, ND 58103

Document Coverage Dates
Aug. 24, 2011

Encounter Date
Aug. 24, 2011

Sandra J Cromwell

Continuity of Care Document, as of Feb. 26, 2016

Patient Demographics - Female, born Apr. 15, 1947

Patient Address	Communication	Language	Race / Ethnicity
14006 37th St SE BUFFALO, ND 58011	701-341-1683 (Home) 701-341-1683 (Mobile) crumbly@yahoo.com	1 (Preferred)	Caucasian or White / Non-Hispanic

Note from Essentia Health

This document contains information that was shared with Sandra J Cromwell. It may not contain the entire record from Essentia Health.

Reason for Visit

Reason
Consult

Encounter Details

Date	Type	Department	Care Team
09/21/2015	Office Visit	SOUTH UNIVERSITY PULMONARY MEDICINE 1702 SOUTH UNIVERSITY DRIVE FARGO, ND 58103 701-364-8900	**Jinnur, Praveen, MD** 1702 SOUTH UNIVERSITY DRIVE FARGO, ND 58103-4940 701-364-8900 701-364-4594 (Fax)

Active Allergies and Adverse Reactions - as of 02/26/2016

Allergen	Noted Date	Severity	Reactions	Comments
Dust Mite Extract	03/28/2014			
Pollen Extract	03/28/2014			
Seasonal	03/28/2014			

Current Medications - as of 02/26/2016

Prescription	Sig.	Disp.	Start Date	End Date	Status
meloxicam (MOBIC) 15 MG tablet	TAKE 1 TABLET BY MOUTH EVERY DAY WITH FOOD	30 Tab	07/20/2015		Active
prochlorperazine (COMPAZINE) 10 MG tablet	Take 1 Tab by mouth every six hours as needed for Nausea.	30 Tab	09/11/2015		Active
citalopram (CELEXA) 20 MG tablet	Take 1 Tab by mouth one time a day.	30 Tab	09/11/2015		Active
albuterol-ipratropium (COMBIVENT RESPIMAT) 20-100 MCG/ACT inhalation aerosol	Inhale 2 Puffs into the lungs four times a day. Dispense with spacer.	1 Inhaler	09/11/2015		Active

Active Problems - as of 02/26/2016

Problem	Noted Date
Pain with swallowing	12/14/2015
Small cell lung cancer, right (HCC)	11/06/2015
New onset of headaches	09/11/2015
Anxiety	09/01/2015
Primary osteoarthritis of both hands	09/01/2015

Resolved Problems - as of 02/26/2016

Problem	Noted Date	Resolved Date
Small cell carcinoma (HCC)	09/01/2015	11/06/2015

Immunizations - as of 02/26/2016

Name	Dates Previously Given	Next Due
Influenza (Historic Use Only)	10/03/2012, 09/25/2010, 10/10/2008	
Influenza Seasonal Inj A,B High Dose	10/29/2015	
Pneumovax 23	10/03/2012	
Tdap >7 years	10/03/2012	

Social History

Tobacco Use	Types	Packs/Day	Years Used	Date
Former Smoker		0.5	47	Quit: 07/17/2015
Smokeless Tobacco: Never Used				

Alcohol Use	Drinks/Week	oz/Week
No	0 Standard drinks or equivalent	0.0

Last Filed Vital Signs (In this Visit)

Vital Sign	Reading	Time Taken
Blood Pressure	110/73	09/21/2015 3:02 PM CDT
Pulse	102	09/21/2015 3:02 PM CDT
Temperature	-	-
Respiratory Rate	-	-
Oxygen Saturation	92%	09/21/2015 3:02 PM CDT
Weight	64.9 kg (143 lb)	09/21/2015 3:02 PM CDT
Height	157.5 cm (5' 2")	09/21/2015 3:02 PM CDT
Body Mass Index	24.69	09/21/2015 3:02 PM CDT

Functional Status

Functional Status	Response	Date of Assessment
Are you deaf or do you have serious difficulty hearing?	No	09/03/2015
Are you blind or do you have serious difficulty seeing, even when wearing glasses?	No	09/03/2015
Do you have serious difficulty walking or climbing stairs?	No	09/03/2015
Do you have difficulty dressing or bathing?	No	09/03/2015
Because of a physical, mental, or emotional condition, do you have difficulty doing errands alone such as visiting a doctor's office or shopping?	No	09/03/2015

Cognitive Status	Response	Date of Assessment
Because of a physical, mental, or emotional condition, do you have serious difficulty concentrating, remembering, or making decisions?	No	09/03/2015

Instructions

Patient Instructions - Johnson, Christina J, LPN - 09/21/2015 3:02 PM CDT

Thank you for choosing Essentia Health for your health care needs.

Here are a few suggestions that will help us in assuring your health care needs are met during your next visit:

· Please arrive 20 minutes before your appointment so that we can complete your registration and collect any other necessary information.

· Bring your medication bottles and an updated medication list with you for your visit.

Remember to always stop at the checkout desk at the end of your visit to schedule your next appointment and to pick up your After Visit Summary, which will contain your updated medication list.

Prescriptions Ordered During Visit

Prescription	Sig	Disp	Start Date	End Date
tiotropium (SPIRIVA HANDIHALER) 18 MCG inhalation capsule	Inhale 1 Cap into the lungs one time a day for 30 days. Remove capsule from foil blister immediately before use; place in chamber of HandiHaler Inhaler.	30 Cap	09/21/2015	10/21/2015
mometasone - formoterol (DULERA) 200-5 MCG/ACT inhalation aerosol	Inhale 2 Puffs into the lungs two times a day for 30 days.	13 g	09/21/2015	10/21/2015

Plan of Care

Upcoming Encounters

Date	Type	Specialty	Providers
03/01/2016	Appointment	Oncology	**Gupta, Mahendra, MD** 1702 SOUTH UNIVERSITY DRIVE FARGO, ND 58103 701-364-3300 701-364-6178 (Fax) **Ancillary, Sucl Infusion Lab**

Results

Not on file

Visit Diagnoses

Small cell carcinoma of lung, right (HCC) - Primary
Dyspnea
Malignant pleural effusion
Postobstructive pneumonia

Document Information

Primary Care Provider
Constance Soper (Sep. 11, 2015 - Present)
701-364-6600 (Work)
701-364-5750 (Fax)
3902 13th Avenue South
Fargo, ND 58103

Custodian Organization
Essentia Health
218-786-2964 (Work)
400 East 3rd Street
Duluth, MN 55805

Document Coverage Dates
Sep. 21, 2015

Encounter Providers
Praveen Jinnur (Attending)
701-364-8900 (Work)
701-364-4594 (Fax)
1702 SOUTH UNIVERSITY DRIVE
FARGO, ND 58103-4940

Encounter Date
Sep. 21, 2015

Sandra J Cromwell

Continuity of Care Document, as of Feb. 26, 2016

Patient Demographics - Female, born Apr. 15, 1947

Patient Address	Communication	Language	Race / Ethnicity
14006 37th St SE BUFFALO, ND 58011	701-341-1683 (Home) 701-341-1683 (Mobile) crumbly@yahoo.com	1 (Preferred)	Caucasian or White / Non-Hispanic

Note from Essentia Health

This document contains information that was shared with Sandra J Cromwell. It may not contain the entire record from Essentia Health.

Reason for Visit

Reason
Consult

Encounter Details

Date	Type	Department	Care Team
11/04/2015	Office Visit	SOUTH UNIVERSITY OTOLARYNGOLOGY 1702 South University Drive Fargo, ND 58103 701-364-8900	**Belizario, Francisco, MD** 1702 SOUTH UNIVERSITY DRIVE FARGO, ND 58103 701-364-3300 701-364-8995 (Fax)

Active Allergies and Adverse Reactions - as of 02/26/2016

Allergen	Noted Date	Severity	Reactions	Comments
Dust Mite Extract	03/28/2014			
Pollen Extract	03/28/2014			
Seasonal	03/28/2014			

Current Medications - as of 02/26/2016

Prescription	Sig.	Disp.	Start Date	End Date	Status
meloxicam (MOBIC) 15 MG tablet	TAKE 1 TABLET BY MOUTH EVERY DAY WITH FOOD	30 Tab	07/20/2015		Active
prochlorperazine (COMPAZINE) 10 MG tablet	Take 1 Tab by mouth every six hours as needed for Nausea.	30 Tab	09/11/2015		Active
citalopram (CELEXA) 20 MG tablet	Take 1 Tab by mouth one time a day.	30 Tab	09/11/2015		Active
albuterol-ipratropium (COMBIVENT RESPIMAT) 20-100 MCG/ACT inhalation aerosol	Inhale 2 Puffs into the lungs four times a day. Dispense with spacer.	1 Inhaler	09/11/2015		Active

Active Problems - as of 02/26/2016

Problem	Noted Date
Pain with swallowing	12/14/2015
Small cell lung cancer, right (HCC)	11/06/2015
New onset of headaches	09/11/2015
Anxiety	09/01/2015
Primary osteoarthritis of both hands	09/01/2015

Resolved Problems - as of 02/26/2016

Problem	Noted Date	Resolved Date
Small cell carcinoma (HCC)	09/01/2015	11/06/2015

Immunizations - as of 02/26/2016

Name	Dates Previously Given	Next Due
Influenza (Historic Use Only)	10/03/2012, 09/25/2010, 10/10/2008	
Influenza Seasonal Inj A,B High Dose	10/29/2015	
Pneumovax 23	10/03/2012	
Tdap >7 years	10/03/2012	

Social History

Tobacco Use	Types	Packs/Day	Years Used	Date
Former Smoker		0.5	47	Quit: 07/17/2015
Smokeless Tobacco: Never Used				

Alcohol Use	Drinks/Week	oz/Week
No	0 Standard drinks or equivalent	0.0

Last Filed Vital Signs (In this Visit)

Vital Sign	Reading	Time Taken
Blood Pressure	133/88	11/04/2015 8:35 AM CST
Pulse	110	11/04/2015 8:35 AM CST
Temperature	35.8 °C (96.4 °F)	11/04/2015 8:35 AM CST
Respiratory Rate	-	-
Oxygen Saturation	-	-
Weight	61.7 kg (136 lb)	11/04/2015 8:35 AM CST
Height	157.5 cm (5' 2")	11/04/2015 8:35 AM CST
Body Mass Index	24.69	11/04/2015 8:35 AM CST

Functional Status

Functional Status	Response	Date of Assessment
Are you deaf or do you have serious difficulty hearing?	No	09/03/2015
Are you blind or do you have serious difficulty seeing, even when wearing glasses?	No	09/03/2015
Do you have serious difficulty walking or climbing stairs?	No	09/03/2015
Do you have difficulty dressing or bathing?	No	09/03/2015
Because of a physical, mental, or emotional condition, do you have difficulty doing errands alone such as visiting a doctor's office or shopping?	No	09/03/2015

Cognitive Status	Response	Date of Assessment
Because of a physical, mental, or emotional condition, do you have serious difficulty concentrating, remembering, or making decisions?	No	09/03/2015

Plan of Care

Upcoming Encounters

Date	Type	Specialty	Providers
03/01/2016	Appointment	Oncology	**Gupta, Mahendra, MD** 1702 SOUTH UNIVERSITY DRIVE FARGO, ND 58103 701-364-3300 701-364-6178 (Fax) **Ancillary, Sucl Infusion Lab**

Results

Not on file

Visit Diagnoses

Dysphonia - Primary

Unilateral complete paralysis of vocal cord

Document Information

Primary Care Provider

Constance Soper (Sep. 11, 2015 - Present)
701-364-6600 (Work)
701-364-5750 (Fax)
3902 13th Avenue South
Fargo, ND 58103

Document Coverage Dates

Nov. 04, 2015

Custodian Organization

Essentia Health
218-786-2964 (Work)
400 East 3rd Street
Duluth, MN 55805

Encounter Providers

Francisco Belizario (Attending)
701-364-3300 (Work)
701-364-8995 (Fax)
1702 SOUTH UNIVERSITY DRIVE
FARGO, ND 58103

Encounter Date

Nov. 04, 2015

Sandra J Cromwell

Continuity of Care Document, as of Feb. 26, 2016

Patient Demographics - Female, born Apr. 15, 1947

Patient Address	Communication	Language	Race / Ethnicity
14006 37th St SE BUFFALO, ND 58011	701-341-1683 (Home) 701-341-1683 (Mobile) crumbly@yahoo.com	1 (Preferred)	Caucasian or White / Non-Hispanic

Note from Essentia Health

This document contains information that was shared with Sandra J Cromwell. It may not contain the entire record from Essentia Health.

Reason for Visit

Reason
Lung Cancer

Encounter Details

Date	Type	Department	Care Team
01/26/2016	Office Visit	SOUTH UNIVERSITY MEDICAL ONCOLOGY 1702 South University Drive Fargo, ND 58103 701-364-8900	**Boehlke-Fiecke, Brittani R, PA-C** 1702 SOUTH UNIVERSITY DRIVE FARGO, ND 58103-4940 701-364-3300 701-364-6178 (Fax)

Active Allergies and Adverse Reactions - as of 02/26/2016

Allergen	Noted Date	Severity	Reactions	Comments
Dust Mite Extract	03/28/2014			
Pollen Extract	03/28/2014			
Seasonal	03/28/2014			

Current Medications - as of 02/26/2016

Prescription	Sig.	Disp.	Start Date	End Date	Status
meloxicam (MOBIC) 15 MG tablet	TAKE 1 TABLET BY MOUTH EVERY DAY WITH FOOD	30 Tab	07/20/2015		Active
prochlorperazine (COMPAZINE) 10 MG tablet	Take 1 Tab by mouth every six hours as needed for Nausea.	30 Tab	09/11/2015		Active
citalopram (CELEXA) 20 MG tablet	Take 1 Tab by mouth one time a day.	30 Tab	09/11/2015		Active
albuterol-ipratropium (COMBIVENT RESPIMAT) 20-100 MCG/ACT inhalation aerosol	Inhale 2 Puffs into the lungs four times a day. Dispense with spacer.	1 Inhaler	09/11/2015		Active

Active Problems - as of 02/26/2016

Problem	Noted Date
Pain with swallowing	12/14/2015
Small cell lung cancer, right (HCC)	11/06/2015
New onset of headaches	09/11/2015
Anxiety	09/01/2015
Primary osteoarthritis of both hands	09/01/2015

Resolved Problems - as of 02/26/2016

Problem	Noted Date	Resolved Date
Small cell carcinoma (HCC)	09/01/2015	11/06/2015

Immunizations - as of 02/26/2016

Name	Dates Previously Given	Next Due
Influenza (Historic Use Only)	10/03/2012, 09/25/2010, 10/10/2008	
Influenza Seasonal Inj A,B High Dose	10/29/2015	
Pneumovax 23	10/03/2012	
Tdap >7 years	10/03/2012	

Social History

Tobacco Use	Types	Packs/Day	Years Used	Date
Former Smoker		0.5	47	Quit: 07/17/2015
Smokeless Tobacco: Never Used				

Alcohol Use	Drinks/Week	oz/Week
No	0 Standard drinks or equivalent	0.0

Last Filed Vital Signs (In this Visit)

Vital Sign	Reading	Time Taken
Blood Pressure	130/70	01/26/2016 10:17 AM CST
Pulse	81	01/26/2016 10:17 AM CST
Temperature	35.7 °C (96.2 °F)	01/26/2016 10:17 AM CST
Respiratory Rate	20	01/26/2016 10:17 AM CST
Oxygen Saturation	-	-
Weight	61.2 kg (135 lb)	01/26/2016 10:17 AM CST
Height	-	-
Body Mass Index	25.09	01/26/2016 10:17 AM CST

Functional Status

Functional Status	Response	Date of Assessment
Are you deaf or do you have serious difficulty hearing?	No	09/03/2015
Are you blind or do you have serious difficulty seeing, even when wearing glasses?	No	09/03/2015
Do you have serious difficulty walking or climbing stairs?	No	09/03/2015
Do you have difficulty dressing or bathing?	No	09/03/2015
Because of a physical, mental, or emotional condition, do you have difficulty doing errands alone such as visiting a doctor's office or shopping?	No	09/03/2015

Cognitive Status	Response	Date of Assessment
Because of a physical, mental, or emotional condition, do you have serious difficulty concentrating, remembering, or making decisions?	No	09/03/2015

Instructions

Patient Instructions - Grode, Alexandria, LPN - 01/26/2016 10:18 AM CST

Thank you for choosing Essentia Health for your health care needs.

Here are a few suggestions that will help us in assuring your health care needs are met during your next visit:

· Please arrive 20 minutes before your appointment so that we can complete your registration and collect any other necessary information.

· Bring your medication bottles and an updated medication list with you for your visit.

Remember to always stop at the checkout desk at the end of your visit to schedule your next appointment and to pick up your After Visit Summary, which will contain your updated medication list.

Plan of Care

Upcoming Encounters

Date	Type	Specialty	Providers
03/01/2016	Appointment	Oncology	**Gupta, Mahendra, MD** 1702 SOUTH UNIVERSITY DRIVE FARGO, ND 58103 701-364-3300 701-364-6178 (Fax) **Ancillary, Sucl Infusion Lab**

Results

Not on file

Visit Diagnoses

Small cell lung cancer, right (HCC) - Primary

Cough

Document Information

Primary Care Provider
Constance Soper (Sep. 11, 2015 - Present)
701-364-6600 (Work)
701-364-5750 (Fax)
3902 13th Avenue South
Fargo, ND 58103

Custodian Organization
Essentia Health
218-786-2964 (Work)
400 East 3rd Street
Duluth, MN 55805

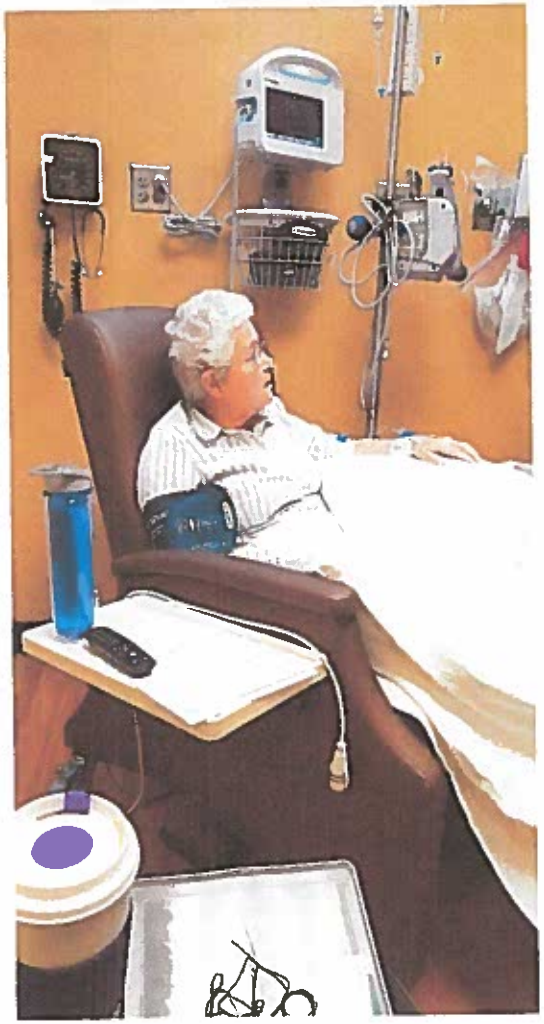
Encounter Providers
Brittani R Boehlke-Fiecke (Attending)
701-364-3300 (Work)
701-364-6178 (Fax)
1702 SOUTH UNIVERSITY DRIVE
FARGO, ND 58103-4940

Document Coverage Dates
Jan. 26, 2016

Encounter Date
Jan. 26, 2016

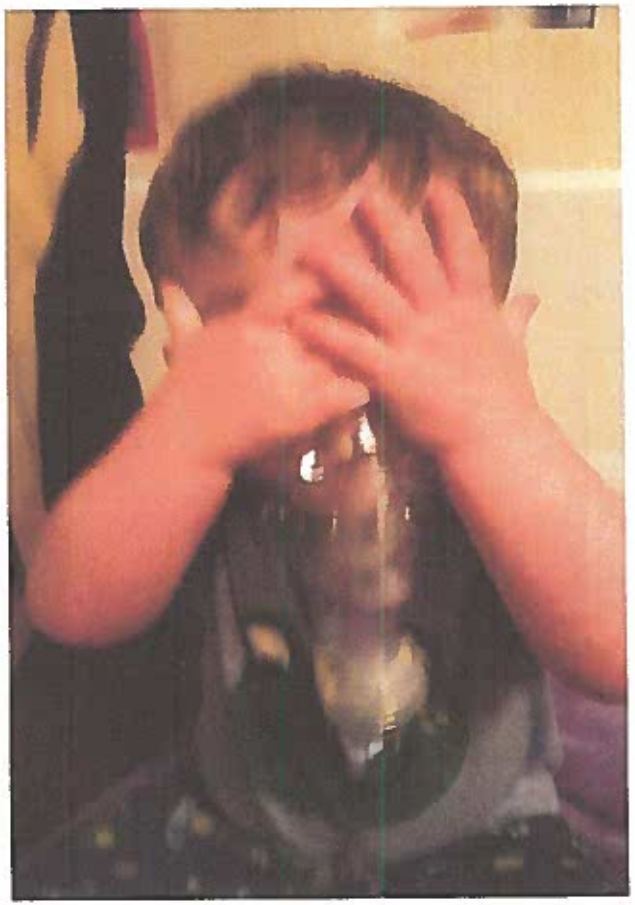
This is a picture of my mom Sandra Cromwell in joying the outdoors on the farm with my husband. We find many fun activities to do outdoors after the long winters. Not much time is spent indoors This picture was taken the summer before. Date is wrong. My mom lives with us in an apt. that we made for her in the lower level of our home.

This is my mom being loaded two days after finding out that she has small cell lung cancer. We made three more emergency trips because her oxygen was down so low before she stated her chemo treatments.



This first picture is of my mom on her first day of chemo treatments. She had treatment for three days a week, every other week for a total of nine treatments. She then had radiation every day for another six weeks after her chemo treatments. The second picture of her is seven days after her first chemo treatment. Her treatments were just to give her comfort to the end. We go back in April for scans to see if the cancer has spread. We do not know how long that we have together, but we want her to enjoy her time to the end.

This first picture is of Gavin (the littlest) with his first cousin Spencer at Grandma and Grandpas house enjoying the outdoors on their toys. The second picture is Gavin and Spencer with REAL motor toys at Grandma and Grandpas. This is last summer (2015). The date is wrong on camera, again. The children spend many days outside when they come to our home. Gavin lives in Fargo in an apt. with his mommy and doesn't get to go out much because there is no were to go, so his mommy brings out. I also watch him when mommy works weekend. Gavin can spend up to three days a week out here. Spencer is a first grader that loves being outside. I watch him after school till a parent gets home. I care for Spencer in the summer when school is out. He also lives on our property in a separate home.



This is a picture of Gavin playing in a little plastic house that we have on the farm. The second picture is of Gavin playing peek- a- boo while getting his nebulizer treatment. He isn't diagnosed with anything yet because he's to young, but is still doctoring to help keep his oxygen levels normal. The first picture was last summer and the second picture was Feb. 14th, 2016.

The date is right on the first picture for both of the pictures. The first picture is of spencer showing how many peas we picked out of the garden that he and I were growing. The second is a picture of Spencer playing in the sand box Grandpa made for him. The air is fresh, and the sand is cool and clean.

ENVIRONMENTAL HEALTH

Understanding Concentrated Animal Feeding Operations and Their Impact on Communities

N A T B O H

National Association of Local Boards of Health

000389

Understanding Concentrated Animal Feeding Operations and Their Impact on Communities

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- *What is a CAFO*
- *Hazards to Human Health*
- *Environmental Damage*
- *Local Economy Degredation*
- *More on the Issues*
- *Take Action*
- *News Articles*

The Issues

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Confined animal feeding operations (CAFOs) have a bad rep - and with good reason. These giant livestock factories cause a multitude of health, environmental, economic, and quality of life problems.

What is a CAFO?

A confined animal feeding operation (CAFO) is a giant livestock factory in which hundreds or thousands of animals are housed and fed in large confinement buildings. The animals have barely any room to move and no opportunity to pasture. In Iowa, CAFOs are predominately hog operations, but chicken, turkey and cattle operations are found in the state, too.

In hog confinements, the pigs stand on slatted floors and their wastes fall into huge lagoons beneath the confinement. These waste pits store anywhere from hundreds of thousands to millions of gallons of liquid manure for months at a time.

Because of the nature of the waste pits, the manure putrefies, emitting toxic ammonia and hydrogen sulfide gases. These gases are so harmful that farm workers have died from asphyxiation when they entered an improperly vented CAFO.

Even without accidents, the noxious gases negatively affecting neighbors when they escape into the environment. Eventually, the liquid manure is applied onto agricultural fields as fertilizer, further disturbing people who don't even live near CAFOs.

Because of the many problems associated with CAFOs, the American Public Health Association called for a moratorium on all new factory farms back in 2003. More recently, a two-year study released in 2008 study by the Pew Commission on Industrial Farm Animal Production outlined the risks of industrial agriculture.

There are many reasons to be concerned if there is a CAFO in your community.

Hazards to Human Health

The byproducts of manure and the rampant use of antibiotics pose a serious health threat to communities with CAFOs.

- The ammonia and hydrogen sulfide gases produced by stagnating liquid manure can cause respiratory problems, nausea, diarrhea, headaches, burning eyes, confusion, tension, depression, and fatigue.
- A University of Iowa study found children are particularly susceptible to asthma.
- Unsanitary, crowded confinements can become a breeding ground for disease. To fend off infections, non-therapeutic antibiotics are added to livestock feed. According to the Union of Concerned Scientists, over 70% of all antibiotics used in the US are fed to livestock for preventive care as well as to boost growth rates.
- In 2001, the American Medical Association has warned in that the rampant use of antibiotics in factory farms is contributing to the evolution of antibiotic-resistant bacteria, which it

considers a serious impending health crisis. We are now starting to see the emergence of deadly strains of antibiotic-resistant bacteria.

- A University of Iowa study published in 2009 has linked MRSA (methicillin-resistant *Staphylococcus aureus*) to factory farms, finding a new strain, ST398, in 70% of hogs and 64% of swine workers in one Midwest facility.
- In Holland, it's been reported that 60% of all pigs are infected with ST398 and 30-40% carry the bacteria in either their respiratory tract or skin. A Dutch government study found MRSA ST398 in 10% of its slaughtered pork and a Dutch journal also reported on a woman not associated with hog farms that contracted MRSA ST398 while hospitalized.
- Similarly, a Worldwatch Institute report linked Avian Flu to the location of large-scale poultry production to nearby cities.
- In 2007, the Food and Agricultural Organization of the United Nations (FAO) warned, "excessive concentration of animals in large scale industrial production units should be avoided."

Environmental Damage

Animal feeding operations produce enormous amounts of manure - 100 times more than the amount of human sewage sludge processed in US municipal wastewater plants. Communities with CAFOs see the their streams, creeks, and ponds deteriorate as nitrogen, phosphorus, microbes, ammonia and antibiotics from liquid manure pollute their waterways.

- Lagoon leaks and manure misapplied on fields can pollute streams and well water of nearby residences.
- Agricultural runoff from spreading manure on crop fields wind up in local waterways from heavy rains and melting snow.
- Accidental manure spills dump high volumes of toxins into waterways causing serious water pollution and fish kills, not to speak of making streams, ponds, and lakes unsuitable for recreational use.
- Since manure contains antibiotics, antibiotic-resistant genes are spreading through waterways. A study conducted at the University of Illinois discovered that some antibiotic-resistant genes found in manure lagoons are transferred "like batons" from one species of bacteria to another.

Local Economy Degradation

- Property owners see the value of their homes and property decrease as much as 30-40% when CAFOs move into an area. One factory farm forces an average of 10 family farms out of business. County economies can weaken as people move away; local businesses lose vitality, and sales and property taxes plummet.
- Hog laden tractor-trailers drive over roads not built to accommodate their heavy weight or frequent trips. The result is the physical deterioration of a community's physical infrastructure. And who winds up paying for repairs? Local communities do, with local taxpayers experiencing higher taxes and reduced local services as communities struggle to keep up with the extra maintenance.
- What about the economic benefits of factory farms to local communities? There aren't many. Few new jobs are created, new building construction materials are often outsourced, and the hog corporations, which are usually located out-of-state, pay no taxes to the community.
- In fact, counties that experienced increasing numbers of CAFOs did not see increased levels of economic development. They also may have lost the opportunity to strengthen their economies with other development projects, says an Iowa Policy Project study conducted by Iowa State University.

Loss of Quality of Life

For many people, what was once a family's cherished home or a retired couple's dream house becomes a prison. Many neighbors of CAFOs report they are unable to leave their homes to enjoy their yards, gardens, or outdoor activities because of the gagging, nauseating odors or overwhelming fly infestations the confinements produce. CAFOs are definitely not good neighbors.

More information on The Issues:

Human Health Hazards Articles
Environmental Impact Articles
Air Pollution and Odor
Water Pollution
Waste
Socioeconomics Articles

Take Action Today!

In many counties throughout Iowa, and throughout many states, the proliferation of CAFOs and the lack of adequate governmental regulations is causing a serious environmental problem, injuring air quality, water quality, and the quality of life for those who live in the vicinity. If this is OK with you, do nothing. However, if you would like to help insure the quality of your environment and your ability to enjoy life in Iowa, there are some simple steps you can take that will help make a difference.*

1. Educate Yourself*
Read articles on this site and articles linked on the many pages of this site. The 30 minutes plus you spend reading will make you an informed citizen and voter. You will understand the issues, the threat to your quality of life, and what needs to happen to protect your quality of life. Sitting on the sidelines is not an option, unless you're comfortable living next to a CAFO and not caring how your community may be affected over time.

2. Contact Elected Officials*
Although they are supposed to be representing the interests of their constituents, they are clearly influenced by agri-business campaign contributions and agribusiness-funded political action committees (PACs). If they don't hear from you, they assume you're happy with the job they are doing and the way they vote. If you DO make the effort to contact them, your voice is amplified many times, as so few people make the effort. This page has all of the contact information, the rest is up to you!

3. Talk to your Neighbors*
Many people are either not informed or are ill-informed. Make the effort to visit with your neighbors; find out their position, and help them find the information they need to develop informed positions.

4. Report Suspicious Activity*
Call Iowa Citizens for Community Improvement at 515-282-0484 immediately if you see what might be a CAFO being constructed or if you see what might be an illegal manure dumping.

5. Consider Legal Action
Unfortunately in today's world, legal action is often the only option that will stop a CAFO in its tracks. David E. Sykes, P.C. offers litigation services for individuals and communities who are impacted by a CAFO in their neighborhood and are seeking to protect their families quality of life and declining property values.

**From the Jefferson County Farmers & Neighbors, Inc. website.*

More Information on Factory Farming

There is no shortage of studies and reports by well-respected institutions and organizations on the damaging impacts of factory farms. Jefferson County Farmers & Neighbor, Inc. has compiled

numerous articles and reports on the negative effects of factory farming on one's health, property values, quality of life, community, and the environment.

It's crucial to become educated on factory farming to learn how they can affect you and your family. These reports and articles will give you a solid education on the problems associated with confined animal feeding operations and why they are a bad idea for neighbors and communities.

< Back to Legal Information

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GPSOLO July/August 2009

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BACK TO *GPSOLO* MAGAZINE'S HOMEPAGE

Agricultural Animals and the Law

By Katherine Hessler and Tanith Balaban

The legal issues surrounding agriculture and livestock farms have undergone vast changes through the last 50 years. These changes were heralded by Earl L. Butz, secretary of agriculture under Presidents Richard Nixon and Gerald Ford, who said that farming "is now a big business" and the family farm "must adapt or die" by expanding into large operations reliant on industrial pesticides, herbicides, and fertilizers. Whether this is true or not is open to debate.

What is not open for debate is that the shift from small to large farms has been dramatic and has led to a panoply of legal issues. These include habitat loss and degradation; soil erosion and sedimentation; water resources depletion; soil and water salinization; agrochemical releases; nonpoint water pollution through runoff from fields and livestock operations; chemical air pollution; antibiotic resistant bacteria; salmonella, E. Coli, and Pfiesteria outbreaks; increased injury to workers; and the development of inhumane animal management practices.

Because the trend is toward larger farms and livestock operations, it is unlikely that a solo or small firm practitioner will represent the larger companies. Instead the solos and small firm lawyers will more likely represent someone complaining about intensive farming practices and must address numerous legal issues, including the impact on land values and the environment as well as concerns of neighbors.

Approximately 10 billion land animals are raised and killed for meat, eggs, and milk each year. Of those 10 billion animals, about 35 million cattle are raised for beef, 9 million for milk, and 1 million for veal. Approximately 95 percent (9.5 billion) of the animals in food production are birds.

Most Americans today get their food from a system that raises animals in intensive confinement—several thousand pigs or tens of thousands of chickens per barn. This system of livestock husbandry is called either an animal feeding operation (AFO) or a concentrated (or confined) animal feeding operation (CAFO) and is commonly known as factory farming. This new system for raising animals for food results in new problems for consumers, neighbors of the operations, the environment, workers, and the animals. Intensive animal crowding indoors is not the traditional form of livestock husbandry and has led the industry to create new techniques in animal handling to make the business more efficient. These new systems also lead to problems that may result in legal issues.

For example, a single hog farm with 10,000 animals will

produce as much waste as a city with a population of 100,000 people. The question of waste disposal becomes one of the central concerns for a factory farm. And the phenomenally high concentration of waste results in bad odors, flies, and chemical and infectious compounds in the air or water runoff sufficient to create significant health and environmental problems. The U.S. Centers for Disease Control and Prevention (CDC) state that in 2003, the nation's 238,000 feeding operations produced 500 million tons of manure. (For more, see the CDC's web page on concentrated animal feeding operations: www.cdc.gov/cafos /about.htm. See also the U.S. Environmental Protection Agency's web page on national pollutant discharge elimination systems: http://cfpub.epa.gov/npdes /home.cfm?program_id=7.)

The overcrowded conditions of the animals create additional problems for the industry, its neighbors, and consumers. The stressful conditions for the animals result in illness and injury. One way factory farmers address the illness problem is to treat *all* the animals with sub–therapeutic levels of antibiotics. This reduces illness among the animals but may contribute to the creation of antibiotic–resistant diseases. The stress of overcrowding can cause the animals to fight among themselves, leading to injury or death. To address these concerns, factory farmers de–beak chickens so they cannot peck at each other and dock the tails of pigs; both procedures are done without anesthesia. Because of the enormous numbers of animals in each barn, the animals typically do not ever leave the barn and are fed automatically, reducing the time people spend tending to them. This results in long delays before dead animals are removed from the midst of the other animals. All of these practices result in concerns for food safety, environmental protection, animal welfare, and the value of adjacent properties.

Federal Legislation

Clean Water Act. On factory farms, raising livestock implicates the Clean Water Act (CWA), which governs the operations of AFOs and CAFOs. In order for an agricultural operation to be considered a CAFO, a facility must first be defined as an AFO.

AFOs are agricultural operations where animals are kept and raised in confined situations. AFOs congregate animals, feed, manure, dead animals, and production operations on a small land area instead of an operation where cattle are allowed to range for food in pastures. AFOs are defined as facilities where animals are confined and fed for 45 or more days in any 12–month period and vegetation or forage is not sustained in the normal growing season over any portion of the lot or facility.

Under the CWA, CAFOs are split into large, medium, and small sizes depending on the number and type of animals, the contact with surface water, and the extent to which the facility could pollute surface and groundwater. Federal regulations require CAFOs to obtain a permit and to develop

plans designed to keep animal waste from contaminating surface water and groundwater. It is important to note there is no private right of action contained within the CWA. Instead, any aggrieved party must file a complaint with the Environmental Protection Agency (EPA).

Clean Air Act. The Clean Air Act (CAA) is also relevant because of the significant amount of chemicals released into the air from CAFOs. These releases come from the barns where the animals are housed as well as from manure lagoons and other waste sites. Methane, hydrogen sulfide, nitrogen, and ammonia are released in significant quantities and can lead to air and water pollution and illness.

Within the CAA are two additional areas of focus for CAFOs. The first is the Comprehensive Environmental Response, Compensation, and Liability Act, and the second is the Emergency Planning and Community Right–to–Know Act. These statutes and related regulations require factory farms to report their emissions of ammonia and hydrogen sulfide when they emit more than 100 pounds per day. Industry response to the reporting requirements has been strong, and it is not clear whether the EPA will stand by them or will weaken or eliminate them.

Other federal statutes. There is no federal legislation regulating the conditions of animals being raised on farms. Federal law focuses primarily on the integrity of the food supply.

The Animal Health Protection Act allows for the quarantine, destruction, and disposal as well as restriction of transit of diseased livestock. The Animal Disease Risk Assessment, Prevention, and Control Act of 2001 requires a report on foot–and–mouth disease, bovine spongiform encephalopathy (BSE—also known as "mad cow disease"), and related diseases. The Animal Enterprise Terrorism Act makes it a crime to travel in interstate commerce or use the mail for the purpose of damaging or interfering with any animal enterprise (including farms). The Commercial Transportation of Equine for Slaughter Act regulates the commercial transportation of equine for slaughter. The Humane Slaughter Act provides acceptable methods of slaughter of animals to be used as food; it exempts birds. The Twenty–Eight Hour Law restricts the transportation of animals such that they may not be confined in a vehicle for more than 28 consecutive hours without unloading them for feeding, water, and rest, with some exceptions that extend the time; birds are not covered.

State Constitutional Protections

Some state constitutions, including those of New York, Hawaii, and Nebraska, contain provisions protecting traditional ways of life, including hunting, fishing, and farming. Thus, depending on the state, a livestock owner may have state constitutional protection.

Other state constitutions contain provisions specifically addressing protections for animals. For example, Florida has

a constitutional provision to protect pigs, and in 2008 California passed Proposition 2 prohibiting veal crates, battery cages, and sow gestation crates that do not allow animals to turn around freely, lie down, stand up, and fully extend their limbs.

State Legislation

All 50 states have animal cruelty statutes. However, most of these statutes explicitly exempt common farming practices. Oregon's anticruelty statute is somewhat different because it exempts only "good" farm practices and has no farm exemption for intentional or knowing torture or the malicious killing of an animal.

Some states are now considering whether to require minimum standards of care. Most notably, New Jersey requires humane standards for the care of farm animals. This statute was challenged in *New Jersey Society for the Prevention of Cruelty to Animals v. New Jersey Department of Agriculture*, 2008. The question presented was whether certain practices could be deemed humane. The court said that the New Jersey Department of Agriculture was required to do more than accept currently used practices: Their job was to identify and allow only those practices that met a humane standard, and they had failed to do that. The court accepted the agency's decision with respect to certain practices but deemed that its blanket exemption of routine practices was an abuse of the interpretive process because the statute requires humane practices.

This is an area likely to see additional development across the country and bears watching.

Right–to–Farm Laws

One aspect that filters into every legal issue surrounding livestock farming is right–to–farm laws (RTFs). RTFs have been adopted in all 50 states. This is important because RTFs modify the law of nuisance (discussed below).

Generally RTFs cover the growing and harvesting of crops; the feeding, breeding, and management of livestock; and other agricultural and horticultural activities. However, many RTFs apply only to commercial activities, so hobbyists or non–farmers do not qualify for the nuisance protection.

Although RTFs modify nuisance laws, they do not have any impact on environmental laws or pollution legislation. Thus, producers must comply with legislation governing clean water and the disposal of animal manure, absent agricultural exemptions. In addition, negligent or improper operation at an agriculture facility is not protected.

Generally, lawsuits against people or companies raising livestock have two points of entry—when the enterprise first starts and when the operation changes or expands the nature or size of its operation.

Public and Private Nuisance Actions

Nuisance is a use of property that causes injury to others

and comes in two forms: private and public. A private nuisance is one that affects the use or enjoyment of land; normally it is privately enforced through a tort action for damages. A public nuisance affects the public at large, does not need to be connected to the land, and is normally enforceable by public officials. However, a public nuisance can give rise to a parallel private nuisance action if private lands are also affected.

As previously stated, the law of nuisance may be modified by RTFs. Common RTFs state that a farming operation shall not be considered or come to be considered a nuisance if it was not a nuisance at the time it began operation, even if conditions change in the surrounding area. Usually the agricultural use must have been in place for one year.

These RTFs modify the traditional "coming to the nuisance" rule—creating an implicit negative easement, prohibiting development on surrounding property and preventing adjacent property owners from suing to prohibit or modify the use as an agricultural nuisance.

In other cases, some courts will consider priority in time as an important factor in nuisance cases and may hold against a plaintiff who "came to a nuisance."

These laws do not always protect a farm once its use changes or expands. For example, if an owner raised livestock but then added a slaughterhouse or a processing plant at a later date, this expanded use may not be protected. It is also not clear how the RTFs would affect a dispute between a small farm and a large one.

Another limitation on RTFs may require that the farm engage in good agricultural practices as a condition to protection under the RTFs. However, "good practices" is not usually a defined term. Perhaps further developments will clarify this dialogue.

Nuisance actions are considered a supplement to regulation and litigation under the environmental laws. Nuisance actions may be precluded if Congress intended an environmental statute to be the exclusive remedy for a particular offensive use or condition, or if the alleged nuisance has received (or is eligible for) a state or federal permit to operate.

Zoning Issues

Zoning is another issue for those who raise livestock. Some communities concerned with the development potential of existing agricultural lands can, and have, adopted zoning laws that are designed especially to protect open tracts of land. This may affect individuals trying to sell their property.

For example, a community may adopt a large lot zoning structure that requires minimum lot sizes to be at least ten to 25 acres per housing unit. There may be other protections such as mandatory cluster design, open space residential design, and transfer of development rights.

Other zoning issues may arise when communities restrict the type or number of animals allowed on a property. It may be unlawful to picket livestock or allow livestock to roam in close proximity with residences or commercial buildings where foodstuff is prepared, kept, or sold.

In addition, some city zoning may not allow roosters, may bar swine, and may limit the number of animals that may be raised as food, such as chickens and rabbits, within the city limits.

Other Issues

Many legal issues arise as a result of factory farming and some are now just beginning to be explored. These issues include, but are not limited to, the demand for organic and locally produced livestock and produce, concern over heavy use of antibiotics fed to livestock (about 70 percent of anti–biotics sold in the United States are given to healthy livestock), and disease outbreaks. From this arises a host of legal issues, including nutrition, conservation, genetic engineering, food safety, animal cruelty, insurance policies for farmers, school lunch programs, water quality, cloning, organic farming, and much more.

This may be a rapidly changing area of law in the coming years. Before he was elected president, Barack Obama talked about the need to change agribusiness, boost organic farming, and promote local and regional food systems. President Obama appointed Tom Vilsack, the former governor of Iowa, to be secretary of agriculture. Vilsack has talked about reducing subsidies to megafarms and supports better treatment of farm animals.

Conclusion

In the end, no agricultural operation should ignore good neighborly relations, adequate buffers from neighboring residences and setbacks from boundary lines and water sources (creeks, wells, and ponds), humane animal husbandry, the health consequences of their actions, and compliance with all environmental laws. The manner in which CAFOs attend to these issues (or fail to do so) will likely be a subject of increasing interest for the legal community in the years to come.

Katherine Hessler is the director and clinical professor for the Center for Animal Law Studies at Lewis and Clark Law School, Portland, Oregon; she may be reached at khessler@lclark.edu. Tanith Balaban is a member of the Oregon State Bar; she may be reached at tbalaban@gmail.com.

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Breaking News on the Global Animal Feed Industry

Impending US swine farm looks to source local feed

By Aerin Curtis, 19-Jan-2016

Related topics: Manufacturers, Suppliers, Markets, Swine

A new swine facility is seeking to find answers to questions from neighbours as it works to source local feed and build in Buffalo, North Dakota.

When completed, the breeding facility operated by Minnesota-based Pipestone Systems would house about 6,500 breeding sows along with young piglets and replacement gilts, said Barry Kerkaert, president of Pipestone Grow Finish.

Piglets would be removed after about 23 days and relocated with the farmers in Minnesota and Iowa who own the farm, he said. The group is still looking for farmers willing to participate from North Dakota.

The $15m project would look to source local feed and feed ingredients, he told us. The feedstuffs include corn, dried distillers grains with solubles, 900 tons of soymeal and 300 tons of other feed ingredients.

"The estimated total feed cost is more than $2m a year and will be sourced locally," he said. *"But we don't have a specific supplier identified at this point."*

Project details

The facility will sit on about 35 acres, including roads and a grove of trees, said Kerkaert. A series of buildings will house the animals, offices, feed and storage and a composting area.

In addition to building costs there would be an additional $4m involved in establishing the livestock production, he said. When operational it should employ about 17-20 full time workers and several part-time positions.

The group is looking to expand into North Dakota after being contacted by the state commissioner of agriculture and asked to bring in a facility, he said. *"They have grains to be fed, and people, and population, and good infrastructure,"* he added.

Additionally, the location offers good bio security as there are not many pigs in the area, he said.

Community questions

The group has had one information meeting with area residents, said Kerkaert. The facility also is moving through the application process and is currently in the comment period for its application to the health department.

"There hasn't been any agricultural development with livestock for 20 years and though they had it when they were younger, it is something they're not familiar with so they have a lot of concerns," he said of the questions the group has received.

The company runs about 56 other, similar facilities, and have more than 300 farm families involved in the process, he said. And the group has been operating for about 25 years, he said.

"We try to instill confidence in the people," he said. *"We do know what we're doing. These facilities are designed to last 40 years, and these farmers that have chosen to invest in those communities are proud [of them] and will take care of those facilities."*

The group fielded questions from the public that predominately dealt with concerns about the smell from the facility, the possibility of flies and road damage, said Kerkaert.

There will be an odor to the facility, as there is with any livestock operation, he said. However, the group will do what it can to mitigate the smell.

Precautions include that all animal waste will be maintained underground in concrete tanks, he said. There won't be earthen lagoons or outdoor storage pits.

"We'll sign a road haul agreement and we'll be maintaining the road in as good or better condition than it was when we came," he said.

There will be flies attracted to the facility and animals, he said, however, the group has had experience in managing pests.

"We have insect management control programs and flies don't fly away, they stay close to the food source," he said. *"It shouldn't be a risk to the neighbors. It's in our interest to control it."*

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North Dakota Department of Health and Water Quality

My name is Gerald Marcks, I was born in the same bedroom that I sleep in now, 77 years later. My Granddad and Dad farmed this land for 90 plus years, before I bought my Dad out. I've farmed since a sophomore in high school. I have been involved with milk cows, beef cattle and hogs in earlier years. I'm, still farming today, as I still enjoy the benefits of being my own boss and seeing what the next years bring.

The last 10-12 years I've had heart disease, two minor heart attacks, triple bypass surgery, two stents put in and have a leaky valve. I take a lot of meds for these conditions. High blood pressure, bad cholesterol, blood thinners and others. Part of my health routine is walking and staying active. I'm concerned that this hog factory will be detrimental to my well being. All my farm land lies within two and a half miles from the planned site and my farm house is a mile and a half away. With all the air pollution (hydrogen sulfide, ammonia, methane, endotoxins, carbon dioxide and particulate matter) that will be released into the area, I am very concerned for my health.

One quarter of my land is only 80 feet from the proposed hog factory. Excess runoff water from the site goes across this land and another quarter that I farm is just across a township road 1860 feet away. If this isn't enough, my neighbors will be applying manure on 1140 acres all around me - north, east and west. All 1500 acres that I farm will be impacted.

I hope you people at the ND Department of Health and Water Quality will address our concerns and deny this permit!!!!!!!

Thank you for your time,

Gerald Marcks

Gerald Marcks

FAM MED WEST FARGO SC
SANFORD WEST FARGO CLINIC
1220 Sheyenne St
West Fargo ND 58078
701-234-4445

March 8, 2016

GERALD DEAN MARCKS
PO BOX 121
BUFFALO ND 58011

TO WHOM IT MAY CONCERN:

This is to certify that Gerald Dean Marcks has been an established patient at this clinic. He has the following cardiac related chronic health conditions based on a search of his records:

Coronary artery disease
Essential hypertension
Hyperlipidemia.

Sincerely,

Matthew J McLeod, MD

Name: Gerald Dean Marcks | DOB: 8/6/1938 | MRN: E2199749 | PCP:

Health Summary

Current Health Issues

Health Issue	Date Noted
Coronary atherosclerosis	
Postsurgical aortocoronary bypass status	04/03/2007
Essential hypertension, benign	
Encounter for long-term (current) use of other medications	
Mixed hyperlipidemia	12/10/2010
Obesity	
Disorder of bursae and tendons in shoulder region	06/30/2011
Gout	02/07/2012

Medications

cyclobenzaprine 10 mg tablet
Commonly known as: FLEXERIL
Instructions: Take 1 tablet by mouth 3 times a day as needed for muscle spasm
Approved by Matthew J McLeod, MD
Prescribed on 3/15/2016
Prescribed quantity: 60 tablets
Request a renewal

metoprolol tartrate 50 mg tablet
Commonly known as: LOPRESSOR
Instructions: Take 1 and 1/2 tablets 2 times a day
Approved by Bruce Dahl, MD
Prescribed on 6/12/2015
Prescribed quantity: 270 tablets
Request a renewal

candesartan 16 mg tablet

Commonly known as: ATACAND

Instructions: Take 1 tablet by mouth 1 time per day.

Approved by Bruce Dahl, MD
Prescribed on 6/12/2015
Prescribed quantity: 90 tablets

Request a renewal

clopidogrel 75 mg tablet

Commonly known as: PLAVIX

Instructions: Take 1 tablet by mouth 1 time per day.

Approved by Bruce Dahl, MD
Prescribed on 6/12/2015
Prescribed quantity: 90 tablets

Request a renewal

allopurinol 300 mg tablet

Commonly known as: ZYLOPRIM

Instructions: Take 1 tablet by mouth every day for gout

Approved by Bruce Dahl, MD
Prescribed on 6/12/2015
Prescribed quantity: 90 tablets

Request a renewal

atorvaSTATin 20 mg tablet

Commonly known as: LIPITOR

Instructions: Take 1 tablet by mouth every day in the evening

Approved by Bruce Dahl, MD
Prescribed on 6/12/2015
Prescribed quantity: 90 tablets

Request a renewal

omega-3 fatty acids 1200 MG capsule

Commonly known as: fish oil

Instructions: Take 1,200 mg by mouth 1 time per day.

Documented by Abstract Provider

aspirin 81 mg chewable tablet

Instructions: Take 2 tablets by mouth 1 time per day.

Approved by David J Clardy, MD
Prescribed on 1/13/2014
Prescribed quantity: 180 tablets

Request a renewal

vitamin D3 (cholecalciferol) 2000 unit tablet
Instructions: Take 2,000 units by mouth 1 time per day.
Documented by Abstract Provider

Allergies

Allergen	Reaction
Lisinopril	Other (Specify in Comments)
Irbesartan	Other (Specify in Comments)

Immunizations

Immunization	Date
Influenza High Dose (65+)	10/2/2014
Influenza High Dose Vaccine (65+)	10/5/2015
Pneumococcal Polysaccharide PPSV23	9/22/2003
Td (adult) preservative free (Tenivac)	9/22/2003

Preventive Care

Name	Status	Last Done
Zostavax Vaccine	Overdue since 8/6/1998	
Pneumococcal Adult	Overdue since 9/22/2004	9/22/2003
Tetanus Vaccine	Overdue since 9/22/2013	9/22/2003
Colonoscopy	Not due until 7/14/2024	7/14/2014
Flu Vaccine	Completed on 10/5/2015	10/5/2015

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North Dakota Department of Health and Water Quality

My name is Jacqueline Marcks, Gerald Marcks is my husband and our farm home is only one and a half miles from the proposed hog factory. I've lived here since we were married 56 years ago.

I am a colon cancer survivor. I was diagnosed with Primary Biliary Cirrhosis of my liver at the Mayo Clinic in Rochester, MN. I doctored there for two years, going every 6 months, and was told that I would be a liver transplant candidate some day. I was told that doctors in Fargo would be able to treat my condition and all my records were transferred to St. Lukes, now Sanford. Two years ago I had a TIPS Procedure done, where the veins to my liver were banded and stents put in. My immune system is weak and my blood panel is askew, however, I'm maintaining now. I've been hospitalized several times in the past two years and have appointments every three month with numerous specialists for all my ailments. I am also currently in a study group with the Mayo Clinic for hereditary Primary Biliary Cirrhosis.

I am very concerned that the air quality coming from the proposed hog factory near Buffalo will be harmful to my weakened condition. I fear the air emissions of hydrogen sulfide, methane, ammonia and particulate matter that will be released from this proposed hog factory and the manure that will be spread on land next to, and all around, our land will add to my medical problems.

In closing, I ask that the ND Department of Health and Water Quality please deny this permit.

Thank you,

Jacqueline Marcks

Jacqueline Marcks

INT MED FGO SC
SANFORD BROADWAY CLINIC
801 Broadway N
Fargo ND 58122
701-234-2261

February 25, 2016

JACQUELINE LAYNE MARCKS
PO BOX 121
BUFFALO ND 58011

Regarding Jacqueline Layne Marcks:

She has chronic liver disease with multiple complications and is concerned about the ammonia, methane and hydrogen sulfide gases that may be produced by the large pig farming operation.

Sincerely,

Janelle C. Sanda, M.D.

Janelle Sanda, MD
SANFORD HEALTH BROADWAY CLINIC
701 - 234 - 2261

Janelle Sanda, MD

Name: Jacqueline Layne Marcks | DOB: 3/25/1940 | MRN: E2199751 | PCP: Laura M Nichols, MD

Health Summary

Current Health Issues

Health Issue	Date Noted
Primary biliary cirrhosis	07/24/2003
Osteoporosis	07/24/2003
Ascites	04/09/2004
Anemia	04/09/2004
Isoimmunization from other and unspecified blood-group incompatibility, unspecified as to episode of care in pregnancy	02/20/2004
Malignant neoplasm of rectum	01/11/2006
Esophageal varices	11/02/2006
Alopecia	02/13/2013
Hypothyroidism	02/13/2013
Diarrhea	04/11/2013
Red blood cell antibody positive with compatible PRBC difficult to obtain	07/09/2013
S/P TIPS (transjugular intrahepatic portosystemic shunt)	07/22/2013
Pancytopenia	07/31/2013
Depression	10/28/2013
Peripheral edema	03/04/2014
Zinc deficiency	07/17/2014
Pain of left thumb	01/13/2015
Left ankle pain	03/13/2015
Chronic pain of left ankle	04/14/2015
Acute deep vein thrombosis of left lower extremity	05/07/2015

Long term current use of anticoagulant therapy	05/15/2015
Acute hepatic encephalopathy	08/03/2015
Thrombocytopenia	08/15/2015
Thrombocytopenia	08/24/2015
Hepatic encephalopathy	09/18/2015
Neutropenia	09/21/2015

Medications

denosumab 60 mg/mL subcutaneous injection
Commonly known as: PROLIA
Instructions: Inject 1 ml (60 mg total) subcutaneously every 6 months
Approved by Niyutchai Chaithongdi, MD
Prescribed on 3/15/2016
Prescribed quantity: 1 mL
Request a renewal

neomycin sulfate 500 MG tablet
Instructions: Take 1/2 tablet by mouth 3 times a day
Approved by Sajid Jalil, MD
Prescribed on 2/23/2016
Prescribed quantity: 45 tablets
Request a renewal

levothyroxine 75 mcg tablet
Instructions: Take 1 tablet (75 mcg total) by mouth 1 time a day in the morning.
Approved by James T Upton, APRN-CNP
Prescribed on 2/16/2016
Prescribed quantity: 90 tablets
Request a renewal

omeprazole 20 mg capsule
Commonly known as: priLOSEC
Instructions: Take 1 capsule (20 mg total) by mouth 2 times a day before meals.
Approved by Doreen Gigstad-Stave, PA
Prescribed on 2/1/2016
Prescribed quantity: 180 capsules
Request a renewal

metoprolol tartrate 25 mg tablet

Commonly known as: LOPRESSOR

Instructions: Take 1/2 tablet by mouth 2 times a day

Approved by Brooke Brekke, APRN-CNP
Prescribed on 1/12/2016
Prescribed quantity: 180 tablets

Request a renewal

furosemide 40 mg tablet

Commonly known as: LASIX

Instructions: Take 60 mg by mouth 1 time per day.

Documented by Abstract Provider

XIFAXAN 550 mg tablet

Generic name: rifaximin

Instructions: Take 1 tablet by mouth 2 times a day

Approved by Sajid Jalil, MD
Prescribed on 10/5/2015
Prescribed quantity: 60 tablets

Request a renewal

calcium carbonate-vitamin D 600 mg-400 unit tablet

Commonly known as: CALTRATE 600 + D

Instructions: Take 1 tablet by mouth 1 time per day.

Documented by Abstract Provider

spironolactone 50 mg tablet

Commonly known as: ALDACTONE

Instructions: Take 3 tablets by mouth once daily

Approved by Sajid Jalil, MD
Prescribed on 9/14/2015
Prescribed quantity: 90 tablets

Request a renewal

denosumab 60 mg/mL subcutaneous injection

Commonly known as: PROLIA

Instructions: Inject 1 ml subcutaneously every 6 months.

Approved by Niyutchai Chaithongdi, MD
Prescribed on 8/26/2015
Prescribed quantity: 1 mL

Request a renewal

ursodiol 250 mg tablet
Commonly known as: URSO
Instructions: Take 250 mg by mouth 3 times a day.
Documented by Abstract Provider

vitamin D3 (cholecalciferol) 2000 unit capsule
Instructions: Take 2,000 units by mouth 1 time per day.
Documented by Abstract Provider

ENSURE COMPLETE PO
Instructions: Take 8 oz by mouth 2 times a day.
Documented by Abstract Provider

Allergies

Allergen	Reaction
Aspirin	Anaphylaxis (High)

Immunizations

Immunization	Date
Denosumab (Prolia)	3/15/2016, 8/26/2015, 2/23/2015, 8/21/2014
HEP B	7/16/1999, 2/4/1999, 1/4/1999
Hep A,peds/adol	9/28/2000, 3/6/2000
Im Medication Administration	12/18/2012
Influenza High Dose (65+)	10/5/2015, 10/2/2014, 9/23/2013, 10/4/2012
Influenza Trivalent w/preserv	9/28/2009
Influenza Vaccine	10/3/2008, 10/15/2007
Pneumococcal Conj PCV13	12/22/2014
Pneumococcal Polysaccharide PPSV23	10/15/2007, 1/4/1999
Td (adult) preservative free (Tenivac)	9/28/2009

Triamcinolone (Kenalog) 5mg/mL	11/19/2012, 11/7/2012, 8/28/2012
Zoster	11/9/2009

Preventive Care

Name	Status	Last Done
Lipid Screening	Overdue since 3/25/1980	
Colonoscopy	Not due until 6/18/2018	6/18/2013
Tetanus Vaccine	Not due until 9/28/2019	9/28/2009
Dexa/heel Scan	Not due until 8/10/2030	8/10/2015
Zostavax Vaccine	Completed on 11/9/2009	11/9/2009
Pneumococcal Adult	Completed on 12/22/2014	12/22/2014
Flu Vaccine	Completed on 10/5/2015	10/5/2015

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Tracie Zaun
304 Wilcox Ave N Buffalo ND 58011
PH: 701-361-1699 Email: tracie.zaun@corelinksolutions.com

March 12, 2016

North Dakota Department of Health
Division of Water Quality
600 E Boulevard Ave
Bismarck, ND 58505

To whom it may concern,

As you are aware, there is a lot of concern stemming from the community meeting in Buffalo, ND on January 18th regarding Rolling Green Family Farms moving in a hog farm operation. I am writing a letter of concern due to medical reasons.

I am a 40 year old female that has been dealing with a compromised immune system, I have Lupus. As you are well aware, when someone has a compromised immune system, they have a harder time fighting off viruses, bacteria and germs. I have days where I feel "normal" but I also have days that make it difficult to leave my house.

When I heard about a hog farm coming to our community, I had immediate concerns for my health and others in the community that also suffer from autoimmune diseases and other health issues. One of my biggest concerns that I have is zoonotic disease transmission especially MRSA. In some of the research that I have looked at, people who live within a mile of a hog operation are nearly 3 times more likely to carry MRSA in their noses than the general population (McKenna, 2014) and also another MRSA study conducted in Pennsylvania in 2013 (Joan A. Casey, Frank C. Curriero, Sara E. Cosgrove, Keeve E. Nachman, & Brian S. Schwartz, 2013) found that people who live near fields treated with industrially farmed hog manure are "significantly" more likely to be treated for infections, and that people who live near hog operations showed a "similar but weaker association" with MRSA infection rates. With this being said, those that have weakened immune systems are at an increased risk for developing staph infections, including MRSA.

It has also been brought to my attention that there will be application of the manure from the hog farm to fields that are adjoining land my husband and I farm. This brings concern to me also as this could increase risks to my health and others near and dear to me.

Thank you for taking the time to listen to my concerns regarding my health and those that live in the community as there are elderly folks that live in this community that could also be affected. Do not allow this illegal permit to build this facility as I do not consider this a family operation and I care about family, friends and neighbors in our community.

Sincerely,

Tracie Zaun

Stellar Healthcare

Melissa Erdmann, NP

3/15/2016

TRACIE ZAUN
304 Wilcox Ave N
Buffalo, ND 58011

To Whom It May Concern:

TRACIE ZAUN has the diagnosis Lupus.. This patient was seen in my office and is currently receiving medical care.

Thank you,

Melissa Erdmann NP

827 28th ST S Suite B. Fargo, ND 58103 Phone: 701-364-3660 Fax: 701-364-3661

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- Author: Maryn McKenna. Maryn McKenna Science
- Date of Publication: 01.22.14. 01.22.14
- Time of Publication: 2:06 pm. 2:06 pm

Almost Three Times the Risk of Carrying MRSA from Living Near a Mega-Farm

Click to Open Overlay GalleryPig farms from the air. *Image: Maryn McKenna*

In the long fight over antibiotic use in agriculture, one of the most contentious points is whether the resistant bacteria that inevitably arise can move off the farm to affect humans. Most of the illnesses that have been associated with farm antibiotic use — resistant foodborne illness, for example — occur so far from farms that opponents of antibiotic control find them easy to dismiss. So whenever a research team can link resistant bacteria found in humans with farms that are close to those humans, it is an important contribution to the debate.

A team from the University of Iowa, Iowa City Veterans Affairs, and Kent State University have done just that. In next month's *Infection Control and Hospital Epidemiology*, they survey 1,036 VA patients who lived in rural Iowa and were admitted to the Iowa City facility in 2010 and 2011. Overall, among those patients, 6.8 percent were carrying MRSA, drug-resistant staph, in their nostrils. But the patients' likelihood of carrying MRSA was 2.76 times higher if they lived within one mile of a farm housing 2,500 or more pigs.

They say:

The increasing populations of swine raised in densely populated CAFOs and exposed to antibiotics presents opportunities for drug-resistant pathogens to be transmitted among human populations. Our study indicates that residential proximity to large numbers of swine in CAFOs in Iowa is associated with increased risk of MRSA colonization.

Some important things to unpack here:

- MRSA (formally, methicillin-resistant *Staphylococcus aureus*) often "colonizes" people — takes up residence on the skin or in the nostrils — before it causes an infection. Studies have shown repeatedly that being colonized with MRSA increases the risk of contracting a difficult-to-treat infection.
- Because of that risk, and because MRSA spreads easily in hospitals, the VA since 2006 has required facilities to screen all incoming patients to see whether they are carrying MRSA and thus are posing a risk to other patients.
- MRSA is frequently found in the vicinity of pigs: not just MRSA ST398, the specific resistant variety that was first identified in pig farmers in the Netherlands in 2004, but the garden-variety community forms as well.
- And Iowa has a lot of pigs: 19 million, according to the US Department of Agriculture, housed in about 7,000 "CAFOs" (for confined or concentrated animal-feeding operations), which the US Environmental Protection Agency defines as a facility of at least 1,000 pigs, though most are many thousands larger.

(If you'd like to know more about MRSA, including the "livestock-associated "pig MRSA" variety, I wrote a book. OK, back to this paper.)

The authors, led by Margaret Carrel, PhD, initially identified 2,996 patient admissions in that 2-year period, and then winnowed out any patients who lived in cities as well as any whose addresses could not be confirmed and plotted using geo-coding. That left them with 1,746 samples taken from 1,036 patients, of which 119 — 6.8 percent — were positive for MRSA. That was a red flag to begin with, because MRSA colonization in the general population is less than 2 percent.

Using data from the Iowa Department of Natural Resources for the locations of very large pig-raising facilities, they then sorted the patients by the distance of their homes from pig CAFOS. Initially, patients who lived 1 mile or less from a CAFO were 1.8 times more likely to be colonized. When the team cleaned up the data — accounting for patients who came into the

hospital more than once in that 2-year period, and also adjusting for the known likelihood that elderly patients, who are likely to be in a VA facility, have higher colonization rates — they came up with a relative risk of 2.76.

This is not the first time that MRSA has been found in people who work on farms or live in the vicinity of them. Last year, a study found "pig MRSA" in workers from North Carolina hog farms, and another identified it in workers in Iowa and Illinois. Meanwhile, a third study published just in November found MRSA among people who lived in the vicinity of fields where swine manure was being applied. And last year, a group in Germany identified MRSA in people who lived near hog farms but did not have contact with animals.

None of these studies have been able to trace with precision how workers and neighbors are acquiring MRSA. The authors of the newest study say:

Although the exact mechanism by which residential proximity to large swine CAFOs increased risk of MRSA is unknown, it appears that there is potential for drug-resistant strains of *S. aureus* in animals to transmit to people living at close distances. For example, a 55-pound or greater hog can produce upward of ~~10~~ 2 *(see Update)* gallons of manure a day. Typically, in Iowa, manure is spread on surrounding fields, and MRSA can be aerosolized from this manure to human food or water sources.

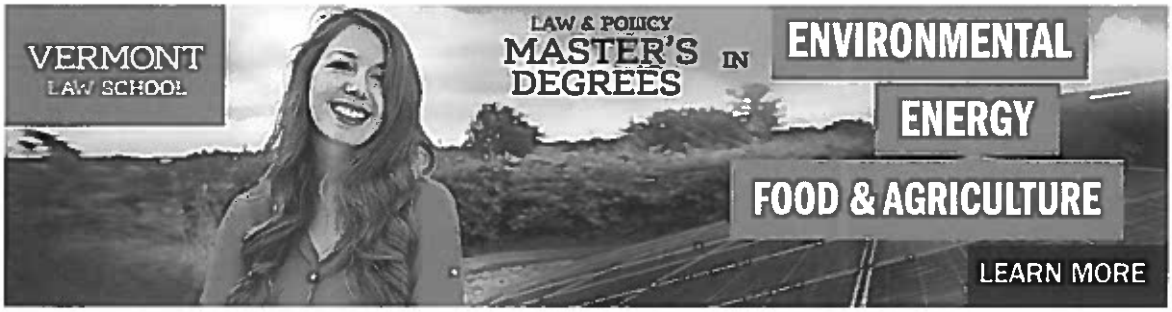
And they add:

Residential proximity to CAFOs could be risky in ways other than simply direct exposure to preexisting livestock-associated *S. aureus* strains, including via exposure to antibiotic residues via air or water, application of manure containing residues near their homes.

As last year ended, a number of food-policy writers noted that 2013 marked the first time that discussion of agricultural use of antibiotics — and the unintended consequences of that use — really emerged into mainstream discourse. Papers like this can move that process along. Throughout the decades-long discussion of farm antibiotics, the challenge has been linking the externalized costs of those antibiotics back to their use on the farm. The more those off-farm effects are elucidated, the more complete and transparent the discussion of on-farm use ought to become.

(Update: Eli Perencevich, the paper's senior author, got in touch to say that an error was edited into the paper when it was cut for length. The correct amount of manure would be 1-2 gallons a day, as noted in this paper from the Clemson University Extension by Chastain et al.)

Cite: Carrel M, Schweizer ML, Sarazin MV, Smith TC, Perencevich EN. Residential Proximity to Large Numbers of Swine in Feeding Operations Is Associated with Increased Risk of Methicillin-Resistant Staphylococcus aureus Colonization at Time of Hospital Admission in Rural Iowa Veterans. Infect Control Hosp Epidemiol 2014;35(2).



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By Tom Philpott (/authors/tom-philpott) | Sat Sep. 13, 2014 6:00 AM EDT

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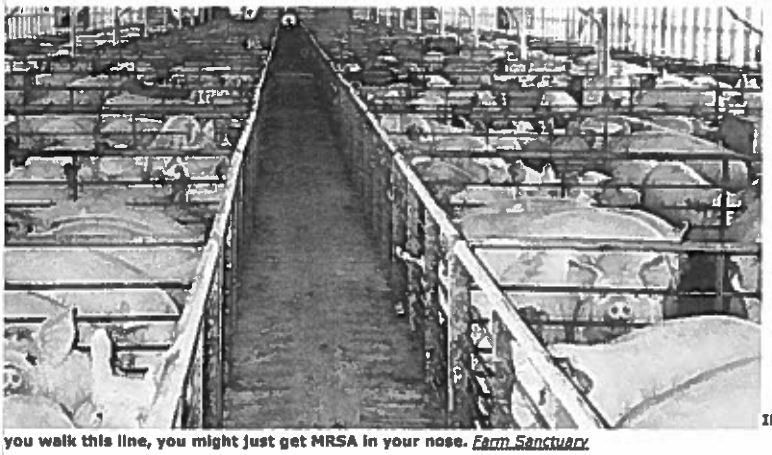

you walk this line, you might just get MRSA in your nose. Farm Sanctuary (https://www.flickr.com/photos/farmsanctuary/12163457236/sizes/m/in/photolist-4ibhBt-5Wo9xi-5WiDKY-aUWp9s-5WcCok-5WfvDy-5WYci-5Wfok5-5WfpJp-5hcfyT-8zHeGQ-4icpQC-4ib5tC-4icnUQ-4i6WJB-4i8bGr-5n6kJB-5n6npD-5n6m8B-5n6mJh-5n6mpk-5n6n6P-5n6mie-5n6p1M-5n6oQD-5n6omi-5n6oCr-5n6ote-MCo8H-5naDtz-5naDm9-5n6o4Z-5naB7o-5naDJE-5naETG-5n6nZB-5DYCKt-4i7m3a-4i6SCP-4icnij-4i6D8x-4i8A4o-4ibqzQ-4iaFnG-4oNNqf-4icbnf-5n6nkv-5n6nqB-5n6kND-5n6kYF-4icbBh/) /Flickr

Factory-scale farms don't just house hundreds of genetically similar animals in tight quarters over vast cesspools collecting their waste. They also house a variety of bacteria that live within those unfortunate beasts' guts. And when you dose the animals daily with small amounts of antibiotics—a common practice—the bacteria strains in these vast germ reservoirs quite naturally develop the ability to withstand anti-bacterial treatments.

Antibiotic-resistant bacteria leave these facilities in two main ways. The obvious one is meat: As Food and Drug Administration data (http://www.fda.gov/downloads/AnimalVeterinary/SafetyHealth/AntimicrobialResistance/NationalAntimicrobialResistanceMonitoringSystem/UCM334841.pdf) shows (http://www.cidrap.umn.edu/news-perspective/2013/02/bacteria-meat-show-growing-drug-resistance-fda-says), the pork chops, chicken parts, and ground beef you find on supermarket shelves routinely carry resistant bacteria strains. But there's another, more subtle way: through the people who work on these operations.

ck.g.doubleclick.net/pcs/click?xai=AKAOjs[illegible] [illegible]adurl=http://adserver.adtechus.com/adlink/5443/[illegible] [illegible]https://donate.doctorswithoutborders.org/surgery.cfm%3Fsource% [illegible]display%26utm_campaign%3Dm-operate)

In a new paper (http://oem.bmj.com/content/early/2014/09/05/oemed-2014-102095.full#ref-5) , a team of researchers from Johns Hopkins and the University of North Carolina-Chapel Hill took nasal swabs from 22 North Carolina hog facility workers over 14 days. The results: 10 of them proved to be "persistent" carriers of a strain of bacteria associated with livestock called *Staphylococcus aureus*—that is, they carried for up to four days after their last day at work. Of those 10, 7 of the workers carried a form of *Staphylococcus aureus* that's resistant to one or more antibiotics.

The researchers report that their study is the first to test the persistence of the bacteria strains that workers pick up at livestock farms. "Researchers had believed that livestock-associated bacteria would clear from the noses of hog workers quickly—within 24 hours," the press release (http://www.jhsph.edu/news/news-releases/2014/hog-workers-carry-drug-resistant-bacteria-even-after-they-leave-the-farm.html) accompanying the report states. Apparently, not so much.

If the sample size sounds small, it is. Most hog production in North Carolina takes place within facilities owned or operated by large meat-processing companies, and they aren't eager to cooperate with independent researchers. Finding workers to participate is tricky. "This study would not have been possible without a strong partnership between researchers and community-based organisations that have the trust of members of communities in areas where the density of industrial hog production is high," the authors state.

The study comes on the heels of another one (http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0067641) , published on *PLOS One* in 2013, which compared nasal swabs from workers on industrial-scale hog farms with those of workers on antibiotic-free operations. Six of 34 industrial-farm workers carried multidrug-resistant forms of livestock-associated staph, compared to none of the antibiotic-free farmworkers.

While these and other studies suggest that farmworkers are moving resistant bacteria from farms and into the world, potentially infecting others, they don't prove that MRSA (http://www.cdc.gov/mrsa/) and other potentially deadly staph strains are spreading from this source. You can carry a staph germ in your nose without becoming infected with it. The authors say (http://www.jhsph.edu/news/news-releases/2014/hog-workers-carry-drug-resistant-bacteria-even-after-they-leave-the-farm.html) they're now studying whether the workers, their families, and their surrounding communities are more prone to infections.

Meanwhile, a University of Iowa study (http://www.wired.com/2014/01/mrsa-col-cafo/) earlier this year found that people who live within a mile of a hog operation are nearly three times more likely to carry MRSA in their noses than the general population. A 2013 Johns Hopkins study (http://archinte.jamanetwork.com/article.aspx?articleid=1738717) that looked at actual MRSA infections in Pennsylvania found that people who live near fields treated with industrially farmed hog manure are "significantly" more likely to be treated for infections, and that people who live near hog operations showed a "similar but weaker association" with MRSA infection rates.

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The horrific ways we are treating farm animals these days no doubt have negative effects on our own health. For decades, scientists have found that meat, eggs and dairy increase our risk of cancer, heart disease, erectile dysfunction, diabetes, osteoporosis and bone loss, bone fracture in children, arthritis, infant apnea and crib death, type 1&2 diabetes, postpartum psychosis, circulatory disorders, food allergies, etc.

It is not only due to the antibiotics, the chemicals and the diseases the animals carry because they are kept only barely alive and all gone crazy with extremely confinement, it is also because animal protein itself is bad for us. Recent research found that animal protein is 'just as bad as smoking'. Physicians and researches have also compared our anatomy with other animals and cite plenty of evidence saying that we humans are "not designed to eat meat". No doubt a small number of our ancestors had evolved to tolerate meat and dairy, but obviously not very well. Note that our ancestors that contributed to our anatomy went way back. For instance, our ear drums are passed on from our fish ancestors.

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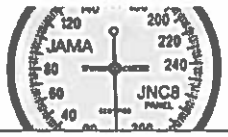

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Original Investigation | November 25, 2013

High-Density Livestock Operations, Crop Field Application of Manure, and Risk of Community-Associated Methicillin-Resistant *Staphylococcus aureus* Infection in Pennsylvania FREE

Joan A. Casey, MA[1,2]; Frank C. Curriero, PhD, MA[1,3]; Sara E. Cosgrove, MD, MS[3,4]; Keeve E. Nachman, PhD, MHS[1,5,6]; Brian S. Schwartz, MD, MS[1,2,7]

[+] Author Affiliations

JAMA Intern Med. 2013;173(21):1980-1990. doi:10.1001/jamainternmed.2013.10408.

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ABSTRACT

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Importance Nearly 80% of antibiotics in the United States are sold for use in livestock feeds. The manure produced by these animals contains antibiotic-resistant bacteria, resistance genes, and antibiotics and is subsequently applied to crop fields, where it may put community members at risk for antibiotic-resistant infections.

Objective To assess the association between individual exposure to swine and dairy/veal industrial agriculture and risk of methicillin-resistant *Staphylococcus aureus* (MRSA) infection.

Design, Setting, and Participants A population-based, nested case-control study of primary care patients from a single health care system in Pennsylvania from 2005 to 2010. Incident MRSA cases were identified using electronic health records, classified as community-associated MRSA or health care–associated MRSA, and frequency matched to randomly selected controls and patients with skin and soft-tissue infection. Nutrient management plans were used to create 2 exposure variables: seasonal crop field manure application and number of livestock animals at the operation. In a substudy, we collected 200 isolates from patients stratified by location of diagnosis and proximity to livestock operations.

Main Outcomes and Measures Community-associated MRSA, health care–associated MRSA, and skin and soft-tissue infection status (with no history of MRSA) compared with controls.

Results From a total population of 446 480 patients, 1539 community-associated MRSA, 1335 health care-associated MRSA, 2895 skin and soft-tissue infection cases, and 2914 controls were included. After adjustment for MRSA risk factors, the highest quartile of swine crop field exposure was significantly associated with community-associated MRSA, health care-associated MRSA, and skin and soft-tissue infection case status (adjusted odds ratios, 1.38 [95% CI, 1.13-1.69], 1.30 [95% CI, 1.05-1.61], and 1.37 [95% CI, 1.18-1.60], respectively); and there was a trend of increasing odds across quartiles for each outcome ($P \leq .01$ for trend in all comparisons). There were similar but weaker associations of swine operations with

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community-associated MRSA and skin and soft-tissue infection. Molecular testing of 200 isolates identified 31 unique *spa* types, none of which corresponded to CC398 (clonal complex 398), but some have been previously found in swine.

Conclusions and Relevance Proximity to swine manure application to crop fields and livestock operations each was associated with MRSA and skin and soft-tissue infection. These findings contribute to the growing concern about the potential public health impacts of high-density livestock production.

The US Food and Drug Administration reports that 80% of antibiotics in the United States are used in food animals, mainly to promote growth of livestock in high-density production.[1,2] In this industrial model, thousands of livestock animals are housed together and fed subtherapeutic doses of antimicrobial agents.[3] This can select for antibiotic-resistant bacteria like methicillin-resistant *Staphylococcus aureus* (MRSA).[4] About 75% of administered antibiotics are not absorbed by the animal and end up in manure.[5] In addition to antibiotics, antibiotic-resistant bacteria and resistance genes have been isolated from manure and are known to persist in the environment.[6] Application of manure to crop fields close to human dwellings may lead to increased risk of antibiotic-resistant infections.[7]

High prevalence of MRSA colonization among pig farmers was first noted in the Netherlands in 2005.[8] Transmission of MRSA among cows, calves, and humans has also been reported.[9,10] A US study reported that 45% of swine workers were colonized, which is 30 times the national average.[11,12] Few studies have assessed risk of MRSA infection. A Danish case-control study (21 cases) found that living or working on a farm was a risk factor for MRSA infection.[13] Other studies of MRSA infection have described the spread of infection within pig farming families.[14,15] To our knowledge, the impact of proximity to high-density livestock production on risk of MRSA infection has not been evaluated. Two studies assessed community livestock density and found no association with MRSA colonization.[16,17] Most studies have implicated clonal complex 398 (CC398) as the most common variant harbored by swine.[9,12-15,17,18]

In the United States, community-associated MRSA (CA-MRSA) now accounts for more than half of all noninvasive MRSA infections.[19-22] CA-MRSA often occurs as a skin and soft-tissue infection (SSTI) in young, otherwise healthy individuals who lack common health care risk factors.[23-25] In contrast, health care –associated MRSA (HA-MRSA) generally occurs in older individuals with comorbidities. Now, the epidemiology and microbiology of 2 epidemics previously considered distinct are merging.[26-28]

The possible contribution of high-density livestock production to these epidemics has been inadequately studied.[29] US data are needed to evaluate which livestock species pose risk, what aspects of the operations and manure handling are involved, and the magnitude of the risk. We conducted a population-based, nested case-control study using electronic health record (EHR) data from the Geisinger Health System, an integrated health services organization with 4 hospitals and 41 outpatient clinics. We evaluated residential proximity to swine and dairy/veal high-density livestock operations and manure-applied crop fields in relation to CA-MRSA, HA-MRSA, and SSTI (without a history of MRSA infection or colonization) case status.

METHODS

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Data Sources

To select cases and controls, we used EHR data from January 1, 2005, to February 9, 2010, from 446 480 patients with a Geisinger primary care provider. Geisinger's primary care patients represent the general population in the region.[30] The study area comprised the health system's primary care market and bordering counties totaling 38 counties in Pennsylvania (Figure 1); approximately 3.8 million people resided in these counties according to the 2000 US Census. The study was approved by institutional review boards at the Geisinger Health System and the Johns Hopkins Bloomberg School of Public Health.

Figure 1.

Crop Field Locations and Methicillin-Resistant *Staphylococcus aureus* (MRSA) Rates

Crop field locations and rates of MRSA per 1000 Geisinger Health System (GHS) primary care patients in townships, boroughs, and cities. Rates in communities with fewer than 50 GHS patients were not estimated. The map demonstrates that crop fields were often located in areas with a range of human population densities.

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Pennsylvania Act 38 of 2005 requires high-density livestock operations to develop and implement nutrient management plans (NMPs) for manure handling. We defined *high-density livestock operations* as agricultural operations where animal density exceeded 2 animal equivalent units (AEUs, 1000 pounds of live weight) per acre and where total AEUs exceeded 8; or operations that exceeded 300 AEUs. When livestock operations have insufficient land for manure application, manure is exported to other areas and applied to crop fields. We focused on swine and dairy/veal operations because of previously identified links with MRSA.[8-10,13-15] The NMPs provided data on livestock operation location, animal type, livestock quantity (AEUs), amount of manure applied to crop fields by season, and crop field area and location. We obtained NMPs from the Pennsylvania Department of Environmental Protection and County Conservation Districts.

Case Ascertainment and Control Selection

Incident MRSA cases were identified primarily using laboratory cultures and secondarily by diagnosis codes (eg, *International Classification of Diseases, Ninth Revision* [*ICD-9*]) that indicated MRSA infection, as previously described.[22] Cases were then classified as either CA-MRSA or HA-MRSA based on presence of health care risk factors (eg, hospitalization, surgery, dialysis, nursing home residence, indwelling device)[22,31] or diagnosis more than 2 days after hospital admission using *ICD-9* codes[21,23,32] and *Current Procedural Terminology* codes. We then randomly selected patients with SSTI but no history of MRSA using 29 *ICD-9* codes (eg, carbuncle, furuncle, abscess)[22] and controls with no history of MRSA, and we frequency matched both groups with case patients by age (0-6, 7-18, 19-45, 46-62, 62-74, ≥75 years), sex, and diagnosis or an outpatient encounter in the same year as MRSA diagnosis. The SSTI cases were evaluated as a separate case group because some SSTIs occurring during the study period were likely to have been caused by MRSA but not diagnosed as such, and high-density livestock production could cause SSTIs from other bacteria. Therefore, we selected patients with SSTIs without reference to any specific pathogen. If a control had multiple outpatient encounters during the year, a single encounter was randomly selected as the date for exposure assignment.

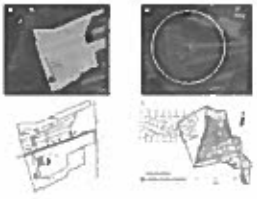
Geographic Location of Patients, Livestock Operation, and Crop Fields

We identified the latitude and longitude of patient addresses using ArcGIS, version 10 (Esri),[33] and calculated MRSA rates by community (Figure 1). The latitude and longitude of livestock operation addresses were located using Google Earth with visual confirmation of the presence of a barn at the address. Three different methods were used to locate crop fields because 131 fields (17.3%) were missing address data (Figure 2). In the absence of an address, we used the county and community of the field from the NMP to locate the crop field.

Figure 2.

Three Methods Used to Identify and Locate Crop Fields

A, Aerial photograph (top) or map (bottom) were located using Google Earth (n = 135). B, Operation addresses known and located using ArcGIS, version 10 (Esri) (n = 420). C, County and township known and addresses were located by identifying cropland, hay land, and pastureland on a land use map and randomly selecting a point within the eligible land use types (n = 131).



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Exposure Assessment

We estimated each individual's exposure to livestock operations and to manure-applied crop fields, for swine and dairy/veal, using an inverse distance-squared approach[34] in R, version 2.14.2 (R Foundation for Statistical Computing). For livestock operations, we used the equation

$$\text{Exposure for patient j} = \sum_{i=1}^{n} \frac{a_i}{d_{ij}^2}$$

where n is the number of operations, a_i is AEUs of livestock at operation I, and d_{ij}^2 is the squared distance (in meters) between operation centroid i and patient j. For crop field manure application during the season of diagnosis or visit, we used the equation

$$\text{Exposure for patient j} = \sum_{i=1}^{n} \frac{c_i}{d_{ij}^2}$$

where n is the number of crop fields, c_i is the concentration of manure (gallons per square meter) applied during the season of diagnosis or visit at field i, and d_{ij}^2 is the squared distance (in meters) between the crop field centroid i and patient j. This resulted in exposure units of gallons per quartic meter (m^4). For missing seasonal application data (40% of fields), we used the regional seasonal average. Exposure variables were modeled as quartiles because they were not normally distributed.

Genetic Typing of MRSA Isolates

In a prospective substudy that occurred from January to December 2012, we identified all primary care patients with a culture-confirmed MRSA infection. We then randomly selected isolates from patients stratified by location of diagnosis (inpatient or outpatient) and presence or absence of a livestock operation or crop field in their zip code of residence. We oversampled outpatient isolates from zip codes with high-density livestock production. All isolates were characterized by DNA sequence analysis of the protein A gene variable repeat region (*spa* typing).[35] The *spa* types were also assigned a Ridom StaphType, using the Ridom SpaServer database (available at http://www.spaserver.ridom.de).[36] Panton-Valentine leukocidin (*PVL*) genes were detected by polymerase chain reaction.[37]

Statistical Analysis

To compare the 4 study groups, we used Kruskal-Wallis tests for comparisons of means and χ^2 tests for comparisons of proportions. We used multilevel multinomial (2 MRSA groups and controls) and multilevel logistic regression (SSTI cases and controls) to assess the association between exposure and case status. We adjusted models for predictors obtained from the EHR: age, sex, race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, and other); ever-smoking status using *ICD-9* codes[22]; antibiotic order in the 2 years preceding diagnosis; and Medical Assistance for health insurance, residential community (city, borough, or township), and community socioeconomic deprivation.[33] *Medical Assistance* is a means-tested program, which we used as a surrogate indicator for low socioeconomic status.[38,39] It was identified for each encounter by 1 of 24 codes and modeled as ever received (if received for >2 encounters) vs never received. The livestock operation model was additionally adjusted for season of infection or visit. Final models were selected based on associations reported in our group's earlier article,[22] and adequate model fit was confirmed using Pearson goodness-of-fit tests and likelihood ratio tests. Semivariograms were used to determine that spatial autocorrelation did not account for the results.[40] We used a 2-sided type 1 error rate of 0.05 as the threshold for statistical significance and made no adjustments for multiple comparisons. Logistic and multinomial logistic regression analyses were completed using Stata statistical software version 11.2 (StataCorp Inc) and the GLLAMM program (www.gllamm.org).

We calculated population attributable fraction (PAF) for CA-MRSA and SSTI cases by using the adjusted odds ratios (AORs) for the third and fourth quartile of crop field swine manure exposure obtained from the final multivariable logistic regression model using the formula PAF = (AOR − 1)/AOR × (proportion of cases exposed to risk factor).[41] The PAF for the third and fourth quartiles were summed to calculate the final PAF. Confidence intervals were computed using the delta method with the postestimation command *nlcom* in Stata.

We performed several sensitivity analyses. First, we evaluated 2 other time windows for crop field manure exposures: a 1-year and a 30-day window before either the date of MRSA diagnosis or the date of a preceding SSTI diagnosis. Second, models were repeated using different methods to identify crop fields (Figure 2). Third, we evaluated effect modification by community type and season. Fourth, analysis was performed to evaluate whether distance to nearest crop field, independent of manure application, was associated with disease outcomes. Finally, we repeated analyses using only culture-confirmed MRSA cases.

RESULTS

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Patients, Farms, and Crop Fields Included in the Study

A total of 1734 CA-MRSA and 1519 HA-MRSA cases were identified between January 2005 and February 2010. Most cases (72.3%) were identified by a positive MRSA culture. We frequency matched 3336 SSTIs and 3336 controls to the cases. Of the 9925 patients, we were able to identify latitude and longitude coordinates for home addresses for 87.5%. Thirty-one patients (0.35%) were excluded because they did not reside in counties for which we collected NMPs. This resulted in a total of 1539 CA-MRSA, 1335 HA-MRSA, and 2895 SSTI cases and 2914 controls with residences in 32 counties and 574 communities defined by *minor civil divisions*, ie, census-designated divisions of a county.

We collected NMPs and identified the location of 326 high-density livestock operations, 123 swine and 203 dairy/veal operations, in 27 counties and 168 townships. Ninety-eight of the swine operations (79.7%) and 71 of the dairy/veal farms (35.0%) exported at least a portion of their manure to a total of 424 crop fields. Crop fields were located in 29 counties, 8 boroughs, and 218 townships, for an average of 3.4 crop fields per township. A reported 637 266 595 gallons of manure was applied to crop fields annually. Among those in the highest quartiles of swine livestock operation exposure and swine crop field manure exposure, the median (IQR) distance to the nearest farm or field was 4.6 km (3.1-6.7 km) and 4.0 km (2.6-7.5 km), respectively. The Pearson *r* correlation between the individual-level exposure assignments from the 2 models was 0.59 (both log transformed).

Demographic Characteristics of Cases and Controls

There were no differences in demographic characteristics between patients included in the study and those excluded because we could not map their home address (n = 1211), except that patients with SSTIs who were included were significantly more likely to have ever smoked than were those who were excluded (eTable 1 in the Supplement). Compared with controls, patients in the CA-MRSA group were significantly younger; they were more likely to be black, to smoke, and to receive Medical Assistance; and they lived in communities with greater socioeconomic deprivation (Table 1). White race/ethnicity (95.3% of the study population) was associated with higher levels of swine and dairy/veal crop field manure exposure (Table 2). Exposures to manure were also the lowest among those who had not received an antibiotic prescription in the 2 years prior to diagnosis or visit, those who had received Medical Assistance, and those residing in cities.

Table 1. Patient Demographic and Clinical Characteristics

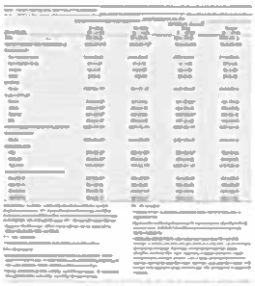

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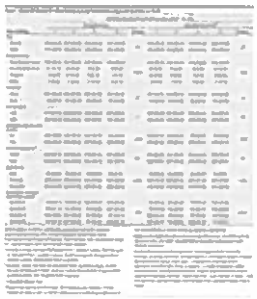
Table 2. Characteristics of CA-MRSA Group by Crop Field Manure Exposure Quartiles (n = 1539)



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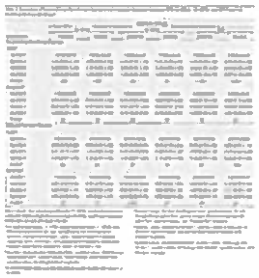
Association of Crop Field Manure Exposure With Case Status

After adjusting for potential confounding variables, we found a significantly increased odds of CA-MRSA, HA-MRSA, and SSTI with higher swine manure exposure (fourth vs first quartile AORs, 1.38 [95% CI, 1.13-1.68], 1.30 [95% CI, 1.05-1.61], and 1.37 [95% CI, 1.18-1.60], respectively; $P = .01$, $P < .001$, and $P < .001$ for trend, respectively) (Table 3). The fourth quartile (vs first quartile) of dairy/veal exposure was also associated with increased odds of CA-MRSA (AOR, 1.24 [95% CI, 1.01-1.52]). The PAFs (95% CI) for the highest 2 quartiles of swine crop field manure exposure for CA-MRSA infection and SSTI were 10.7% (5.0-16.4%) and 11.5% (7.0-16.0%), respectively.

Table 3. Association of Seasonal Crop Field Manure Exposure and Livestock Operation Exposure With CA-MRSA, HA-MRSA, and SSTI From Full Multilevel Multivariate Model[a]



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Association of High-Density Livestock Operations With Case Status

The fourth quartile vs first quartile of swine livestock operation exposure was associated with increased odds of CA-MRSA and SSTI (AORs, 1.25 [95% CI, 0.99-1.58] and 1.27 [95% CI, 1.08-1.50], respectively; $P = .04$ and $P = .002$, respectively) but not HA-MRSA (Table 3). No associations were seen with dairy/veal operations. Receipt of Medical Assistance remained independently associated with MRSA and SSTI outcomes in all adjusted analyses.

MRSA Isolate Substudy

A total of 200 isolates were randomly selected from 1128 patients with isolates (Table 4). Of these, 133 (66.5%) were common community strains (*spa* types t008, t024, t064, t206, t211); 33 (16.5%) were common health care strains (t002, t010, t062, t105); and the remainder were divided among 22 additional types. Notably, none was a *spa* type associated with CC398. A total of 27 community-onset isolates were *PVL*-negative.

Table 4. Summary of MRSA Genetics

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Sensitivity Analyses

Evaluation of the 2 other time windows for manure application revealed slightly attenuated but otherwise similar results, except in the case of annual dairy/veal exposure, where the association strengthened for both CA-MRSA and SSTI cases (fourth vs first quartile AORs, 1.41 [95% CI, 1.13-1.77] and 1.26 [95% CI 1.08-1.48], respectively; $P = .01$ and $P = .02$, respectively) (eTable 2 in the Supplement). Exclusion of crop fields without aerial photographs and/or addresses, including interaction terms for community type or season, and restricting analysis to culture-confirmed MRSA cases did not alter results. Distance to nearest crop field, independent of manure application, was not associated with MRSA or SSTI.

DISCUSSION

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High-density swine production was an independent risk factor for CA-MRSA and HA-MRSA infection and SSTI in patients without a history of MRSA. There was evidence that both a crop field manure application model that incorporated distance, swine manure volume, season of application, and field area, as well as a livestock operation model that incorporated distance and swine count, were each associated with increased risk of infection. Exposure assignments from these 2 models were moderately correlated, suggesting 2 independent sources of risk. Furthermore, while livestock operations are easily identifiable and fixed, manure-applied crop fields are not necessarily easily identifiable, are scattered, and may change from year to year. Associations with dairy/veal operations were less consistent and weaker than those for swine operations, which was not surprising, given the limited number studies on the topic. Our data also suggest that approximately 11% of CA-MRSA and SSTI cases in the study population could be attributed to crop field application of swine manure.

The association with SSTIs is notable because there were more than 50 000 such cases, compared with 4000 MRSA cases, in the region since 2001.[22] Crop field manure application may lead to SSTI either by causing MRSA infection that goes undiagnosed as such or by exposure to other bacteria that cause SSTI. We cannot attribute these infections to any single pathogen. Subanalysis of 258 SSTI cases (9%) identified from culture data as methicillin-susceptible *S aureus* (MSSA) revealed an association with swine livestock exposure (AOR, 1.70 [95% CI, 1.15-2.52]) that was stronger than for all SSTIs together. The public health burden of SSTIs[25-42] warrants future study of links to high-density livestock production. Concerning the association with HA-MRSA, this finding does not imply that livestock-associated strains are in hospitals. Rather, these older patients may have been colonized in the community with livestock strains and then had health care contact (eg, hospitalization, surgery, dialysis, indwelling device) before infection.

To our knowledge, no studies have examined the association between high-density livestock operations and MRSA infection in the community, and only 2 studies have assessed risk of colonization.[16,17] Study of colonization may not be useful when evaluating the risk of MRSA infection associated with industrial agriculture because, first, environmental exposure or direct contact may more often lead to CA-MRSA infection than does colonization[43] and second, MRSA colonization may not persist for more than 24 hours after livestock exposure.[44] Prior studies limited their ability to identify risk from high-density livestock exposure by including only patients with CC398,[13,45] by studying only people who lived or worked on farms,[9,12,46-48] and by not including crop field manure exposure.

A unique aspect of this study is the consideration of risk from manure application to crop fields. Sensitivity analyses across time (eg, annual, seasonal, and 30-day exposure) and across space (eg, restricting analysis to fields with aerial photographs or maps) did not substantively change results. Our findings are likely not an artifact of rural residents in the study population because, while manure-applied crop fields were associated with risk, residence in a township (where 98.5% of crop fields are located) and distance to nearest crop field independent of manure application were not associated with the 3 outcomes.

Previous studies have used community-level livestock density as a marker of livestock exposure.[16,17,45] We estimated exposure at the individual level, incorporating several features of these operations and fields. Operation and field sites were confirmed using Google Earth rather than physical inspection of the area, which may have led to some misclassification. Additional exposure misclassification may have occurred since the exposure assessment did not capture all smaller farms. In Pennsylvania, only large operations, specifically concentrated animal feeding operations, or operations with greater than 2 AEUs per acre are required to produce NMPs. The 2007 US Census of Agriculture revealed that our exposure models included 89% of swine AEUs present in the study area. Because characteristics of high-density livestock practices differ by and within states, our results may not apply in full to other areas with these operations.

A limitation of this study is that we did not measure how livestock-associated pathogens may reach individuals in a community, but several ways have been considered in prior studies. Aerosolized MRSA has been isolated from the air up to 150 m downwind and from the soil up to 300 m downwind of swine operations.[49,50] Studies have also reported that tetracycline, the most commonly used antimicrobial agent used in food-producing animals in the United States,[1] was found at concentrations sufficient to select for resistant bacteria in both swine manure and manure-fertilized soil.[51] These studies provide biologic plausibility for our findings, but more research is needed to establish sources, media, routes, and behaviors that may lead to infection. Other animals,[52] slaughterhouses,[53] and meat consumption[54] may be involved.

We did not find any *spa* types associated with clonal complex CC398. Most MRSA found on farms or in farmers has been characterized as CC398, though other types have been identified.[9,12,13,45,55,56] However, few studies have assessed MRSA infection, instead focusing on MRSA carriage, and those that do come from Europe[14,15,57,58] and/or deal exclusively with CC398 MRSA.[58-60] The most common strains on US farms are not well known. In Ohio, the closest state to Pennsylvania for which there are data, common health care strains were most often isolated from swine; CC398 was secondary.[53] We were limited in that genetic data did not come from the same time period as the main study, and isolate strains could have changed over time.

We used *ICD-9* codes to classify MRSA cases as CA or HA and to derive the predictor variables used in the analysis. The primary HA epidemiologic factors[31] are well captured by the EHR. Ever-smoking status can also be effectively obtained using *ICD-9* codes.[61] Unfortunately, the EHR did not directly capture data on individual-level socioeconomic status or occupation, so our results could have been due to these variables. To evaluate this potential confounding, we adjusted the final models for 2 surrogates for socioeconomic status: Medical Assistance at the individual level and community socioeconomic deprivation at the community level. As expected, patients with CA-MRSA were more likely to receive Medical Assistance and more likely to live in more deprived communities than controls, associations that persisted in the adjusted models.[62,63] Previous literature has suggested increased prevalence of MRSA colonization in livestock workers.[8] However, given the low prevalence of this employment (1% of population in any agricultural work, according to US Census data) even in townships and boroughs in the study area, it seems unlikely that farming occupation could account for the reported associations. Moreover, inclusion of community-level percentage of agricultural workers in the multilevel model did not change associations.

In conclusion, proximity to and size of high-density livestock production were associated MRSA infection and SSTI, and the population-attributable fraction of crop field manure application exceeded 10% for CA-MRSA and SSTI. The findings contribute to the growing concern about the potential public health impacts of high-density livestock production.

ARTICLE INFORMATION

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Acquisition of data: Casey, Schwartz.

Analysis and interpretation of data: Casey, Curriero, Cosgrove, Nachman, Schwartz.

Drafting of the manuscript: Casey.

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Statistical analysis: Casey, Curriero.

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Study supervision: Cosgrove.

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63 Bratu S, Landman D, Gupta J, Trehan M, Panwar M, Quale J. A population-based study examining the emergence of community-associated methicillin-resistant *Staphylococcus aureus* USA300 in New York City. *Ann Clin Microbiol Antimicrob*. 2006;5:29.
PubMed | Link to Article

JAMA Internal Medicine

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March 16, 2016

Dear North Dakota Department of Health

I am very worried about the effects the large swine operation will have on me if allowed to be built just two miles from the City of Buffalo, where I live. I have congestive heart failure and COPD. I use oxygen almost continuously. I own land within one mile of where the operation would be built and often give rides to and from there during farming season. I like to be outside and enjoy the fresh air. Will I be able to do so in the future without jeopardizing my health?

I have attached a letter from my doctor stating her concerns. Reading it makes me even more concerned, and scared.

I ask you to deny the permit so my health and wellbeing, and that of my family and friends in and near Buffalo, is not sacrificed for the growth of one business.

Thank you for your time and consideration.

Carol Beilke
Po Box 186
Buffalo ND 58011

Carol Beilke

INT MED FGO SC
SANFORD BROADWAY CLINIC
801 Broadway N
Fargo ND 58122
701-234-2261

SANFORD HEALTH

March 11, 2016

CAROL MARLYS BEILKE 3 - 480
PO BOX 186
BUFFALO ND 58011-0186

To whom it may concern,

Mrs. Carol Beilke is a patient of mine followed in Internal Medicine at Sanford Health System. I have cared for Carol for many years.

She suffers from a serious lung condition requiring continuous oxygen.

I have concerns about her health in the event that a large confined animal feeding operation be located near her home.

My concerns include air contamination with dust, mold, bacterial endotoxins and volatile gas which would very likely negatively affect her breathing capacity and respiratory status.

Studies have clearly documented respiratory symptoms associated with exposure to chemical components of CAFO air emissions in particular, ammonia and hydrogen sulfide. This would be severely detrimental to my patient.

I encourage the North Dakota State Health Department to take this into close consideration and ban CAFO's near communities that will suffer from toxic air emissions.

Thank you for your time and kind consideration.

Sincerely,

Doreen Gigstad-Stave, PA

PMID:24043228 [PubMed - indexed for MEDLINE] PMCID:PMC4372690 Free PMC Article

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- Abstract

Apply

Send to:

J Toxicol Environ Health B Crit Rev. 2012;15(8):524-41. doi: 10.1080/10937404.2012.744288.

Respiratory health effects of large animal farming environments.

May S[1], Romberger DJ, Poole JA.

Author information

- [1]Pulmonary, Critical Care, Sleep & Allergy Division, Department of Internal Medicine, University of Nebraska Medical Center, Omaha, NE 68198, USA.

Abstract

With increases in large animal-feeding operations to meet consumer demand, adverse upper and lower respiratory health effects in exposed agriculture workers are a concern. The aim of this study was to review large animal confinement feeding operational exposures associated with respiratory disease with a focus on recent advances in the knowledge of causative factors and cellular and immunological mechanisms. A PubMed search was conducted with the keywords airway, farm, swine, dairy, horse, cattle inflammation, organic dust, endotoxin, and peptidoglycan, among items were published between 1980 and now. Articles were selected based on their relevance to environmental exposure and reference to airway diseases. Airway diseases included rhinitis, sinusitis, mucus membrane inflammation syndrome, asthma, chronic bronchitis, chronic obstructive pulmonary disease, hypersensitivity pneumonitis, and organic dust toxic syndrome. There is lower prevalence of immunoglobulin (Ig) E-mediated asthma and atopy in farmers and their children, but organic dust worsens existing asthma. Multiple etiologic factors are linked to disease, including allergens, organic dusts, endotoxins, peptidoglycans, and gases. Large animal confinement feeding operations contain a wide diversity of microbes with increasing focus on gram-positive bacteria and archaebacteria as opposed to gram-negative bacteria in mediating disease. Toll-like receptors (TLR) and nucleotide oligomerization domain (NOD)-like innate immune pathways respond to these exposures. Finally, a chronic inflammatory adaptation, tolerance-like response in chronically exposed workers occurs. Large animal confinement farming exposures produce a wide spectrum of upper and lower respiratory tract diseases due to the complex diversity of organic dust, particulates, microbial cell wall components, and gases and resultant activation of various innate immune receptor signaling pathways.

COPD

PMID: 23199220 [PubMed - indexed for MEDLINE] PMCID:PMC4001716 Free PMC Article

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Environ Health Perspect. 2013 Jan;121(1):92-6. doi: 10.1289/ehp.1205109. Epub 2012 Oct 28.

To: North Dakota Department of Health
Division of Water Quality & Division of Air Quality

RE: Permit Application #DNAF00853

My name is Sheila Thompson. I want to speak on behalf of my husband Roy and myself. We live about 1 mile from the site of this proposed operation. We built our own home, handicapped accessible, planning on it being our retirement home, and also for our grandson Jake, who is crippled.

Being outside is one of our great pleasures. Having a big garden and flowerbeds, we spend many evenings working in them, and enjoying our gazebo.

If this operation is built, the manure would be spread on every field surrounding our home. We will be endangering our health by being outside, breathing the exhaust of these hog barns. What effect will the hydrogen sulfide and high levels of ammonia have on our health, the vegetables we grow, or more importantly our kids and grandkids?

Our oldest grandson Jake is with us every weekend. He has had many brain surgeries, and has cerebral palsy. He is blind in one eye, and losing sight in the other. We are very concerned how air quality will affect him.

Our kids and grandkids come for visits. Our daughter Rachel, has asthma and allergies, so bad, she has to have inhalers and a portable breathing machine with her at all times. If it's too bad, she'll no longer be able to visit us.

The Health Department should be concerned for all North Dakotans.

Everyone should be able to breathe clean air and have clean water.

We are asking you to please deny this permit.

Thank you

Print This Page | **Close This Window**

Name: Jacob Scott Thompson | DOB: 1/21/1998 | MRN: E2534774 | PCP: Stephen Tinguely, MD

Health Summary

Current Health Issues

Health Issue	Date Noted
Presence of ventricular shunt	11/18/2005
Partial epilepsy with impairment of consciousness	11/18/2005
Spastic hemiplegia	11/18/2005
Generalized anxiety disorder	
Disruptive behavior disorder	
Scoliosis (and kyphoscoliosis), idiopathic	03/17/2010
Short stature	04/01/2011
Abnormality of gait	05/23/2011
Unequal leg length (acquired)	05/23/2011
Other congenital varus deformity of feet	05/23/2011
Encounter for long-term (current) use of other medications	08/22/2011
ADHD (attention deficit hyperactivity disorder)	06/22/2012
Pressure ulcer of foot, stage 3	03/05/2013
Left hemiparesis	05/06/2013
Hydrocephalus	08/26/2013

Medications

risperiDONE 0.25 mg tablet
Commonly known as: RisperDAL

Instructions: Take 1 tablet by mouth ever y morning & take 1 tablet e very night atbedtime

Approved by Charlotte A Siemens, MD
Prescribed on 2/15/2016

Prescribed quantity: 60 tablets

Request a renewal

traZODone 50 mg tablet
Commonly known as: DESYREL

Instructions: Take 1 tablet by mouth ever y night at bedtime

Approved by Charlotte A Siemens, MD
Prescribed on 2/15/2016
Prescribed quantity: 30 tablets

Request a renewal

sertraline 50 mg tablet
Commonly known as: ZOLOFT

Instructions: Take 1 & 1/2 tablets by mou th once daily with food

Approved by Charlotte A Siemens, MD
Prescribed on 2/15/2016
Prescribed quantity: 45 tablets

Request a renewal

lisdexamfetamine 40 mg capsule
Commonly known as: VYVANSE

Instructions: Take 1 capsule (40 mg total) by mouth 1 time a day in the morning earliest fill date: 2/10/16.

Approved by Rachel Fleissner, MD
Prescribed on 2/10/2016
Prescribed quantity: 30 capsules

Request a renewal

hydrOXYzine pamoate 25 mg capsule
Commonly known as: VISTARIL

Instructions: Take 1 capsule by mouth every morning , at 11 am , at 4 pm , &at 7 pm

Approved by Stefanie Hanisch, MD
Prescribed on 1/28/2016
Prescribed quantity: 120 capsules

Request a renewal

Incontinence Supply Disposable Misc

Instructions: Attends dermadry extra large disposable brief, uses 5-7 per day as needed

Approved by Stephen Tinguely, MD
Prescribed on 1/19/2016
Prescribed quantity: 180 each

Request a renewal

incontinence supplies Misc

Instructions: Incontinence pads for full size bed. use 5-7 per day as needed.

Approved by Stephen Tinguely, MD
Prescribed on 1/19/2016
Prescribed quantity: 180 each

Request a renewal

loratadine 10 mg tablet
Commonly known as: CLARITIN

Instructions: Take 1 tablet by mouth once daily as needed

Approved by Stephen Tinguely, MD
Prescribed on 9/3/2015
Prescribed quantity: 30 tablets

Request a renewal

cholecalciferol 2000 units Caps capsule
Commonly known as: Vitamin D3

Instructions: Take 1 capsule by mouth once a day

Approved by Stephen Tinguely, MD
Prescribed on 6/29/2015
Prescribed quantity: 100 capsules

Request a renewal

prednisoLONE acetate 1 % ophthalmic suspension
Commonly known as: PRED FORTE

Instructions: Apply twice daily to left eye

Documented by Stefanie Hanisch, MD
Started taking on 1/19/2015

acetaminophen 325 mg tablet
Commonly known as: TYLENOL

Instructions: Take 650 mg by mouth every 4 to 6 hours as needed (rash and itching).

Documented by Abstract Provider

MINERAL OIL PO

Instructions: Take 2 teaspoonsful by mouth 1 time per day.

Documented by Abstract Provider

docusate sodium 100 mg capsule
Commonly known as: COLACE

Instructions: Take 100 mg by mouth 1 time per day.
Documented by Abstract Provider

Knee Sleeve/Kids Large Misc
Instructions: 1 device continuous.
Approved by Stephen Tinguely, MD
Prescribed on 1/30/2013
Prescribed quantity: 1 Device
Request a renewal

melatonin 3 mg tablet
Instructions: Take 3 mg by mouth every night at bedtime.
Documented by Abstract Provider

senna 8.6 MG Tabs
Commonly known as: SENOKOT
Instructions: Take 17.2 mg by mouth every night at bedtime.
Documented by Abstract Provider

citrate of magnesia 1.745 GM/30ML Soln
Instructions: Take 150 ml by mouth 1 time when needed (constipation).
Approved by Anna Marie Lindley, MD
Prescribed on 10/26/2012
Prescribed quantity: 1 Bottle
Request a renewal

pediatric multiple vitamins Chew
Instructions: Take by mouth 1 time per day.
Documented by Abstract Provider

Allergies

You have no allergies on file.

Immunizations

Immunization	Date

Immunization	Date
Ceftriaxone 1000mg	12/6/2012
Hep A,peds/adol	7/31/2008, 1/28/2008
Influenza Quadrivalent W/preserv	10/26/2015, 11/18/2014
Influenza Trivalent W/preservative 3yr+	10/2/2013
Lidocaine 1%	12/6/2012
Meningococcal B,OMV (Bexsero)	2/19/2016
Meningococcal MCV4P	2/6/2014, 9/22/2009
TDAP	9/22/2009
Varicella	1/28/2008

Preventive Care

Name	Status	Last Done
Hpv	Overdue since 1/21/2009	
Tetanus Vaccine	Not due until 9/22/2019	9/22/2009
Flu Vaccine	Completed on 10/26/2015	10/26/2015

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Name: Rachel Stangeland | DOB: 12/14/1973 | MRN: E2491620 | PCP:

Health Summary

Current Health Issues

Health Issue	Date Noted
Gastric ulcer	10/18/2005
Anxiety state	06/21/2006
Disorder of phosphorus metabolism	11/30/2006
Other hyperparathyroidism	11/30/2006
Other diseases of larynx	01/10/2007
Myalgia and myositis	12/18/2007
Vitamin D deficiency	02/07/2008
Other specified disorders resulting from impaired renal function	11/30/2006
Major depressive disorder, recurrent episode, moderate	10/01/2003
Other specified disorders of rotator cuff syndrome of shoulder and allied disorders	02/20/2009
Disorder of bursae and tendons in shoulder region	03/17/2009
Scanty or infrequent menstruation	03/31/2010
Female infertility	
Female genital symptoms	07/02/2010
Pregnancy with history of infertility	03/18/2011
Hyperemesis gravidarum with metabolic disturbance	04/28/2011
De Quervain's tenosynovitis, left	02/08/2013
Intractable chronic migraine without aura and with status migrainosus	02/26/2013
Myopia	04/08/2013
Balance problems	05/03/2013
Hydrocephalus	05/03/2013

Health Issue	Date Noted
Obstructive sleep apnea	05/16/2013
Allergic rhinitis	05/31/2013
Asthma	05/31/2013
Insomnia secondary to depression with anxiety	01/13/2015
Morbid obesity with BMI of 50.0-59.9, adult	03/28/2015

Medications

cyclobenzaprine 10 mg tablet
Commonly known as: FLEXERIL

Instructions: Take 1 tablet by mouth twice a day as needed

Approved by Angela A Dolalie Kelsch, APRN-CNP
Prescribed on 2/29/2016
Prescribed quantity: 60 tablets

Request a renewal

dihydroergotamine mesylate 1 mg/mL Soln injection solution
Commonly known as: D.H.E.45

Instructions: One muscular injection for moderate to severe migraine. max 3 doses per week.

Approved by Cynthia Knutson, MD
Prescribed on 2/5/2016
Prescribed quantity: 10 mL

Request a renewal

FLUoxetine 40 mg capsule
Commonly known as: PROzac

Instructions: Take 2 capsules (80 mg total) by mouth 1 time per day.

Approved by Harish Goyal, MD
Prescribed on 1/12/2016
Prescribed quantity: 60 capsules

Request a renewal

QUEtiapine 50 mg tablet
Commonly known as: SEROQUEL

Instructions: Take 1 tablet (50 mg total) by mouth every night at bedtime. take 1-2 tablets every 8 hours as needed for severe migraine.

Approved by Harish Goyal, MD
Prescribed on 1/12/2016
Prescribed quantity: 90 tablets

Request a renewal

gabapentin 600 mg tablet
Commonly known as: NEURONTIN

Instructions: Take two tablets by mouth at bedtime.

Approved by Jeffrey M Tiongson, MD
Prescribed on 12/20/2015
Prescribed quantity: 60 tablets

gabapentin 600 mg tablet
Commonly known as: NEURONTIN

Instructions: May take one and one-half tablet (900mg) as needed every 6 hours as needed for persistent headache.

Approved by Jeffrey M Tiongson, MD
Prescribed on 12/20/2015
Prescribed quantity: 90 tablets

ondansetron 4 mg dispersible tablet
Commonly known as: ZOFRAN ODT

Instructions: Take 1 tablet (4 mg total) by mouth every 4 hours as needed for nausea.

Approved by Jeffrey M Tiongson, MD
Prescribed on 12/20/2015
Prescribed quantity: 20 tablets

sumatriptan 100 mg tablet
Commonly known as: IMITREX

Instructions: Take 1 tablet by mouth at onset of headache, may repeat in 1hour. lim it 2 tablets per day.

Approved by Cynthia Knutson, MD
Prescribed on 12/18/2015
Prescribed quantity: 18 tablets

Request a renewal

propranolol 160 mg extended release capsule
Commonly known as: INDERAL LA

Instructions: Take 1 capsule by mouth once a day

Approved by Shaveta Goyal, MD
Prescribed on 12/11/2015
Prescribed quantity: 30 capsules

Request a renewal

budesonide-formoterol 160-4.5 mcg/puff inhaler
Commonly known as: SYMBICORT

Instructions: Inhale 2 puffs orally 2 times a day. shake well before using. rinse mouth after use.

Approved by Woei Yeang Eng, MD
Prescribed on 11/17/2015
Prescribed quantity: 1 Inhaler

Request a renewal

albuterol HFA 108 (90 BASE) MCG/ACT inhaler
Commonly known as: PROVENTIL,PROAIR,VENTOLIN

Instructions: Inhale 2 puffs orally every 4 to 6 hours as needed for shortness of breath, wheezing or cough. shake well before using.

Approved by Woei Yeang Eng, MD
Prescribed on 11/17/2015
Prescribed quantity: 1 Inhaler

Request a renewal

cetirizine 10 mg tablet
Commonly known as: zyrTEC

Instructions: Take 10 mg by mouth as needed.

Documented by Abstract Provider

albuterol (2.5 mg/3mL) 0.083% inhalation solution
Commonly known as: PROVENTIL

Instructions: Inhale 1 unit-dose by nebulization every 4 hours as needed for shortness of breath, wheezing or cough.

Approved by Woei Yeang Eng, MD
Prescribed on 9/2/2015
Prescribed quantity: 90 mL

Request a renewal

buPROPion 150 mg tablet (24 hr)
Commonly known as: WELLBUTRIN XL

Instructions: Take 1 tablet by mouth 1 time per day.

Approved by Ronald Wiisanen, MD
Prescribed on 8/19/2015
Prescribed quantity: 90 tablets

Request a renewal

naltrexone 50 MG Tabs
Commonly known as: REVIA

Instructions: Take 0.5 tablets by mouth 1 time per day.

Approved by Ronald Wiisanen, MD
Prescribed on 8/19/2015
Prescribed quantity: 45 tablets

Request a renewal

modafinil 200 mg tablet
Commonly known as: PROVIGIL

Instructions: Take 1 tablet by mouth each morning and 1/2 tablet at noon on an empty stomach.

Approved by Samy S Karaz, MD
Prescribed on 7/24/2015
Prescribed quantity: 45 tablets

Request a renewal

hydrOXYzine pamoate 50 mg capsule
Commonly known as: VISTARIL

Instructions: Take 1 capsule by mouth every 6 hours as needed for anxiety.

Approved by Harish Goyal, MD
Prescribed on 3/26/2015
Prescribed quantity: 120 capsules

Request a renewal

meloxicam 7.5 mg tablet
Commonly known as: MOBIC

Instructions: Take 1 tablet by mouth twic e a day as needed

Approved by Shaveta Goyal, MD
Prescribed on 11/3/2014
Prescribed quantity: 60 tablets

Request a renewal

naproxen 220 mg tablet
Commonly known as: ALEVE

Instructions: Take 440 mg by mouth as needed.

Documented by Abstract Provider

Allergies

Allergen	Reaction
Sulfa Drugs	Nausea and Vomiting, Diarrhea
Promethazine Hcl	Wheezing/Bronchospasm (High)
Erythromycin	Nausea and Vomiting, Diarrhea

Allergen	Reaction
Codeine	Nausea and Vomiting, Diarrhea
Latex	Unknown/Not Verified

Immunizations

Immunization	Date
Ceftriaxone 1000mg	2/5/2014
H1N1 Injectable Vaccine	12/17/2009
Influenza Quadrivalent W/preserv	10/26/2015
Influenza Trivalent w/preservative 3yr+	9/26/2013
Influenza Vaccine	10/21/2010, 9/23/2009, 11/4/2008, 10/22/2007, 10/26/2006, 2/16/2006, 10/21/2003, 11/22/2002, 11/14/2001, 12/4/2000, 11/10/1999
Lidocaine 1%	2/5/2014
Pneumococcal Polysaccharide PPSV23	6/20/2008

Preventive Care

Name	Status	Last Done
Screening Mammogram	Overdue since 12/14/1991	
Pap Smear	Overdue since 4/26/2013	4/26/2010
Lipid Screening	Overdue since 12/14/2013	
Asthma Action Plan & Environmental Control	Overdue since 6/13/2015	6/13/2014
Asthma Control Test	Not due until 11/17/2016	11/17/2015
Tetanus Vaccine	Not due until 11/4/2021	11/4/2011
Flu Vaccine	Completed on 10/26/2015	10/26/2015

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Health Petition

My name is Antoinette Babcock and I am a resident of Buffalo. I am speaking on behalf of the Concerned Citizens who are submitting a Health Petition which has been signed by 194 people.

The petition reads as follows: We the undersigned citizens and/or property owners, who live and/or work in Buffalo or in the surrounding townships of Buffalo, Hill, Howes, Tower, and Wheatland, have been provided information from the document entitled **"Understanding Concentrated Animal Feeding Operations and their Impact on Communities"** authored by Carrie Hribar, MA, (2010) National Association of Local Boards of Health, Bowling Green, Ohio. We are alarmed by the magnitude of environmental problems associated with CAFO's which pose a direct impact on our health and welfare. We do hereby **oppose** the permit for Application No. DNAF00853 filed by Rolling Green Family Farms RE, LLP of Pipestone, MN for permission to operate a swine production facility on the SE ¼ of the NW ¼ of Section 4, Township 139 N, Range 54 W, in Cass County, North Dakota.

In addition to the Health Petition, we are also submitting a reference list of our research data and the printed documents that address health risks related to swine CAFO's, including issues regarding socioeconomic impact, water and air pollution and various diseases such as MRSA.

We also have attached 12 letters written by concerned citizens addressing their individual health issues that affect their daily life. These concerned citizens do not want the North Dakota Department of Health to grant this illegal permit.

We all rely on the North Dakota Department of Health to protect our health, safety and welfare.

TO: The North Dakota Department of Health
Division of Water Quality and Division of Air Quality

We the undersigned citizens and/or property owners, who live and/or work in Buffalo or in the surrounding townships of Buffalo, Hill, Howes, Tower, and Wheatland, have been provided information from the document entitled **"Understanding Concentrated Animal Feeding Operations and Their Impact on Communities"** authored by Carrie Hribar, MA, (2010) National Association of Local Boards of Health, Bowling Green, Ohio. We are alarmed by the magnitude of environmental problems associated with CAFO's which pose a direct impact on our health and welfare. We do hereby oppose the permit for Application No. DNAFOO853 filed by Rolling Green Family Farms RE, LLP of Pipestone MN for permission to operate a swine production facility on the SE ¼ of the NW ¼ of Section 4, Township 139 N, Range 54 W, in Cass County, ND.

Signature	Print Name	Location	Date
	Mary Kliniske	Buffalo, ND	3.5.16
	LEE FRAASE	BUFFALO ND	3-5-16
	Eileen Beilke	Buffalo, ND.	3-5-16
	Kent Beilke	Buffalo ND	3-5-16
	Lindsey Peterson	Buffalo, ND	3-5-16
	Virgil Olson	Buffalo, ND	03/05/16
	Sandra Cromwell	Buffalo N.D.	3.5.16
	Heidi Fruch	Buffalo ND	3.5.16
	Mari Ketterer	Buffalo, ND	3-5-16
	Eric Licea	Buffalo ND	3/5/16
	Amanda Licea	Buffalo ND	3/5/16
	JACQUELINE MARCKS	Buffalo, ND	3-5-16
	Antoinette M. Babcock	Buffalo, ND	3-5-16
	W. R. Babcock	Buffalo, ND	3-5-16

TO: The North Dakota Department of Health
Division of Water Quality and Division of Air Quality

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Signature	Print Name	Location	Date
Claudia VonBank	CLaudia Von Bank	Buffalo, N.D	3-5-16
[illegible]	Philip Wesnevski	Buffalo, ND	3-5-16
Linda Wendel	Linda Wendel	Buffalo ND	3-5-16
Janice Kasowsky	JANICE KASOWSKI	Buffalo ND	3-5-16
Marian Kasowski	MARIAN KASOWSKI	Buffalo, ND.	3-5-16
Harold Kasowski	HAROLD KASOWSKI	Buffalo, N.D.	3-5-16
Laura Biggers	Laura Biggers	BuffaloND	3-5-16
Frank Biggers	Frank Biggers	Buffalo	3-5-16
Judith VonBank	Judith VonBank	Buffalo	3-5-16
Sue Buhr	Sue Buhr	Buffalo	3-5-16
Robert VonBank	Robert VonBank	Buffalo	3-5-16
Betty Fraase	Betty Fraase	Buffalo	3-5-16
Ken Ronning	KEN RONNING	Buffalo ND	
Richard Smith	Richard Smith	Alice ND	3/5/16

TO: The North Dakota Department of Health
Division of Water Quality and Division of Air Quality

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Signature	Print Name	Location	Date
Hal Grieve	Hal Grieve	Buffalo ND.	3-4-16
Terry Grieve	Terry Grieve	Buffalo ND	3-4-16
Lonnie Larson	Lonnie Larson	Buffalo ND	3-4-16
Bill Marcks	BILL MARCKS	Buffalo, ND	3-4-16
	Tim Frueh	Buffalo N.D.	3-4-16
Arretta Frueh	Arretta Frueh	Buffalo ND	3-4-16
Gerald Marcks	GERALD MARCKS	Buffalo N.D	3-4-16
Carolyn Dostert	Carolyn Dostert	Buffalo	3-4-16
Randy Coon	Randy Coon	Buffalo	3-4-16
Debbie Coon	Debbie Coon	Fargo	3-4-16
David W Percel	David W Percel	Buffalo	3-4-16
Sherry J Peterson	Sherry J. Peterson	Buffalo	3-4-16
Marlyn Nudell	MARLYN NUDELL	Wheatland	3-5-16
	Dustin Peterson	Buffalo	3-5-16

TO: The North Dakota Department of Health
Division of Water Quality and Division of Air Quality

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Signature	Print Name	Location	Date
Carol Hoveskeland	Carol Hoveskeland	Buffalo, N.D.	3-5-16
Robert A. Pierce	Robert A. Pierce	Wheatland ND	3-5-16
Keith Biggers	Keith Biggers	Buffalo ND	3-5-16
Joni Biggers	Joni Biggers	Buffalo, ND	3-5-16
Karen Smith	Karen Smith	Alice ND	3-5-16
Debora Miller	Debora Miller	Buffalo ND	3-5-16
Corey J. Tabor	Corey J. Tabor	Buffalo ND	3-5-16
Betty J. VonBank	Betty J. VonBank	Buffalo N.D	3-5-16
Cecil P. VonBank	Cecil VonBank	Buffalo N.D.	3.5.16
Jodi Combs	Jodi Combs	Buffalo	3-5-16
Liane Stout	Liane Stout	Buffalo	3-5-16
Alan D. Dostert	Alan D. Dostert	Buffalo, ND	3-5-16
Lois J. Smith	Lois J. Smith	Buffalo, ND	3/5/16
Carole Beilke	Carole Beilke	Buffalo, ND	3/6/16

TO: The North Dakota Department of Health
Division of Water Quality and Division of Air Quality

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Signature	Print Name	Location	Date
Rachel Stangeland	Rachel Stangeland	West Fargo	03/05/16
Rachel Stangeland for Jacob Thompson	Jacob Thompson	West Fargo	03/05/16
Roy Thompson	Roy Thompson	Buffalo	03/05/16
Sheila Thompson	Sheila Thompson	Buffalo	3-5-16
Carol Marcus	Carol Marcus	Buffalo	3-5-16
Kim Haman	Kim Haman	Buffalo	3-6-16
LeRoy Haman	LeRoy Haman	Buffalo	3-6-16
Angela McGuire	Angela McGuire	Buffalo	3-6-16
Bradley Kliniske	Bradley Kliniske	Buffalo	3-6-16
Vicki Wendt	Vicki Wendt	Buffalo	3-6-16
Craig Wendt	Craig Wendt	Buffalo	3-6-16
Peter Baasch	Peter Baasch	Buffalo	3-6-16
Melissa Baasch	Melissa Baasch	Buffalo	3-6-16
David Baasch	David Baasch	Buffal	3-6-16

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Signature	Print Name	Location	Date
Beverly Jagor	Beverly Jagor	601 Main	3-6-16
Jeffrey VonBank	JEFF VONBANK	Buffalo	3-6-16
Clyde Anderson	CLYDE ANDERSON	Buffalo	3-6-16
Jane Anderson	JANE ANDERSON	Buffalo	3-6-16
Kerry Ronning	Kerry Ronning	Buffalo	3-6-16
Gary Zeeb	GARY ZEEB	BUFFALO	3-6-16
Renee Zeeb	Renee Zeeb	Buffalo	3-6-16
Douglas E. Gately	DOUGLAS E. GATELY	BUFFALO	3-6-16
Randolph M. Ries	Randolph M. Ries	Buffalo	3-6-2016
Laurine Ries	Laurine Ries	Buffalo	3/6/2016
Corinne Erwin	CORINNE ERWIN	Buffalo	3/6/2016
Cassandra Bohanna	Cassandra Bohanna	Buffalo	3/6/2016
Raymond Bohanna	RAYMOND BOHANNA	Buffalo	3/6/2016
[illegible]	[illegible]	Buffalo	3/6/2016

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Signature	Print Name	Location	Date
Janice Diemert	Janice Diemert	Buffalo ND	3-6-16
Stephanie Baasch	Stephanie Baasch	Buffalo ND	3-6-16
Casey Marcks	CASEY MARCKS	BUFFALO ND	3-6-16
Linda K. Milbrandt	Linda K. Milbrandt	Buffalo ND	3-6-16
Gary Milbrandt	Gary Milbrandt	Buffalo ND	3-6-16
Justin Marcks	Justin Marcks	Buffalo	ND 3-6-16
Katie Borge	Katie Borge	Buffalo	ND 3-6-16
Justin Killoran	Justin Killoran	Buffalo	ND 3-6-16
Caitlin Killoran	Caitlin Killoran	Buffalo	ND 3-6-16
Paul Kasowski	Paul Kasowski	Buffalo	3-6-16
Heidi Baasch	Buffalo ND		3-6-16
Jessica Peterson	Jessica Peterson	Tower City, ND	3-6-16
Joshua Peterson	Joshua Peterson	Tower City, ND	3-6-16
Ashley Kasowski	Ashley Kasowski	Ayr ND	3/6/16

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Signature	Print Name	Location	Date
Kayla Fallon	Kayla Fallon	300 1st Ave E Buffalo, ND	3-6-16
Connie Boyd	Connie Boyd	Buffalo, ND	3-6-16
Kalvin Boyd	Kalvin Boyd	Buffalo, ND	3-6-16
Gwen Fraase	Gwen FRAASE	Buffalo, ND	3-7-16
Lillian VonBank	Lillian VonBank	Buffalo, ND	3-8-16
Jeff Zaun	Jeff Zaun	Buffalo ND	3-7-16
Ron Fraase	Ron FRAASE	Buffalo, ND	3-7-16
Renee Glasser	RENEE GLASSER	14081 33RD St SE	3-7-16
Theresa Tallackson	Theresa Tallackson	1005 Michigan Ave. Tower City	3/7/16
	Tom Cole	Buffalo, ND	3-7-16
Dan Sheldon		Buffalo ND	3-7-16
Wendy Rueppke	Wendy Rueppke	3062-142nd Ave SE Buffalo ND	3-7-16
	Christopher Frueh	Buffalo ND	3-7-16
Marlene Sheldon	Marlene Sheldon	Buffalo	3-7-16

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Signature	Print Name	Location	Date
	BILL SHELDON	Buffalo	3-7-16
	Eric Kettever	Buffalo	3/7/16
	Candy Blom	Buffalo	3/7/16
	William Vorbeck	Buffalo	3/7/16
	Jaci Gately	Buffalo	3/7/16
	Renee Wilm	Buffalo	3-7-16
	EeJay Smith	Buffalo	3-7-16
	Linda Smith	Buffalo	3/7/16
	Eileen Sauer	Buffalo	3-7-16
	Ronald Sauer	Buffalo	3-7-16
	Kristin Sheldon	Buffalo	3-7-16
	Emily Wolff	Buffalo	3/7/16
	Brent Wolff	Buffalo	3/7/16
	Lee Fischer	Buffalo	3-9-16

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Signature	Print Name	Location	Date
Kristi Hovelson	Kristi Hovelson	Buffalo	3-8-16
Corey Hovelson	Corey Hovelson	Buffalo	3-8-16
LeRoi Cromwell	LeRoi Cromwell	Buffalo	38-16
James Cromwell	James Cromwell	Buffalo	3 8-16
Mike Mjor	Mike Mjor	Buffalo	3-8-16
R.B. Glazer Mjor	R.B. Glazer Mjor	Buffalo	3-8-16
Diana Thuzhia	Diana Thuzhia	Buffalo	3-8-16
Anthony J. Krznia	Anthony J. Krznia	Buffalo	3-8-16
	Mason Guilbault	Buffalo	38-16
Kim VonBank	Kim VonBank	Buffalo	3-8-16
Mitchell VonBank	Mitchell VonBank	Buffalo	3-8-16
Jill M. Zaun	Jill M. Zaun	Buffalo	3-8-16
Dale Zaun	Dale Zaun	Fargo	3-8-16
Thomas Jorgensen	Thomas Jorgensen	Tower City	3 9-16

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Signature	Print Name	Location	Date
Peter Lunder	Peter Lunder	Tower City, ND	3/7/2016
	S. H Kehler	Tower City ND	3-7-16
J Haselen	Jody Haselen	Tower City	3-7-16
Scott Salberg	Scott Salberg	Tower City	3-7-16
Tom Millbrandt	Tom Millbrandt	Tower City	3-7-16
Kenny Trenda	Kenny Trenda	Tower City	
Rita Lenud	Rita Lenud	Tower City	3-13-16
Christopher Erickson	Christopher Erickson	Tower city	3-13-16
Tim Olson	Tim Olson	Tower City	3-13-16
Tracie Kresse	Tracie Kresse	Tower City	3-13-
Corey Kresse	Corey Kresse	Tower City	3-13-16
Darcie Besette	Darcie Besette	Tower City	3-13-16
Darian Halland	Darian Halland	Tower City	3-13-16
Jill Halland	Jill Halland	Tower City	3/13/16

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Signature	Print Name	Location	Date
Jessica Theurer	Jessica Theurer	MV School Buffalo	3-9-16
Julie Krist	Julie Krist	MV School Buffalo	3-9-16
Adele Smith	Adele Smith	MV School Buffalo	3/9/16
Polly Wolf	Polly Wolf	MV School Buffalo	3/9/16
Dan Johnson	Dan Johnson	MV School Buffalo	3/9/16
Sonja Jorgensen	Sonja Jorgensen	MV School	Buffalo 3/9/16
Cody Burington	Cody Burington	MV school	Buffalo 3/9/16
Jessie Regner	JessieqRegner	MV School	Buffalo 3/9/16
[redacted]	Jayson Kocka	MV School	Buffalo 3-9-16
Sandra Sidler	Sandra Sidler	MV School	Buffalo 3-9-16
Cheri Anderson	Cheri Anderson	MV School	Buffalo 3-10-16
Brian Wolf	Brian Wolf	MV School	Buffalo 3-14-16
Shirley J. Stevens	Shirley Stevens	Maple River Eq	3-16-16

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Signature	Print Name	Location	Date
[signature]	Grant Besette	Tower City	3-6-16
[signature]	Kirk Besette	Tower City	3-6-16
[signature]	Mark Hill	Tower Ct.	3-6-16
[signature]	Todd Lussa	Tower City	3-6-16
[signature]	SCOTT MCKENZIE	TOWER CITY	3-6-16
[signature]	Jessica Hill	Tower City ND	3-6-16
[signature]	TRAVIS McMULLEN	Tower City ND	3-6-16

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Signature	Print Name	Location	Date
Michelle R Deitz	Michelle R Deitz	305 3rd St N Buffalo ND 58011	03/8/16
Zachariah L Deitz	Zachariah L Deitz	305 3rd St W Buffalo, ND 58011	8 MAR 2016
Ann M Jarvis	ANN M JARVIS	306 4th AVE AYR, ND 58007	
Lette Anderson	Lette Anderson	Buffalo, ND	
Richard Beems	Richard Beems	Buffalo	3-10-16
Jack Grant	Jack Grieve	Buffalo	3-10-16
Cynthia Allen	Cynthia ALLEN	BUFFALO	3-10-16
Deon Evenson	Deon Evenson	Buffalo	3-11-16

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Signature	Print Name	Location	Date
Jennifer Fraase	Jennifer Fraase	Buffalo, ND	3-11-16
Ryan Zaun	Ryan Zaun	Buffalo, ND	3-11-16
Tracie Zaun	TRACIE ZAUN	Buffalo ND	3-11-16
Joann Boyd	Joann Boyd	Buffalo, ND	3-11-16
Kelly Boyd	Kelly Boyd	Buffalo, ND	3-11-16
Jon Wendling	Jon Wendling	Buffalo, ND	3-13-16
Denise Gaudreault	Denise Gaudreault	Buffalo, ND	3-13-16

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Signature	Print Name	Location	Date
Bob Killoran	Bob Killoran	Buffalo	3-9-2016
William E. Grieve	William E. Grieve		3-13-16

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Signature	Print Name	Location	Date
T Besette	Travis Besette	Tower City	13 MAR 16
Adam Walburn	Adam Walburn	Tower City, ND	3/13/16

Research

Understanding Concentrated Animal Feeding Operations and Their Impact on Communities

ENVIRONMENTAL HEALTH

NALBOH
National Association of Local Boards of Health

000477

Understanding Concentrated Animal Feeding Operations and Their Impact on Communities

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Foreword

The National Association of Local Boards of Health (NALBOH) is pleased to provide *Understanding Concentrated Animal Feeding Operations and Their Impact on Communities* to assist local boards of health who have concerns about concentrated animal feeding operations (CAFOs) or large industrial animal farms in their communities. The Environmental Health Services Branch of the Centers for Disease Control and Prevention (CDC), National Center for Environmental Health (NCEH) encouraged the development of this product and provided technical oversight and financial support. This publication was supported by Cooperative Agreement Number 5U38HM000512. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the CDC.

The mission of NALBOH is to strengthen boards of health, enabling them to promote and protect the health of their communities, through education, technical assistance, and advocacy. Boards of health are responsible for fulfilling three public health core functions: assessment, policy development, and assurance. For a health agency, this includes overseeing and ensuring that there are sufficient resources, effective policies and procedures, partnerships with other organizations and agencies, and regular evaluation of an agency's services.

NALBOH is confident that *Understanding Concentrated Animal Feeding Operations and Their Impact on Communities* will help local board of health members understand their role in developing ways to mitigate potential problems associated with CAFOs. We trust that the information provided in this guide will enable board of health members to develop and sustain monitoring programs, investigate developing policy related to CAFOs, and create partnerships with other local and state agencies and officials to improve the health and well-being of communities everywhere.

A special thanks to Jeffrey Neistadt (NALBOH's Director – Education and Training), NALBOH's Environmental Health subcommittee, and any local board of health members and health department staff who were contacted during the development of this document for their contributions and support.

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Introduction

Livestock farming has undergone a significant transformation in the past few decades. Production has shifted from smaller, family-owned farms to large farms that often have corporate contracts. Most meat and dairy products now are produced on large farms with single species buildings or open-air pens (MacDonald & McBride, 2009). Modern farms have also become much more efficient. Since 1960, milk production has doubled, meat production has tripled, and egg production has quadrupled (Pew Commission on Industrial Animal Farm Production, 2009). Improvements to animal breeding, mechanical innovations, and the introduction of specially formulated feeds and animal pharmaceuticals have all increased the efficiency and productivity of animal agriculture. It also takes much less time to raise a fully grown animal. For example, in 1920, a chicken took approximately 16 weeks to reach 2.2 lbs., whereas now they can reach 5 lbs. in 7 weeks (Pew, 2009).

New technologies have allowed farmers to reduce costs, which mean bigger profits on less land and capital. The current agricultural system rewards larger farms with lower costs, which results in greater profit and more incentive to increase farm size.

AFO vs. CAFO

A CAFO is a specific type of large-scale industrial agricultural facility that raises animals, usually at high-density, for the consumption of meat, eggs, or milk. To be considered a CAFO, a farm must first be categorized as an animal feeding operation (AFO). An AFO is a lot or facility where animals are kept confined and fed or maintained for 45 or more days per year, and crops, vegetation, or forage growth are not sustained over a normal growing period (Environmental Protection Agency [EPA], 2009). CAFOs are classified by the type and number of animals they contain, and the way they discharge waste into the water supply. CAFOs are AFOs that contain at least a certain number of animals, or have a number of animals that fall within a range and have waste materials that come into contact with the water supply. This contact can either be through a pipe that carries manure or wastewater to surface water, or by animal contact with surface water that runs through their confined area. (See Appendix A)

History

AFOs were first identified as potential pollutants in the 1972 Clean Water Act. Section 502 identified "feedlots" as "point sources" for pollution along with other industries, such as fertilizer manufacturing. Consequently, a permit program entitled the National Pollutant Discharge Elimination System (NPDES) was created which set effluent limitation guidelines and standards (ELGs) for CAFOs. CAFOs have since been regulated by NPDES or a state equivalent since the mid-1970s. The definitions of what was considered an AFO or CAFO were created by the EPA for the NPDES process in 1976. These regulations remained in effect for more than 25 years, but increases and changes to farm size and production methods required an update to the permit system.

The regulations guiding CAFO permits and operations were revised in 2003. New inclusions in the 2003 regulations were that all CAFOs had to apply for a NPDES permit even if they only discharged in the event of a large storm. Large poultry operations were included in the regulations, regardless of their waste disposal system, and all CAFOs that held a NPDES permit were required to develop and implement a nutrient management plan. These plans had CAFOs identify ways to treat or process waste in a way that maintained nutrient levels at the appropriate amount.

The 2003 CAFO rule was subsequently challenged in court. A Second Circuit Court of Appeals decision required alteration to the CAFO permitting system. In *Water Keeper et al. vs. the EPA*, the court directed the EPA to remove the requirement for all CAFOs to apply for NPDES. Instead, the court required that nutrient management plans be submitted with the permit application, reviewed by officials and the public, and the terms of the plan be incorporated into the permit.

As a result of this court decision, the CAFO rule was again updated. The current final CAFO rule, which was revised in 2008, requires that only CAFOs which discharge or propose to discharge waste apply for permits. The EPA has also provided clarification in the discussion surrounding the rule on how CAFOs should assess whether they discharge or propose to discharge. There is also the opportunity to receive a no discharge certification for CAFOs that do not discharge or propose to discharge. This certification demonstrates that the CAFO is not required to acquire a permit. And while CAFOs were required to create nutrient management plans under the 2003 rule, these plans were now included with permit applications, and had a built-in time period for public review and comment.

Benefits of CAFOs

When properly managed, located, and monitored, CAFOs can provide a low-cost source of meat, milk, and eggs, due to efficient feeding and housing of animals, increased facility size, and animal specialization. When CAFOs are proposed in a local area, it is usually argued that they will enhance the local economy and increase employment. The effects of using local materials, feed, and livestock are argued to ripple throughout the economy, and increased tax expenditures will lead to increase funds for schools and infrastructure.

Environmental Health Effects

The most pressing public health issue associated with CAFOs stems from the amount of manure they produce. CAFO manure contains a variety of potential contaminants. It can contain plant nutrients such as nitrogen and phosphorus, pathogens such as *E. coli*, growth hormones, antibiotics, chemicals used as additives to the manure or to clean equipment, animal blood, silage leachate from corn feed, or copper sulfate used in footbaths for cows.

Depending on the type and number of animals in the farm, manure production can range between 2,800 tons and 1.6 million tons a year (Government Accountability Office [GAO], 2008). Large farms can produce more waste than some U.S. cities—a feeding operation with 800,000 pigs could produce over 1.6 million tons of waste a year. That amount is one and a half times more than the annual sanitary waste produced by the city of Philadelphia, Pennsylvania (GAO, 2008). Annually, it is estimated that livestock animals in the U.S. produce each year somewhere between 3 and 20 times more manure than people in the U.S. produce, or as much as 1.2–1.37 billion tons of waste (EPA, 2005). Though sewage treatment plants are required for human waste, no such treatment facility exists for livestock waste.

While manure is valuable to the farming industry, in quantities this large it becomes problematic. Many farms no longer grow their own feed, so they cannot use all the manure they produce as fertilizer. CAFOs must find a way to manage the amount of manure produced by their animals. Ground application of untreated manure is one of the most common disposal methods due to its low cost. It has limitations, however, such as the inability to apply manure while the ground is frozen. There are also limits as to how many nutrients from manure a land area can handle. Over application of livestock wastes can overload

soil with macronutrients like nitrogen and phosphorous and micronutrients that have been added to animal feed like heavy metals (Burkholder et al., 2007). Other manure management strategies include pumping liquefied manure onto spray fields, trucking it off-site, or storing it until it can be used or treated. Manure can be stored in deep pits under the buildings that hold animals, in clay or concrete pits, treatment lagoons, or holding ponds.

Animal feeding operations are developing in close proximity in some states, and fields where manure is applied have become clustered. When manure is applied too frequently or in too large a quantity to an area, nutrients overwhelm the absorptive capacity of the soil, and either run off or are leached into the groundwater. Storage units can break or become faulty, or rainwater can cause holding lagoons to overflow. While CAFOs are required to have permits that limit the levels of manure discharge, handling the large amounts of manure inevitably causes accidental releases which have the ability to potentially impact humans.

The increased clustering and growth of CAFOs has led to growing environmental problems in many communities. The excess production of manure and problems with storage or manure management can affect ground and surface water quality. Emissions from degrading manure and livestock digestive processes produce air pollutants that often affect ambient air quality in communities surrounding CAFOs. CAFOs can also be the source of greenhouse gases, which contribute to global climate change.

All of the environmental problems with CAFOs have direct impact on human health and welfare for communities that contain large industrial farms. As the following sections demonstrate, human health can suffer because of contaminated air and degraded water quality, or from diseases spread from farms. Quality of life can suffer because of odors or insect vectors surrounding farms, and property values can drop, affecting the financial stability of a community. One study found that 82.8% of those living near and 89.5% of those living far from CAFOs believed that their property values decreased, and 92.2% of those living near and 78.9% of those living far from CAFOs believed the odor from manure was a problem. The study found that real estate values had not dropped and odor infestations were not validated by local governmental staff in the areas. However, the concerns show that CAFOs remain contentious in communities (Schmalzried and Fallon, 2007). CAFOs are an excellent example of how environmental problems can directly impact human and community well-being.

Groundwater

Groundwater can be contaminated by CAFOs through runoff from land application of manure, leaching from manure that has been improperly spread on land, or through leaks or breaks in storage or containment units. The EPA's 2000 National Water Quality Inventory found that 29 states specifically identified animal feeding operations, not just concentrated animal feeding operations, as contributing to water quality impairment (Congressional Research Service, 2008). A study of private water wells in Idaho detected levels of veterinary antibiotics, as well as elevated levels of nitrates (Batt, Snow, & Alga, 2006). Groundwater is a major source of drinking water in the United States. The EPA estimates that 53% of the population relies on groundwater for drinking water, often at much higher rates in rural areas (EPA, 2004). Unlike surface water, groundwater contamination sources are more difficult to monitor. The extent and source of contamination are often harder to pinpoint in groundwater than surface water contamination. Regular testing of household water wells for total and fecal coliform bacteria is a crucial element in monitoring groundwater quality, and can be the first step in discovering contamination issues related to CAFO discharge. Groundwater contamination can also affect surface water (Spellman &

Whiting, 2007). Contaminated groundwater can move laterally and eventually enter surface water, such as rivers or streams.

When groundwater is contaminated by pathogenic organisms, a serious threat to drinking water can occur. Pathogens survive longer in groundwater than surface water due to lower temperatures and protection from the sun. Even if the contamination appears to be a single episode, viruses could become attached to sediment near groundwater and continue to leach slowly into groundwater. One pollution event by a CAFO could become a lingering source of viral contamination for groundwater (EPA, 2005).

Groundwater can still be at risk for contamination after a CAFO has closed and its lagoons are empty. When given increased air exposure, ammonia in soil transforms into nitrates. Nitrates are highly mobile in soil, and will reach groundwater quicker than ammonia. It can be dangerous to ignore contaminated soil. The amount of pollution found in groundwater after contamination depends on the proximity of the aquifer to the CAFO, the size of the CAFO, whether storage units or pits are lined, the type of subsoil, and the depth of the groundwater.

If a CAFO has contaminated a water system, community members should be concerned about nitrates and nitrate poisoning. Elevated nitrates in drinking water can be especially harmful to infants, leading to blue baby syndrome and possible death. Nitrates oxidize iron in hemoglobin in red blood cells to methemoglobin. Most people convert methemoglobin back to hemoglobin fairly quickly, but infants do not convert back as fast. This hinders the ability of the infant's blood to carry oxygen, leading to a blue or purple appearance in affected infants. However, infants are not the only ones who can be affected by excess nitrates in water. Low blood oxygen in adults can lead to birth defects, miscarriages, and poor general health. Nitrates have also been speculated to be linked to higher rates of stomach and esophageal cancer (Bowman, Mueller, & Smith, 2000). In general, private water wells are at higher risk of nitrate contamination than public water supplies.

Surface Water

The agriculture sector, including CAFOs, is the leading contributor of pollutants to lakes, rivers, and reservoirs. It has been found that states with high concentrations of CAFOs experience on average 20 to 30 serious water quality problems per year as a result of manure management problems (EPA, 2001). This pollution can be caused by surface discharges or other types of discharges. Surface discharges can be caused by heavy storms or floods that cause storage lagoons to overfill, running off into nearby bodies of water. Pollutants can also travel over land or through surface drainage systems to nearby bodies of water, be discharged through manmade ditches or flushing systems found in CAFOs, or come into contact with surface water that passes directly through the farming area. Soil erosion can contribute to water pollution, as some pollutants can bond to eroded soil and travel to watersheds (EPA, 2001). Other types of discharges occur when pollutants travel to surface water through other mediums, such as groundwater or air.

Contamination in surface water can cause nitrates and other nutrients to build up. Ammonia is often found in surface waters surrounding CAFOs. Ammonia causes oxygen depletion from water, which itself can kill aquatic life. Ammonia also converts into nitrates, which can cause nutrient overloads in surface waters (EPA, 1998). Excessive nutrient concentrations, such as nitrogen or phosphorus, can lead to eutrophication and make water inhabitable to fish or indigenous aquatic life (Sierra Club Michigan Chapter, n.d.). Nutrient over-enrichment causes algal blooms, or a rapid increase of algae growth in an aquatic environment (Science Daily, n.d.). Algal blooms can cause a spiral of environmental problems to an aquatic system. Large groups of algae can block sunlight from underwater plant life, which are

habitats for much aquatic life. When algae growth increases in surface water, it can also dominate other resources and cause plants to die. The dead plants provide fuel for bacteria to grow and increased bacteria use more of the water's oxygen supply. Oxygen depletion once again causes indigenous aquatic life to die. Some algal blooms can contain toxic algae and other microorganisms, including *Pfiesteria*, which has caused large fish kills in North Carolina, Maryland, and the Chesapeake Bay area (Spellman & Whiting, 2007). Eutrophication can cause serious problems in surface waters and disrupt the ecological balance.

Water tests have also uncovered hormones in surface waters around CAFOs (Burkholder et al., 2007). Studies show that these hormones alter the reproductive habits of aquatic species living in these waters, including a significant decrease in the fertility of female fish. CAFO runoff can also lead to the presence of fecal bacteria or pathogens in surface water. One study showed that protozoa such as *Cryptosporidium parvum* and *Giardia* were found in over 80% of surface water sites tested (Spellman & Whiting, 2007). Fecal bacteria pollution in water from manure land application is also responsible for many beach closures and shellfish restrictions.

Air Quality

In addition to polluting ground and surface water, CAFOs also contribute to the reduction of air quality in areas surrounding industrial farms. Animal feeding operations produce several types of air emissions, including gaseous and particulate substances, and CAFOs produce even more emissions due to their size. The primary cause of gaseous emissions is the decomposition of animal manure, while particulate substances are caused by the movement of animals. The type, amount, and rate of emissions created depends on what state the manure is in (solid, slurry, or liquid), and how it is treated or contained after it is excreted. Sometimes manure is "stabilized" in anaerobic lagoons, which reduces volatile solids and controls odor before land application.

The most typical pollutants found in air surrounding CAFOs are ammonia, hydrogen sulfide, methane, and particulate matter, all of which have varying human health risks. Table 1 on page 6 provides information on these pollutants.

Most manure produced by CAFOs is applied to land eventually and this land application can result in air emissions (Merkel, 2002). The primary cause of emission through land application is the volatilization of ammonia when the manure is applied to land. However, nitrous oxide is also created when nitrogen that has been applied to land undergoes nitrification and denitrification. Emissions caused by land application occur in two phases: one immediately following land application and one that occurs later and over a longer period as substances in the soil break down. Land application is not the only way CAFOs can emit harmful air emissions—ventilation systems in CAFO buildings can also release dangerous contaminants. A study by Iowa State University, which was a result of a lawsuit settlement between the Sierra Club and Tyson Chicken, found that two chicken houses in western Kentucky emitted over 10 tons of ammonia in the year they were monitored (Burns et al., 2007).

Most studies that examine the health effects of CAFO air emissions focus on farm workers, however some have studied the effect on area schools and children. While all community members are at risk from lowered air quality, children take in 20-50% more air than adults, making them more susceptible to lung disease and health effects (Kleinman, 2000). Researchers in North Carolina found that the closer children live to a CAFO, the greater the risk of asthma symptoms (Barrett, 2006). Of the 226 schools that were included in the study, 26% stated that there were noticeable odors from CAFOs outdoors, while 8% stated

Table 1 Typical pollutants found in air surrounding CAFOs.

CAFO Emissions	Source	Traits	Health Risks
Ammonia	Formed when microbes decompose undigested organic nitrogen compounds in manure	Colorless, sharp pungent odor	Respiratory irritant, chemical burns to the respiratory tract, skin, and eyes, severe cough, chronic lung disease
Hydrogen Sulfide	Anaerobic bacterial decomposition of protein and other sulfur containing organic matter	Odor of rotten eggs	Inflammation of the moist membranes of eye and respiratory tract, olfactory neuron loss, death
Methane	Microbial degradation of organic matter under anaerobic conditions	Colorless, odorless, highly flammable	No health risks. Is a greenhouse gas and contributes to climate change.
Particulate Matter	Feed, bedding materials, dry manure, unpaved soil surfaces, animal dander, poultry feathers	Comprised of fecal matter, feed materials, pollen, bacteria, fungi, skin cells, silicates	Chronic bronchitis, chronic respiratory symptoms, declines in lung function, organic dust toxic syndrome

they experience odors from CAFOs inside the schools. Schools that were closer to CAFOs were often attended by students of lower socioeconomic status (Mirabelli, Wing, Marshall, & Wilcosky, 2006).

There is consistent evidence suggesting that factory farms increase asthma in neighboring communities, as indicated by children having higher rates of asthma (Sigurdarson & Kline, 2006; Mirabelli et al., 2006). CAFOs emit particulate matter and suspended dust, which is linked to asthma and bronchitis. Smaller particles can actually be absorbed by the body and can have systemic effects, including cardiac arrest. If people are exposed to particulate matter over a long time, it can lead to decreased lung function (Michigan Department of Environmental Quality [MDEQ] Toxics Steering Group [TSG], 2006). CAFOs also emit ammonia, which is rapidly absorbed by the upper airways in the body. This can cause severe coughing and mucous build-up, and if severe enough, scarring of the airways. Particulate matter may lead to more severe health consequences for those exposed by their occupation. Farm workers can develop acute and chronic bronchitis, chronic obstructive airways disease, and interstitial lung disease. Repeated exposure to CAFO emissions can increase the likelihood of respiratory diseases. Occupational asthma, acute and chronic bronchitis, and organic dust toxic syndrome can be as high as 30% in factory farm workers

(Horrigan, Lawrence, & Walker, 2002). Other health effects of CAFO air emissions can be headaches, respiratory problems, eye irritation, nausea, weakness, and chest tightness.

There is evidence that CAFOs affect the ambient air quality of a community. There are three laws that potentially govern CAFO air emissions—the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, also known as the Superfund Act), the Emergency Planning & Community Right to Know Act (EPCRA), and the Clean Air Act (CAA). However, the EPA passed a rule that exempts all CAFOs from reporting emissions under CERCLA. Only CAFOs that are classified as large are required to report any emission event of 100 pounds of ammonia or hydrogen sulfide or more during a 24-hour period locally or to the state under EPCRA (Michigan State University Extension, n.d.). The EPA has also instituted a voluntary Air Quality Compliance Agreement in which they will monitor some CAFO air emissions, and will not sue offenders but instead charge a small civil penalty. These changes have attracted criticism from environmental and community leaders who state that the EPA has yielded to influence from the livestock industry. The changes also leave ambiguity as to whether emission standards and air quality near CAFOs are being monitored.

Greenhouse Gas and Climate Change

Aside from the possibility of lowering air quality in the areas around them, CAFOs also emit greenhouse gases, and therefore contribute to climate change. Globally, livestock operations are responsible for approximately 18% of greenhouse gas production and over 7% of U.S. greenhouse gas emissions (Massey & Ulmer, 2008). While carbon dioxide is often considered the primary greenhouse gas of concern, manure emits methane and nitrous oxide which are 23 and 300 times more potent as greenhouse gases than carbon dioxide, respectively. The EPA attributes manure management as the fourth leading source of nitrous oxide emissions and the fifth leading source of methane emissions (EPA, 2009).

The type of manure storage system used contributes to the production of greenhouse gases. Many CAFOs store their excess manure in lagoons or pits, where they break down anaerobically (in the absence of oxygen), which exacerbates methane production. Manure that is applied to land or soil has more exposure to oxygen and therefore does not produce as much methane. Ruminant livestock, such as cows, sheep, or goats, also contribute to methane production through their digestive processes. These livestock have a special stomach called a rumen that allows them to digest tough grains or plants that would otherwise be unusable. It is during this process, called enteric fermentation, that methane is produced. The U.S. cattle industry is one of the primary methane producers. Livestock production and meat and dairy consumption has been increasing in the United States, so it can only be assumed that these greenhouse gas emissions will also rise and continue to contribute to climate change.

Odors

One of the most common complaints associated with CAFOs are the odors produced. The odors that CAFOs emit are a complex mixture of ammonia, hydrogen sulfide, and carbon dioxide, as well as volatile and semi-volatile organic compounds (Heederik et al., 2007). These odors are worse than smells formerly associated with smaller livestock farms. The anaerobic reaction that occurs when manure is stored in pits or lagoons for long amounts of time is the primary cause of the smells. Odors from waste are carried away from farm areas on dust and other air particles. Depending on things like weather conditions and farming techniques, CAFO odors can be smelled from as much as 5 or 6 miles away, although 3 miles is a more common distance (State Environmental Resource Center, 2004).

Because CAFOs typically produce malodors, many communities want to monitor emissions and odors. Quantifying odor from industrial farming can be challenging because it is a mixture of free and particle-bound compounds, which can make it hard to identify what specifically is causing the odor. Collecting data on specific gases, such as hydrogen sulfide, can be used as a proxy for odor levels.

CAFO odors can cause severe lifestyle changes for individuals in the surrounding communities and can alter many daily activities. When odors are severe, people may choose to keep their windows closed, even in high temperatures when there is no air conditioning. People also may choose to not let their children play outside and may even keep them home from school. Mental health deterioration and an increased sensitization to smells can also result from living in close proximity to odors from CAFOs. Odor can cause negative mood states, such as tension, depression, or anger, and possibly neurophysciatric abnormalities, such as impaired balance or memory. People who live close to factory farms can develop CAFO-related post traumatic stress disorder, including anxiety about declining quality of life (Donham et al., 2007).

Ten states use direct regulations to control odors emitted by CAFOs. They prohibit odor emissions greater than a set standard. States with direct regulations use scentometers, which measure how many times an odor has to be doused with clean air before the smell is undetectable. An additional 34 states have indirect methods to reduce CAFO odors. These include: setbacks, which specify how far CAFO structures have to be from other buildings; permits, which are the most typical way of regulating CAFOs; public comment or involvement periods; and operator or manure placement training.

Insect Vectors

CAFOs and their waste can be breeding grounds for insect vectors. Houseflies, stable flies, and mosquitoes are the most common insects associated with CAFOs. Houseflies breed in manure, while stable and other flies breed in decaying organic material, such as livestock bedding. Mosquitoes breed in standing water, and water on the edges of manure lagoons can cause mosquito infestations to rise. Flies can change from eggs to adults in only 10 days, which means that substances in which flies breed need to be cleaned up regularly.

Flies are typically considered only nuisances, although insects can agitate livestock and decrease animal health. The John Hopkins Bloomberg School of Public Health found evidence that houseflies near poultry operations may contribute to the dispersion of drug-resistant bacteria (Center for Livable Future, 2009). Since flies are attracted to and eat human food, there is a potential for spreading bacteria or pathogens to humans, including microbes that can cause dysentery and diarrhea (Bowman et al., 2000). Mosquitoes spread zoonotic diseases, such as West Nile virus, St. Louis encephalitis, and equine encephalitis.

Residences closest to the feeding operations experience a much higher fly population than average homes. To lower the rates of insects and any accompanying disease threats, standing water should we cleaned or emptied weekly, and manure or decaying organic matter should be removed twice weekly (Purdue Extension, 2007). For more specific insect vector information, please refer to NALBOH's vector guide (*Vector Control Strategies for Local Boards of Health*).

Pathogens

Pathogens are parasites, bacterium, or viruses that are capable of causing disease or infection in animals or humans. The major source of pathogens from CAFOs is in animal manure. There are over 150 pathogens in manure that could impact human health. Many of these pathogens are concerning because

they can cause severe diarrhea. Healthy people who are exposed to pathogens can generally recover quickly, but those who have weakened immune systems are at increased risk for severe illness or death. Those at higher risk include infants or young children, pregnant women, the elderly, and those who are immunosuppressed, HIV positive, or have had chemotherapy. This risk group now roughly compromises 20% of the U.S. population.

Table 2 Select pathogens found in animal manure.

Pathogen	Disease	Symptoms
Bacillus anthracis	Anthrax	Skin sores, headache, fever, chills, nausea, vomiting
Escherichia coli	Colibacilosis, Coliform mastitis-metris	Diarrhea, abdominal gas
Leptospira pomona	Leptospirosis	Abdominal pain, muscle pain, vomiting, fever
Listeria monocytogenes	Listerosis	Fever, fatigue, nausea, vomiting, diarrhea
Salmonella species	Salmonellosis	Abdominal pain, diarrhea, nausea, chills, fever, headache
Clostirdum tetani	Tetanus	Violent muscle spasms, lockjaw, difficulty breathing
Histoplasma capsulatum	Histoplasmosis	Fever, chills, muscle ache, cough rash, joint pain and stiffness
Microsporum and *Trichophyton*	Ringworm	Itching, rash
Giardia lamblia	Giardiasis	Diarrhea, abdominal pain, abdominal gas, nausea, vomiting, fever
Cryptosporidium species	Cryptosporidosis	Diarrhea, dehydration, weakness, abdominal cramping

Sources of infection from pathogens include fecal-oral transmission, inhalation, drinking water, or incidental water consumption during recreational water activities. The potential for transfer of pathogens among animals is higher in confinement, as there are more animals in a smaller amount of space. Healthy or asymptomatic animals may carry microbial agents that can infect humans, who can then spread that infection throughout a community, before the infection is discovered among animals.

When water is contaminated by pathogens, it can lead to widespread outbreaks of illness. Salmonellosis, cryptosporidiosis, and giardiasis can cause nausea, vomiting, fever, diarrhea, muscle pain, and death, among other symptoms. *E.coli* is another serious pathogen, and can be life-threatening for the young, elderly, and immunocompromised. It can cause bloody diarrhea and kidney failure. Since many CAFO use sub-therapeutic antibiotics with their animals, there is also the possibility that disease-resistant bacteria can emerge in areas surrounding CAFOs. Bacteria that cannot be treated by antibiotics can have very serious effects on human health, potentially even causing death (Pew Charitable Trusts, n.d.).

There is also the possibility of novel (or new) viruses developing. These viruses generate through mutation or recombinant events that can result in more efficient human-to-human transmission. There has been some speculation that the novel H1N1 virus outbreak in 2009 originated in swine CAFOs in Mexico. However, that claim has never been substantiated. CAFOs are not required to test for novel viruses, since they are not on the list of mandatory reportable illness to the World Organization for Animal Health.

Antibiotics

Antibiotics are commonly administered in animal feed in the United States. Antibiotics are included at low levels in animal feed to reduce the chance for infection and to eliminate the need for animals to expend energy fighting off bacteria, with the assumption that saved energy will be translated into growth. The main purposes of using non-therapeutic doses of antimicrobials in animal feed is so that animals will grow faster, produce more meat, and avoid illnesses. Supporters of antibiotic use say that it allows animals to digest their food more efficiently, get the most benefit from it, and grow into strong and healthy animals.

The trend of using antibiotics in feed has increased with the greater numbers of animals held in confinement. The more animals that are kept in close quarters, the more likely it is that infection or bacteria can spread among the animals. Seventy percent of all antibiotics and related drugs used in the U.S. each year are given to beef cattle, hogs, and chickens as feed additives. Nearly half of the antibiotics used are nearly identical to ones given to humans (Kaufman, 2000).

There is strong evidence that the use of antibiotics in animal feed is contributing to an increase in antibiotic-resistant microbes and causing antibiotics to be less effective for humans (Kaufman, 2000). Resistant strains of pathogenic bacteria in animals, which can be transferred to humans thought the handling or eating of meat, have increased recently. This is a serious threat to human health because fewer options exist to help people overcome disease when infected with antibiotic-resistant pathogens. The antibiotics often are not fully metabolized by animals, and can be present in their manure. If manure pollutes a water supply, antibiotics can also leech into groundwater or surface water.

Because of this concern for human health, there is a growing movement to eliminate the non-therapeutic use of antibiotics with animals. In 2001, the American Medical Association approved a resolution to ban all low-level use of antibiotics. The USDA has developed guidelines to limit low-level use, and some major meat buyers (such as McDonald's) have stopped using meat that was given antibiotics that are also used for humans. The World Health Organization is also widely opposed to the use of antibiotics, calling for a cease of their low-level use in 2003. Some U.S. legislators are seeking to ban the routine use of antibiotics with livestock, and there has been legislation proposed to solidify a ban. The Preservation of Antibiotics for Medical Treatment Act (PAMTA), which was introduced in 2009, has the support of over 350 health,

consumer, and environmental groups (H.R. 1549/S. 619). The act, if passed, would ban seven classes of antibiotics important to human health from being used in animals, and would restrict other antibiotics to therapeutic and some preventive uses.

Other Effects – Property Values

Most landowners fear that when CAFOs move into their community their property values will drop significantly. There is evidence that CAFOs do affect property values. The reasons for this are many: the fear of loss of amenities, the risk of air or water pollution, and the increased possibility of nuisances related to odors or insects. CAFOs are typically viewed as a negative externality that can't be solved or cured. There may be stigma that is attached to living by a CAFO.

The most certain fact regarding CAFOs and property values are that the closer a property is to a CAFO, the more likely it will be that the value of the property will drop. The exact impact of CAFOs fluctuates depending on location and local specifics. Studies have found differing results of rates of property value decrease. One study shows that property value declines can range from a decrease of 6.6% within a 3-mile radius of a CAFO to an 88% decrease within 1/10 of a mile from a CAFO (Dakota Rural Action, 2006). Another study found that property value decreases are negligible beyond 2 miles away from a CAFO (Purdue Extension, 2008). A third study found that negative effects are largest for properties that are downwind and closest to livestock (Herriges, Secchi, & Babcock, 2005). The size and type of the feeding operation can affect property value as well. Decreases in property values can also cause property tax rates to drop, which can place stress on local government budgets.

Considerations for Boards of Health

Right-to-Farm Laws

With all of the potential environmental and public health effects from CAFOs, community members and health officials often resort to taking legal action against these industrial animal farms. However, there are some protections for farms in place that can make lawsuits hard to navigate. Right-to-farm laws were created to address conflicts between farmers and non-farming neighbors. They seek to override common laws of nuisance, which forbid people to use their property in ways that are harmful to others, and protect farmers from unreasonable controls on farming.

All 50 states have some form of right-to-farm laws, but most only offer legal protections to farms if they meet certain specifications. Generally, they must be in compliance with all environmental regulations, be properly run, and be present in a region first before suburban developments, often a year before the plaintiff moves to that area. These right-to-farm laws were originally created in the late 1970s and early 1980s to protect family farms from suburban sprawl, at a time when large industrial farms were not the norm. As industrial farms grew in size and number, the agribusiness industry lobbied for and achieved the passage of stricter laws in the 1990s, many of which are now being challenged in court by homeowners and small family farmers. Opponents to these laws argue that they deprive them of their use of property and therefore violate the Fifth Amendment to the Constitution.

Some state courts have overturned their strict right-to-farm laws, such as Iowa, Michigan, Minnesota, and Kansas. Others such as Vermont have rewritten their laws. Vermont's updated right-to-farm bill

protects established farm practices as long as there is not a substantial adverse effect on health, safety, or welfare.

Boards of health need to be aware of what legal protection their state offers farms. Right-to-farm laws can hinder nuisance complaints brought about by community members. State laws can prevent local government or health officials from regulating industrial farms.

Board of Health Involvement with CAFOs

Boards of health are responsible for fulfilling the three public health core functions: assessment, policy development, and assurance. Boards of health can fulfill these functions through addressing problems stemming from CAFOs in their communities. Specific public health services that can tackled regarding CAFOs include monitoring health status, investigating health problems, developing policies, enforcing regulations, informing and educating people about CAFOs, and mobilizing community partnerships to spread awareness about environmental health issues related to CAFOs.

Assessment: Board of health members should ensure that there is an effective method in place for collecting and tracking public complaints about CAFOs and large animal farms. Since environmental health specialists at local health departments are often responsible for investigating complaints, the board of health must take measures to ensure that they are properly trained and educated about CAFOs. It is possible that the board of health may be responsible or choose to do some investigations itself. Schmalzried and Fallon (2008) advocate that local health districts adopt a proactive approach for addressing public concerns about CAFOs, stating that health districts can offer some services that may help ease public frustration with CAFOs. A fly trapping program can establish a baseline for the average number of flies present prior to the start-up of CAFOs or large animal farms, which can then establish if a fly nuisance exists in the area. Testing for water quality and quantity can provide evidence if CAFOs are suspected of affecting private water supplies. Boards of health can also monitor exposure incidences that occur in emergency rooms to determine if migrant or farm workers are developing any adverse health conditions as a result of their work environments. Establishing these programs benefit both members of the community and provide information to future animal farm operators, and local boards of health should recommend them if they've been receiving complaints about CAFOs.

Policy Development: Boards of health in many states can adopt health-based regulations about CAFOs, however, they may be met with some resistance. Humbolt County, Iowa, adopted four health-based ordinances concerning CAFOs that became models for regulations in other states, but the Iowa Supreme Court ruled the ordinances were irreconcilable with state laws. Boards of health that choose to regulate CAFOs can also be subject to pressure from outside forces, including possible lawsuits or withdrawal of funding. Boards of health should also consider working with other local officials to institute regulations on CAFOs, such as zoning ordinances.

Assurance: Boards of health can execute the assurance function by advocating for or educating about better environmental practices with CAFOs. Board members may receive complaints from the public about CAFOs, and boards can hold public meetings to receive complaints and hear public testimony about farms. If boards of health are not capable of regulating industrial farms in their communities, they can still try to collaborate with other local agencies that have jurisdiction. Board of health members can educate other local agencies and public officials about CAFOs and spread awareness about the environmental and health hazards. They can request a public hearing with the permitting agency of the

CAFO to express their concerns about the potential health effects. They can also work with agricultural and farm representatives to teach better environmental practices and pollution reduction techniques.

In many states, boards of health are empowered to adopt more stringent rules than the state law if it is necessary to protect public health. Board of health members should examine their state laws before they take any action regarding CAFOs to determine the most appropriate course of action. Any process should include an investigative period to gather evidence, public hearings, and a time for public review of draft policies.

Board of Health Case Studies

Tewksbury Board of Health, Massachusetts

Locals have complained about Krochmal Farms, a pig farm, for many years, but complaints have increased recently. The addition of a hog finishing facility to the farm coincided with the time that community member complaints grew. Most complaints are centered on the odor coming from the farm. The complaints were originally just logged when phone calls were received; however, the health department added a data tracking system as the number of complaints increased. After a complaint is received, the sanitarian or health director does a site visit to investigate.

The health director in Tewksbury filed an order of prohibition against the farm, which is allowed under Massachusetts law 111, section 143, for anything that threatens public health. The order of prohibition was appealed and the matter was taken to the board of health for a grievance hearing. The board of health hearing included months of testimony about the pig farm. The board of health is also doing a site assignment, which determines if a location is appropriate for treating, storing, or disposing of waste, including agricultural waste. The site assignment process includes both the Department of Environmental Protection (DEP) and the local board of health. The board of health holds a public hearing process, while the DEP reviews the site assignment application. The board of health grants the site assignment only if it is concurrently approved by the DEP.

The health director in Tewksbury points out that the only laws the board of health is able to regulate the farm under are nuisance laws. There have been efforts by the community to do a home rule petition to address the air quality and pest management complaints. The home rule petition is currently working its way through the Massachusetts state house. The status of the petition is unknown.

The board of health has tried to work directly with the pig farm to manage complaints. The farm contains manure composting facilities and the health district has requested advance notice to warn the community before manure is treated or applied to the soil. The farm has adopted a new manure management system. This system uses Rapp technology to control odors and reduce ammonia and hydrogen sulfide levels. However, questions still remain as to whether this addition will fully solve the odor issue. Typically, systems using Rapp technology include an oil cap that floats on manure holding pools and helps seal odors inside. These techniques have been researched and proven to reduce odors. However, the Tewksbury farm did not install the oil cap, and it is unknown whether the exclusion of the cap will hinder the technology's ability to reduce odors.

The complaints about the farm primarily concern the odor that emanates from the farm. The complaints do include mention of health side effects, including nausea and burning eyes. The health director has also heard concerns about potential environmental effects from the pig manure. Community members are

worried the manure runoff is entering and contaminating Sutton Brook, since there has been flooding in that area. There has been no confirmation of this occurring. The board of health is aware that the farm has a nutrient management plan, but they are not allowed to request and find out what is incorporated in that plan.

The Tewksbury piggery is technically not classified as a CAFO, though it is believed to be the largest pig farm in the commonwealth of Massachusetts. The area around it has become densely populated and the community members state that they just want to live peacefully with the farm. The board of health has submitted multiple grant applications to study the health effects associated with the farm. After the site assignment process is complete, the board of health will decide how it will regulate the farm. At the beginning of 2010, the board of health was still working on drafting regulations for the pig farms.

Wood County Board of Health, Ohio

Wood County, Ohio, contains two existing large dairy farms, both of which were proposed in 2001 to be expanded to over 1500 cows each. It is also the site for three other proposed dairy farms. There is a large community effort that supports restricting the operation and expansion of these farms, mainly represented by the community group Wood County Citizens Opposed to Factory Farms. The Wood County Board of Health became involved in investigating these dairy farms through this community group and other local officials. The Trustees of Liberty Township requested assistance from the Wood County Board of Health in supporting a moratorium on factory farm operations until local regulations were in effect. The trustees believed that manure runoff from the farms could contaminate local waterways, lower the ground water table, increase the presence of insect vectors, and devalue local properties.

The Wood County Health Director, in cooperation with the board of health, contacted nearby counties to determine what actions they had taken against farms in their communities. While the health director and board of health investigated action in the form of a nuisance regulation against the farms, they were advised that nuisance lawsuits filed against farms in Ohio were held to a tough standard, and they would be forced to demonstrate with scientific proof that the farms have a substantial adverse effect on health. They found that no other board of health in Ohio had opted to regulate farming operations and relied on the enforcement of existing state laws.

The board of health held a public forum to hear public opinion regarding the industrial farms. Ultimately, the Wood County Board of Health took actions other than regulations to help protect the health and environment of its community. They helped community members protect the safety of their water wells by offering free and low cost water well testing and inspections. They tested area ditch and water ways for fecal coliform bacteria, phosphorous, and nitrates to monitor the impact of farm runoff. They also purchased fly traps to monitor and count fly types to determine if the farms have caused an increase in insect vectors. Board of health members also met with state officials from the Ohio EPA in an effort to facilitate cooperation regarding the factory farms. While the Wood County Board of Health and Health Department chose not to institute any local regulations, they continue to monitor the situation and respond to community complaints.

Cerro Gordo County Board of Health, Iowa

Officials in Cerro Gordo County, Iowa, began looking into regulating animal feeding operations after the number of hog farms in Iowa started to grow. Floods in North Carolina and new regulations in Colorado meant that many hog farms began relocating to Iowa. Many citizens had concerns over the effects of

CAFOs, and the Iowa State Association of Counties wanted to review air quality issues. Officials in Cerro Gordo County originally began working on a regulation that required inspections and was based on public health concerns, since farms were already exempt from any regulations related to zoning. However, Iowa state senators soon introduced legislation that passed and prevented any animal feeding operations from being regulated from a public health angle as well.

As Iowans were now prevented from regulating animal feeding operations in terms of zoning or public health, officials in Cerro Gordo County decided to place a moratorium on the construction of new animal feeding operations in that county. They wanted to temporarily stop the growth of animal feeding operations until they could get better science about their effects. Cerro Gordo County Ordinance #40, the "Animal Confinement Moratorium Ordinance," went into effect on May 14, 2002. Since the moratorium did not address public health or zoning, officials were able to get around the rules and still have a way to temporarily control animal feeding operation growth in their county. The ordinance placed "a 1-year moratorium on any new construction, expansion, or activity occurring on land used for the production, care, feeding, or housing of animals." The ordinance also afforded "local public health officials adequate time to appropriately assess health and environmental concerns that may be related to confined animal feeding operations and concentration of animals; establish objective measurable standards of enforcement; exercise the Board of Health's responsibility to protect and improve the health of the public; refrain from impacting farm operators unfairly; and provide penalties for violations of the provisions hereof pursuant to Chapter 137, Code of Iowa" (Cerro Gordo County, 2002).

The moratorium was first adopted by the Cerro Gordo County Board of Health. It was then presented to the county board of supervisors by the health director on behalf of the board of health. Before the board of health adopted the moratorium, they held an investigative meeting in which representatives from the Iowa Farm Bureau and other industry spokespeople exchanged opinions on the issue of animal feeding operations. The moratorium was created through a collaboration between local and county officials—health department staff, the board of health, and the board of supervisors. The moratorium did not receive any help or backing from state officials, who were concerned about the political nature of the ordinance. However it did receive backing from a *Globe Gazette* editorial.

The moratorium was immediately met with resistance from state officials. The Cerro Gordo County Board of Supervisors was contacted by a local legislator, and the Iowa Farm Bureau stated they would challenge the county budget. The Iowa Farm Bureau threatened to take the county to court. There were concerns over the cost of a court trial, which was estimated to be as high as $60,000. The county attorney doubted the legality of the moratorium and ultimately recommended removing it. The moratorium was in effect until June of 2005, when it was repealed by the county board of supervisors.

Since the moratorium was repealed there have been a few hog farms built in Cerro Gordo County, but the decline in pork prices has prevented any large growth of hog farms. Health officials believe that if the county had not implemented the animal confinement moratorium, there would have been many more farms built in their county, since many hog farms were built in counties south of Cerro Gordo County. There is now a process for siting new animal confinement operations in Iowa that uses a Master Matrix scoring system. The Cerro Gordo County Board of Supervisors tracks the Master Matrix system, but so far no animal feeding operations in Iowa who have applied using this system have been denied the right to build.

Conclusion

Concentrated animal feeding operations or large industrial animal farms can cause a myriad of environmental and public health problems. While they can be maintained and operated properly, it is important to ensure that they are routinely monitored to avoid harm to the surrounding community. While states have differing abilities to regulate CAFOs, there are still actions that boards of health can and should take. These actions can be as complex as passing ordinances or regulations directed at CAFOs or can be simply increasing water and air quality testing in the areas surrounding CAFOs. Since CAFOs have such an impact locally, boards of health are an appropriate means for action. Boards of health should take an active role with CAFOs, including collaboration with other state and local agencies, to mitigate the impact that CAFOs or large industrial farms have on the public health of their communities.

Appendix A: Regulatory Definitions of Large CAFOs, Medium CAFOs, and Small CAFOs

Animal Sector	Size Thresholds (number of animals)		
	Large CAFOs	Medium CAFOs[1]	Small CAFOs[2]
Cattle or cow/calf pairs	1,000 or more	300-999	Less than 300
Mature dairy cattle	700 or more	200-699	Less than 200
Veal calves	1,000 or more	300-999	Less than 300
Swine (over 55 pounds)	2,500 or more	750-2,500	Less than 750
Swine (under 55 pounds)	10,000 or more	3,000-9,999	Less than 3,000
Horses	500 or more	150-499	Less than 150
Sheep or lambs	10,000 or more	3,000-9,999	Less than 3,000
Turkeys	55,000 or more	16,500-54,999	Less than 16,500
Laying hens or broilers[3]	30,000 or more	9,000-29,999	Less than 9,000
Chickens other than laying hens[4]	125,000 or more	37,500-124,999	Less than 37,500
Laying hens[4]	82,000 or more	25,000-81,999	Less than 25,000
Ducks[4]	30,000 or more	10,000-29,999	Less than 10,000
Ducks[3]	5,000 or more	1,500-4,999	Less than 1,500

Data: Environmental Protection Agency

1 Must also meet one of two "method of discharge" criteria to be defined as a CAFO or must be designated.

2 Never a CAFO by regulatory definition, but may be designated as a CAFO on a case-by-case basis.

3 Liquid manure handling system

4 Other than a liquid manure handling system

Appendix B: Additional Resources

American Public Health Association. *Precautionary moratorium on new concentrated animal feed operations*. http://www.apha.org/advocacy/policy/policysearch/default.htm?id=1243

Center for a Livable Future. http://www.livablefutureblog.com/

Environmental Health Sciences Research Center. *Iowa concentrated animal feeding operation air quality study*. http://www.public-health.uiowa.edu/ehsrc/CAFOstudy.htm

Environmental Protection Agency. *Animal feeding operations*. http://cfpub.epa.gov/npdes/home.cfm?program_id=7

Food and Water Watch. http://www.foodandwaterwatch.org/

Impacts of CAFOs on Rural Communities. http://web.missouri.edu/ikerdj/papers/Indiana%20--%20CAFOs%20%20Communities.htm#_ftn1

Land Stewardship Project. http://www.landstewardshipproject.org/index.html

Midwest Environmental Advocates. http://www.midwestadvocates.org/

National Agriculture Law Center. *Animal feeding operations reading room*. http://www.nationalaglawcenter.org/readingrooms/afos

National Association of Local Boards of Health. *Vector control strategies for local boards of health*. http://www.nalboh.org/publications.htm

Pew Charitable Trusts. *Human health and industrial farming*. http://www.saveantibiotics.org/index.html

Pew Commission on Industrial Animal Farm Production. http://www.ncifap.org/

Purdue Extension. *Concentrated animal feeding operations*. http://www.ansc.purdue.edu/CAFO/

State Environmental Resource Center. http://serconline.org

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Industrial Hog Production and the Hog-barn Neighbourhood Effect in Lethbridge County, Alberta

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Hog production in North America and Western Europe is increasingly characterized by large-scale, capital intensive operations. These structural changes, combined with emerging spatial concentrations, have caused researchers to speculate that people living in the vicinity of hog barns may display some of the negative health effects that have already been well documented among hog-barn workers. This paper builds on three previous US-based studies, attempting to detect the presence of a hog-barn neighbourhood effect in the County of Lethbridge in southern Alberta. Results, while not definitive, are generally consistent with previous studies, indicating the possibility of this phenomenon in the region. The paper concludes that planning and development-control authorities should continue to apply the precautionary principle when considering development-permit applications for intensive livestock feeding operations.

Introduction

The Canadian swine sector has undergone a remarkable transformation over the last three decades or so. Key changes, which have also occurred in the United States (Hart and Mayda, 1997) and

Western Europe (Jongbloed and Lenis, 1998), include a decline in the number of individual hog operations, an increase in the scale of production, a rise in the degree of specialization, and widespread adoption of total confinement systems. We have also witnessed some noteworthy changes in the spatial distribution of hog production in Canada. Once highly concentrated in Québec and Ontario, other regions are now challenging the historical dominance of central Canada. Western Canada in general, and southern Manitoba and southern Alberta in particular, have each recorded some of the most substantial percentage increases in hog numbers in the country in recent years. Moreover, much of this growth has occurred in the context of very large, highly capitalized and specialized operations.

Coincident with these changes have been mounting concerns over the human health and quality of life implications of the trend toward large-scale industrial hog operations. A considerable amount of the research undertaken to date has focused on the health status of hog-barn workers, and a consensus now exists that, compared with the general population, hog-barn workers are more likely to exhibit a range of respiratory system ailments, suffer from mucous membrane syndrome, and present with a flu-like illness called organic dust toxic syndrome (see, for example, Von Essen and Konham, 1999). Questions regarding the "neighbourhood effect", namely the impact of large-scale hog operations on people living close to them, however, have attracted much less attention. Acknowledging that only a handful of studies have been published in the literature, there is some evidence to suggest that people living in the vicinity of large scale hog operations report many of the same symptoms as hog barn workers do, although not as severely, and experience a somewhat lower quality of life when compared with the general population. Nevertheless, it is too far early to draw general conclusions or to make any definitive statements regarding the applicability of research conducted in only two regions (Iowa and North Carolina) to other regions.

Consequently, the objective of this paper is to test for the existence of the hog-barn neighbourhood effect in the County of Lethbridge, which is located in southern Alberta's agricultural heartland. The question we ask is whether findings from research conducted in other places, where the hog-barn neighbourhood effect has been documented, can be replicated. Not only will this work contribute to the general literature on the question under investigation, but it is especially timely since the provincial government in Alberta has recently announced its intention to promote

substantial expansion of the province's livestock sector, including hog production. Furthermore, concerns over the hog-barn neighbourhood effect have played a central role in heated debates in the province over several proposals for very large hog barns submitted over the last couple of years.

The paper comprises three sections. We start with an overview of what is known about the implications of large-scale, industrial hog production for humans in order to set the context. We then outline the research design used, and present and discuss our empirical results. The paper concludes with some general observations regarding the implications of our findings for local development control authorities.

Industrial Hog Production and Human Health

The odors we typically associate with swine operations come from a variety of volatile organic compounds (VOCs) and other odorants, and include ammonia and various sulfur and sulphide-containing compounds (see, for example, Hobbs et al, 1995). The product of the anaerobic decomposition of proteins and carbohydrates contained in hog manure and urine, Schiffman (1998) has identified four ways that VOCs can negatively affect humans. First, at sufficient concentrations, VOCs can be toxic (Shusterman, 1992). Because such concentrations are rare, however, even close to very large confined animal feeding operations (CAFOs), any health symptoms associated with VOCs are far more likely to be the product of non-toxicological mechanisms (Reynolds et al., 1997; McGinn et al., 2003). Secondly, VOCs have been shown in experimental research to irritate eyes, nose, and throat, and to cause headaches and drowsiness (see, for example, Hudnell et al, 1992). Third, neuro-scientists have known for some time that odors, including VOC's, can affect neuro-chemical activity which can impair a person's mood and performance (see, for example, Lorig et al, 1991). Finally, it has been shown that odors, acting as what Cann and Ross (1989) called context cues, can trigger memories that affect cognitive function, altering one's emotional state and mood (Herz and Engen, 1996).

As observed by Merchant et al (2002), concerns over the health effects of working in CAFOs is a relatively recent phenomenon, having been first raised in the 1970s (Donham et al, 1977). Nevertheless, the occupational risks faced by these workers have now been widely studied and "the scientific literature is quite clear that workers in swine or poultry CAFOs are at risk to diseases from

concentrated emissions inside CAFOs" (Merchant et al, 2002: 136). However, the effects of large-scale, industrial hog operations on the health status and quality of life of people living in the vicinity of such operations, referred to in the literature as the "hog-barn neighbourhood effect", have received considerably less attention. To date only a few studies on the question have been published in the scientific literature.

In the first published study to examine the question, Schiffman et al (1995) used a psychological test known as the "Profile of Mood States Test" to compare a study group living close to large-scale hog operations with a control group. They found that the study group was much more likely to report being tense, depressed, angry, fatigued, and confused. The relationship between odours and health status, including mental state and mood is complex, and so "complaints of health effects from odors associated with livestock operations probably derive from a combination of physiological and psychogenic sources" (Schiffman, 1998: 1343). Nevertheless, despite a lack of understanding of the particular mechanism or combination of mechanisms at work, the research undertaken by Schiffman and her colleagues suggests that people living close to industrial-scale hog operations may confront risks that the general population does not, for no other reason than where they live.

In a second study, Thu et al (1997) matched 18 people living within 3.2 km (two miles) of a large swine operation (4,000 sows) with 18 demographically similar people living more than 3.2 km (two miles) away from the operation. Respondents identified which of 18 physical symptoms, organized into four clusters, they had experienced. The study group reported statistically significantly higher rates of respiratory symptoms (Cluster 1), headaches and plugged ears (Cluster 3) and burning eyes, runny nose, and sore throat (Cluster 4). No significant difference between the study and control groups in the incidence of nausea, dizziness, weakness, and fainting (Cluster 2) was found.

In a third study Wing and Wolf (1999) surveyed three groups of rural North Carolina residents collecting information on their health status and three quality of life indicators. Data were collected on 155 respondents in total, 55 from households located in the vicinity of a 6,000 head hog operation, 50 living in the vicinity of two intensive livestock operations, and 50 people from a rural agricultural area where none of the livestock operations stored or spread liquid manure. Consistent with the findings from studies of hog-barn workers, this research found that respondents in the

vicinity of the hog operation reported significantly higher "occurrence of headaches, runny nose, sore throat, excessive coughing, diarrhea, and burning eyes" (Wing and Wolf, 1999: 233).

It is worthwhile at this point to echo the caution made by Merchant et al (2002: 138): "The three published, peer reviewed studies of community residents exposed to confined animal-feeding operation emissions are limited and should be interpreted with caution because of the relatively small numbers of participants, because they did not report environmental exposure data and likely contain some recall bias". Nevertheless, Merchant and his colleagues go on to observe that the studies are "notable because they were all well designed, controlled studies, and because two of the three that examined respiratory and other symptoms common among confined animal-feeding operation workers found similar symptom patterns (while not as prevalent or severe) as those observed among confined animal-feeding operation workers".

The Lethbridge County Study

In light of the findings reported in the literature and given the Alberta government's plans to promote expansion of the livestock sector, we set out to determine whether or not a hog-barn neighbourhood effect could be detected in the County of Lethbridge. The county is located in south-central Alberta, about 200 km south of Calgary. It is dominated by agriculture, although the City of Lethbridge, with a population of nearly 73,000, is an important educational, research, and administrative centre. The county has one of the highest concentrations of beef-cattle feedlots in Canada (Beaulieu et al, 2001), but there has also been a noteworthy increase in the number of large-scale hog operations over the last decade or so. The region's location relative to the US, its bio-physical setting, a secure supply of high-quality feed supported by irrigation agriculture, and a political climate long sympathetic to agriculture have combined to make the county very attractive to this form of investment. The decision in the early 1990s by Maple Leaf Foods, one of the Canada's largest meat packers, to devote its Lethbridge plant to hog processing has also been an important factor in the expansion of hog production in the county.

We began by developing and piloting our survey instrument. Using Thu et al (1997) and Wing and Wolf (1999) for guidance, our questionnaire comprised two sections. The first part asked for information on each respondent's age, gender, employment, tobacco use, residential history, and occupation. This was followed by a

section in which respondents were presented with a list of 23 physical-health symptoms. Here we replicated the questions asked by Wing and Wolf (2000), who provided us with a copy of their questionnaire. Eighteen of the symptoms can be directly matched to those used by Thu el al (1997), whose published article contains a copy of their questionnaire.

We then obtained two maps from the County of Lethbridge Planning and Development Department. The first showed all of the approved intensive livestock operations in the county in operation at the time, categorized by livestock type, while the second map showed the locations of individual residences. Hog-operation locations were transferred to the second map and a 3.2 km (two-mile) radius was drawn around each unit to replicate the protocol used by Thu et al (1997). Households located within the specified zone and downwind of a hog operation were identified and used to draw the study group. Respondents living outside the study zone in any direction were allocated to the control group. Households from which the study group members were to be drawn were each assigned a unique identifier, and then selected randomly. Interviews concluded when the target number (n=30) was achieved. The control group was geographically stratified in order to avoid encountering unforeseen localized problems such as possible groundwater contamination.

Many of the symptoms included on the survey are often unreported (they are not life threatening), and so, acting on the advice of the Medical Officer of Health for the Chinook Health Region, the interviewer made sure to stipulate that respondents should answer in the affirmative if the symptom had been experienced, whether or not medical attention had been sought. Since growth in the number of large, intensive livestock-feeding operations in the region has been a matter of heated debate in recent years, the study was introduced as "an investigation of the health status of rural residents in the County of Lethbridge" in order to reduce the possibility of respondent bias. The survey was administered in face-to-face interviews during the late winter and early spring of 2003 to one person aged 18 or over per identified household. Potential respondents employed on a hog operation at the time of the interview were excluded from the study.

In order to achieve a target of 60 participants overall, 83 potential respondents were contacted, 44 potential study group members and 39 potential control group members. The refusal rate for potential study group members was 31.8% and for the control group 23.7%. Because we neglected to record basic demographic informa-

tion for those who refused to participate in the survey, we were unable to consider non-response bias.

Following the collection of basic demographic information, respondents were asked to indicate on a 5-point scale (never, rarely, sometimes, often, and very often) the frequency of occurrence of 21 specific physical-health symptoms over the six months prior to being interviewed. For purposes of this paper we have collapsed the 21 symptoms into five separate symptom clusters (see Table 1). The first four clusters are consistent with the categories used by Thu et al (1997), grouping symptoms that have been found in empirical studies in combination with one another. The final category is, more or less, a "catch all" one.

Table 1 The Physical Health Symptoms Included in the Survey

Cluster #	Symptoms in Cluster	Comments
1	Coughed up Mucus or Phlegm, Excessive Coughing, Wheezing, Tightness in Chest, and Shortness of Breath	According to Thu et al, these symptoms are associated with "chronic bronchitis and hyperreactive airways.
2	Felt faint/dizzy, Fainted, Felt Weak, Nausea, and Lack of Appetite	Thu et al (1997: 18) observed that Auger et al (1994) argued that these symptoms suggest "long term exposure to less than acutely toxic levels of endotoxin and hydrogen sulfide".
3	Headaches and Plugged Ears	These symptoms, which have been found in up to 25% of hog-barn worker in at least one study (Donham, 1993), are often associated with chronic sinusitis.
4	Burning Eyes, Runny Nose, Scratchy Throat, Teary Eyes, and Burning Nose	These symptoms are associated with a condition called mucus membrane irritation (Thu et al, 1997).
5	Fever, Trouble Hearing, Joint and/or Muscle Pain, Trouble any specific condition or syndrome.	Symptoms in this cluster are not associated with Sleeping, and Sore Throat*

*The final two symptoms in Cluster #5 were included in Wing and Wolf (2000), but not in Thu et al (1997).

Results and Interpretation

The characteristics of the study and control groups were quite similar. The majority of respondents in each group were women (73% and 60% respectively) and all but one person in each group were non-smokers. The average age of the control group (48 years) and the study group (51 years) was also similar. Of the 31 respondents who answered the question about their occupation, 20 (8 study group and 12 control) told us there were employed in agriculture, while the rest were employed primarily in the tertiary sector. These results were expected since agriculture is an important activity in the County of Lethbridge. Finally, respondents lived an average 20 years in their place of residence (19 years for the study group and 21 years for the control group). Because the control and study groups were so similar, any differences observed between the two groups are unlikely to stem from demographic differences.

Table 2 summarizes the results of data collected regarding the health status of the respondents during the in the six months prior to the study. In order to meet the requirements of the Chi-square test vis-à-vis expected values, we have collapsed the response categories from 5 to 2. Specifically, "never" and "rarely" have been combined in the first response category, while "sometimes", "often" and "very often" have been grouped together.

Table 2 Frequency of Clustered Health Symptoms Experienced by Study and Control Groups

Cluster Number	Never or Rarely		Sometimes to Very Often		Total	Chi-Square Calculated Value	Stat. Sig. Diff at 95% ($\chi^2_{critical}$ = 3.841)
	Study Group	Control Group	Study Group	Control Group			
1	142	145	8	5	300	1.02	No
2	134	143	16	7	300	3.82	No
3	36	47	24	13	180	4.74	Yes
4	130	140	20	10	300	3.72	No
5	139	156	41	24	360	5.42	Yes

As shown in Table 2, for every cluster of symptoms, the number of control group members experiencing various symptoms within the clusters "sometimes", "often" or "very often" exceeds the number of control group members. Similarly, more of the control group members reported experiencing the various symptoms comprising the five clusters "never" or "rarely" as compared to the study group. As regards the sample data, then, our findings are

indicative of the existence of a hog-barn neighbourhood effect and are consistent with expectations based on the literature.

The seventh column in Table 2 reports the results of the Chi-square tests that were undertaken to look for statistically significant differences in terms of the experiences of the study and control groups. For two of the five symptom clusters, Cluster 3 which is indicative of chronic sinusitis and has been well documented amongst hog-barn workers, and Cluster 5 which was our "catch all" category, the reporting incidence for the study group is significantly higher than for the control group at the 95% (_ = 0.05) confidence level. However, if we relax our confidence level to 90%, then we find statistically significant differences between study and control groups for all but one of the symptom clusters (Cluster 1). Interestingly, Thu et al (1997) found that respondents living in the vicinity of large-scale intensive livestock feeding operations reported significantly higher rates of symptoms contained in this cluster.

These results, both for the sample data and from the inferential testing, are consistent with the general picture painted by previous studies, and are indicative of the existence of a hog-barn neighbourhood effect in the study area. However, the absolute number of respondents reporting the various symptoms beyond the rare occurrence is relatively low, and with the exception of Cluster #3, the margin of difference between the number of respondents occupying the "never or rarely" category as compared to the number in the "sometimes to very often" category, is large. Consequently, having produced results that are generally consistent with previous studies but not startlingly definitive, we now face the task of explaining our findings. Given that our study was broadly similar in research design, even to the point of replicating many of the questions used by previous researchers, we should first identify any regional differences that might account for our findings. Because Wing and Wolf's work was conducted in North Carolina's coastal plain, we will use Duplin County, which is located in heart of North Carolina's southern coastal plain hog belt, for purposes of comparison.

To begin, as observed by Furuseth (1997), North Carolina's hog sector has been at the forefront of the adoption of the split-phase production model of industrial hog production. Under this system, animals are moved between highly specialized structures each dedicated to a specific phase of the swine life-cycle (viz, farrowing, weaning and then finishing). Feed rations are designed to maximize daily weight gain for each specific phase. Animals may also be separated by sex. First employed in the poultry industry, this

system is highly specialized, capital intensive and sensitive to economies of scale. It has yet to be widely adopted in southern Alberta and so, not surprisingly, the average hog operation in Duplin County in 1997 housed 5,086 animals, as compared with an average of 1,309 in the County of Lethbridge, indicating a substantial difference in the scale of production.

Adoption of the split-phase production model also tends to result in increasing geographic concentrations of individual barns at the local scale as a means of reducing animal mortality and controlling transport costs when animals are moved between structures. Here again, we observe a difference between our two regions in terms of hog densities. According to the US Census of Agriculture, the density of hogs in Duplin County in 1997 was 1,545 swine per square kilometer, whereas according to the 2001 Canadian Census of Agriculture, the density of hogs in County of Lethbridge is considerably lower (47 hogs per square kilometer).

We should also take into account some climatic differences between southern Alberta and eastern North Carolina, specifically differences in the potential for the dispersion of hazardous agents by wind. For those familiar with southern Alberta it will come a little surprise that it is one of the windier regions in the country. Based on 30-year climate norms obtained from Environment Canada, the Lethbridge area experiences an average annual wind speed of 18.2 km/hr, with average monthly wind speeds ranging from a low of 14.3 km/hr in August to a high of 21.2 km/hr in January. By contrast, the Raleigh-Durham region is less windy with an average annual wind speed of 11.9 km/hr, and a range in mean monthly wind speeds from 9.1 km/hr in August to 16.2 km/hr in March. The wind dispersion thesis may help explain why McGinn et al (2003: 1173) found that concentrations of atmospheric ammonia, volatile fatty acids and other odorants "declined sharply with distance" away from large-scale beef feedlots.

A fourth factor that might help explain our findings relates to differences in the land-use policies having to do with negative externalities generated by livestock operations, especially odours. Odours are a natural product of livestock production and are, to some extent, unavoidable. However, land-use planning has developed several tools to limit their impact. In areas where confined-feeding operations are permitted, planners often apply a minimum distance separation formula, or use a set-back policy to distance these operations from other land uses. In Lethbridge County, for example, provincial guidelines stipulating minimum distance separations between confined-feeding operations and "other signifi-

cant buildings", have been employed in the county for nearly 20 years (Paladino, 2004), even though they have only recently been made binding. By contrast, Osterberg and Melvin (2002) report that local planning restrictions vis-à-vis hog operations in North Carolina are generally less strict and less widely adopted. Moreover, recent court decisions striking down county-level planning ordinances concerning CAFO's in two North Carolina counties have placed similar ordinances throughout the state in question (Osterberg and Melvin, 2002).

Fifth, there is evidence in the literature to suggest that our sample may have been desensitized to the effects of odours associated with hog-related emissions. To illustrate, Wysocki et al (1997) tested workers who had repeatedly been exposed to acetone and butanol and found that when compared with a control group, the exposed workers were able to withstand higher concentrations before detecting the odours and even higher concentrations before reporting irritation. If we translate these findings to our study and take into account that a majority of our respondents (both study and control group members) were long-time rural residents, many of whom were also employed in agriculture, then it is possible that a substantial number of people in our sample may have also undergone a similar process of desensitization. Now let us turn our attention to the North Carolina case. Even though hog production has long been part of the agricultural fabric in eastern North Carolina, the rate of growth in the number and concentration of very large industrial hog operations has been stunning in comparison to the situation in southern Alberta (Furuseth, 1997). Consequently, it is conceivable the rapid rate of industry expansion, combined with its spatial concentration and density, have not enabled a similar adaptation processes to occur.

Our final observation concerns two elements in our research design. First, by conducting the interviews during the late winter and early spring, and having respondents report on their experiences during the six months previous, we focused on a period of time during which it is unlikely that respondents would have been spending extended periods of time out-of-doors or would have had windows open in their homes for appreciable periods of time. Had we been able to administer our survey in the fall, perhaps different results may have been produced. Secondly, because many of the symptoms listed in our questionnaire go unreported, we relied on respondents to recall whether or not they had experienced the various symptoms in the six months prior to being interviewed.

Given the problems of recall, the possibility of some symptoms being under-reported cannot be discounted.

Conclusion

Over the past several decades, hog production in North America, as elsewhere, has undergone a remarkable transformation. Large-scale, capital intensive, confined feeding systems have become the norm in many regions. These changes have transformed local landscapes and economies, increasingly embedding local areas in global systems of production, processing, distribution and consumption. Proliferation of industrial hog production has also sparked much concern over the consequences of this phenomenon for the health and well being of humans. Most of the research to date has focused on the health status of hog-barn workers, and we now know that this group is at significantly greater risk than the general population for a variety of ailments. More recently scientists have turned their attention to the possibility that populations living in the vicinity of industrial hog operations face risks similar to hog-barn workers. The "hog-barn neighbourhood effect" has been documented in three studies conducted in the United States, two in North Carolina and one in Iowa, and has figured prominently in debates over the construction of new hog operations in many parts of Canada, including southern Alberta where the study reported here was undertaken.

Our work replicated previous research on the hog-barn neighbourhood effect, and produced results that suggest the existence of this phenomenon in southern Alberta, although perhaps at a lower level than elsewhere. The problem might be more prevalent than our findings indicate, however, and we were just not able to detect it. Alternatively, the hog-barn neighbourhood effect could be less problematic in the County of Lethbridge than elsewhere owing to regional differences in (1) the structure of hog production, (2) the bio-physical environment, (3) local planning policy, or (4) in the rate and magnitude of growth of the industry.

Even if we accept the second of these two positions, namely that the hog-barn neighbourhood effect is less problematic in southern Alberta than elsewhere, it does not follow that development authorities should abandon employing the the precautionary principle when considering permit applications for large-scale hog operations. Indeed, our results may well underscore the effectiveness of the precautionary principle. Given experience elsewhere, there is little reason to believe that, if the number, size, and density

of hog barns goes unchecked, and especially if the split-phase production system becomes more widely adopted, a threshold will not be met beyond which hog-barn emissions will become a greater problem than they appear to be today. Based on available evidence, no one can conclusively identify where that threshold is. However, once it has been exceeded, human health will be negatively affected and remedial action will be prohibitively expensive. Development authorities face a difficult and unenviable task. Confronted with much scientific uncertainly, they must strike a balance between the legitimate interests of producers and investors, and local residents who increasingly expect environmental quality to be preserved and enhanced. Clearly, more research needs to be done to reduce these uncertainties.

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Notes

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The Public Health Impacts of Concentrated Animal Feeding Operations on Local Communities

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Large-scale farm animal production facilities, also known as concentrated animal feeding operations (CAFOs), release a significant amount of contaminants into the air and water. Adverse health effects related to exposure to these contaminants among CAFO workers have been well-documented; however, less is known about their impact on the health of residents in nearby communities. Epidemiological research in this area suggests that neighboring residents are at increased risk of developing neurobehavioral symptoms and respiratory illnesses, including asthma. Additional research is needed to better understand community-scale exposures and health outcomes related to the management practices and emissions of CAFOs. **Key words:** *agriculture, air pollution, animals, concentration animal feeding operations, public health, water pollution*

THE US Government Accountability Office (GAO) estimated in 2008 that the number of farm animals raised in large-scale industrial production facilities increased 246% from 1982 to 2002.[1] In 2008, nearly 10 billion land animals were raised for meat, egg, and milk production in the United States.[2-4] Approximately half (54%) of all confined farm animals by weight are concentrated in just 5% of the country's animal agriculture operations.[5]

The rapid growth of these concentrated animal feeding operations (CAFOs) has contributed to significant animal welfare issues, as well as to human health concerns for workers and residents of nearby communities. The US Environmental Protection Agency (EPA) estimates that there are approximately 18 800 CAFOs in the United States.[6] Poor waste management practices, the widespread use of pesticides, and confinement and feeding practices customary to industrial farm animal production systems all have potential environmental and public health consequences.

Although the adverse health effects related to exposure to CAFO pollutants among workers have been well-documented, less is known about their impact on the health of residents of nearby communities. Community health issues are more recently being identified as a significant area of concern, as noted in the 2008 report by the Pew Commission on Industrial Farm Animal Production, which states that

> public health concerns associated with ... [CAFOs] include heightened risks of pathogens (disease- and nondisease-causing) passed from animals to humans; the emergence of microbes resistant to antibiotics and antimicrobials, due in large part to widespread use of antimicrobials for nontherapeutic purposes; food-borne disease; worker health concerns; and dispersed impacts on the adjacent community at large.[7(p11)]

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CAFO-RELATED EXPOSURES

The EPA has estimated that confined farm animals generate 3 times more excrement than is produced by humans in the United States.[8] Much of the environmental harm caused by CAFOs results from that volume of manure, which must be stored and disposed of when continuously confining so many animals exclusively or primarily indoors, with some operations producing as much waste as a city.[9] According to data from the US Department of Agriculture (USDA) and the EPA, farm animal confinement operations produce approximately 500 million tons of manure every year,[8] with CAFOs generating 47%[10] to 60%[6] of this excrement. The GAO has reported that the manure that a large facility can generate depends primarily on the types and numbers of animals confined on-site, but can range from more than 2 800 tons to more than 1.6 million tons per year.[1]

Over the past 2 decades, shifts in animal agriculture industries have exacerbated existing waste management problems, with more animals being intensively confined in fewer, but larger, operations.[11,12] The USDA's Natural Resources Conservation Service and the EPA outline the changes as follows:

- the move toward intensive confinement;
- the steady replacement of small- and medium-sized operations with large confinement operations;
- the continued consolidation of all aspects of production;
- the increase in numbers of confined animals per operation; and
- the spatial concentration of operations in high-production areas.[11,12]

These developments have resulted in industrial animal agriculture facilities producing more manure than can be assimilated by available land, particularly in high-production areas,[11,12] which is a significant concern given that CAFOs tend to cluster in geographic locales where input costs—expenses for components such as land and labor—are lower and where their vertically integrated industry infrastructure is well-developed.[13]

A customary manure storage system used in pig and dairy operations is the manure "lagoon."[14,15] In this system, liquefied manure is stored in an outdoor, open-air pit and ultimately sprayed onto fields.[10] Manure lagoons pose the risk of spillage or leakage, poisoning surface or groundwater. In one incident, more than 20 million gallons of waste spilled from a North Carolina pig production operation into a nearby river, causing a massive fish kill.[16] In 2005, a manure lagoon at an upstate New York dairy farm burst, polluting the nearby Black River with millions of gallons of manure and killing more than 375 000 fish.[17]

Although it takes no more than a single CAFO to cause a spill or leak, the trend toward concentrating these operations within discrete geographical areas raises concerns over the ability to maintain water quality for residents within a particular watershed.[5,18]

Even when intact, CAFO manure lagoons may threaten groundwater and air quality through leaching and volatilization.[19] Manure lagoons decrease the amount of nutrients that must be applied to land, in part because much of the nitrogen content is volatilized into ammonia emissions from the pit itself.[20] These ammonia emissions can contribute to increased concentrations of nitrogen (nitrate) in precipitation.[21] If the waste is then overapplied to land, it can further contaminate water supplies[22] and emit harmful gases into the atmosphere.[10] Because there is no requirement that CAFO manure be treated before it is applied, its disposal poses additional risks to public health.[23] Of particular concern are pathogens that may contaminate surface water and antibiotics, heavy metals, pesticides (such as dithiocarbamates),[24] and nutrients (such as nitrogen and phosphorous), all of which can leach into groundwater, run off fields where manure has been applied, and, in the case of nitrogen, volatilize into ammonia emissions.[10,12]

According to the EPA, "the agricultural sector ... is the leading contributor to identified water quality impairments in the nation's rivers and streams, lakes, ponds, and reservoirs."[8(p7237)] It was estimated in 2003,

for example, that more than $1 million per year would be required to remove nitrates from water in California's Chino Basin due to local dairies and the relatively rapid transformation of nitrogen in manure into nitrates, which were ultimately transported into the community's drinking water supply.[8] The USDA reported that the problem of excess nutrients is most pronounced in poultry operations, which produce 52% of the excess phosphorous and 64% of the excess nitrogen created by farm animal waste.[5] Epidemiological studies have linked farm animal waste runoff to several waterborne outbreaks involving pathogens such as *Campylobacter*, *Salmonella*, *Listeria monocytogenes*, *Helicobacter pylori*, and *Escherichia coli* 0157:H7, as well as the protozoa *Cryptosporidium parvum*.[23]

Animal confinement facilities also generate a variety of air contaminants, including skin cells, feed, fungi, and other particulates, which can become airborne.[25] Additional contaminants include ammonia, hydrogen sulfide, and antimicrobials.

In addition, a 2006 report by the Food and Agriculture Organization of the United Nations noted that, on a global scale, the animal agriculture sector accounts for approximately 18% of all anthropogenic greenhouse gas emissions.[26] In the United States, methane emissions from pig and dairy cow manure increased by 34% and 49%, respectively, between 1990 and 2006. The EPA attributed this rise to the shift toward confining pigs and cows in larger operations by using liquid manure management systems,[27] or manure lagoons.

Many of the air pollutants in CAFOs do not currently have occupational exposure limits.[25] Complicating the issue, contaminants released by CAFOs are often mixtures of a variety of pollutants. Very little is known about the risks these contaminant mixtures pose to human health, and even less is known about synergistic effects of such mixtures.

Of all the gaseous by-products of farm animal manure decomposition, hydrogen sulfide is regarded as the most dangerous, creating a risk of both unconsciousness and death for those who work in or near manure pits.[28] The National Institute for Occupational Safety and Health (NIOSH) has deemed hydrogen sulfide to be "a leading cause of sudden death in the workplace."[29(p1)] A number of reports on the NIOSH Web site document worker fatalities caused by exposure to the chemicals in manure pits.[30–33] Indeed, the agency issued an alert in 1990 titled "Preventing Deaths of Farm Workers in Manure Pits,"[34] which details the harmful effects of the chemicals commonly found in these excrement pits.

Airborne bacteria present at CAFOs can be a potential pathway for transferring antibiotic-resistant bacteria from farm animals to humans. Workers in CAFOs and members of nearby communities are at potential risk of exposure.[35] In a study of airborne concentrations of resistant bacterial forms at CAFOs, Gibbs et al[36] found that bacteria were recovered inside and downwind of the facilities at concentrations that could cause a potential human health hazard. Alarming rates of methicillin-resistant *Staphylococcus aureus* (MRSA) detection in live farm animals and retail meat in Europe has led to increased scrutiny of the agricultural use of antibiotics.[37] The recent discovery of MRSA in North American pigs and pig farmers suggests that the potential public health risk attributed to farm animal-associated MRSA may be a global phenomenon.[38,39] While the European Union banned the use of medically important antibiotics as farm animal growth promoters in 2006,[40] no such comprehensive step has yet taken place in the United States.

HEALTH OUTCOMES ASSOCIATED WITH CAFO-RELATED EXPOSURES

There has been significant research in the area of occupational health at CAFOs. More than 70 articles have documented adverse health outcomes in workers at pig CAFOs.[41] These studies note that at least 25% of the workers report respiratory problems, including asthma, bronchitis, acute respiratory distress syndrome, and, in some cases, organic

dust toxic syndrome.[25,41] Exposure to endotoxin, a family of gram-negative bacteria membrane lipopolysaccharide fragments, is often implicated in adverse respiratory effects, particularly among workers in caged hen facilities.[42] Studies also indicate that 6 or more years of exposure at these facilities put workers at risk for chronic health problems.[41]

Despite strong evidence linking adverse health outcomes to occupational exposures at CAFOs, the impact on community health has not been studied as intensively. The 2008 report by the Pew Commission on Industrial Farm Animal Production noted that

> [c]ommunities near ... [CAFO] facilities are subject to air emissions that, although lower in concentration, may significantly affect certain segments of the population. Those most vulnerable—children, the elderly, individuals with chronic or acute pulmonary or heart disorders—are at particular risk. The impact on the health of those living near [CAFO] facilities has increasingly been the subject of epidemiological research.[7(p17)]

Studies have indicated that people residing near CAFOs may be at increased risk of developing respiratory illnesses, neurobehavioral symptoms, and psychological impairments because of exposure to contaminants released at the facilities. The disproportionate siting of CAFOs proximate to nonwhite, high-poverty communities may further exacerbate the disease burden already faced by these vulnerable populations.[43]

In 1997, Thu and colleagues conducted a study of a community situated close to a pig CAFO. The authors noted that "neighbors of the large-scale swine operation ... reported experiencing increased rates of a number of interrelated symptoms, including headaches, respiratory problems, eye irritation, nausea, weakness, and chest tightness."[44(p20)] In 2002, Thu noted that

> recent research and results from federally sponsored scientific symposia consistently indicate that neighbors of swine CAFOs can experience health problems at significantly higher rates than controlled comparison populations. Moreover, such problems can be created by several different CAFO emission constituents acting alone or synergistically.[45(p182)]

Studies of asthma and allergies among children exposed to a farm environment have generally been inconclusive. Some studies have found lower prevalences of asthma[46–48] and allergies[46,48,49] among those with early exposures to a farm environment. For example, Kilpeläinen et al found that "[a] childhood farm environment seems to have a protective effect against allergic rhinitis and/or conjunctivitis, and more weakly against asthma and wheezing irrespective of family size,"[46(p201)] and Ernst and Cormier[47] found a significantly lower prevalence of asthma among children raised in a farm environment than among children living in a rural environment but not near a farm. Similarly, Riedler et al found that "[l]ong-term and early-life exposure to stables and farm milk induces a strong protective effect against development of asthma, hay fever, and atopic sensitisation."[48(p1129)] The protective effect associated with early farm exposure has been postulated, as childhood allergy risk is immunologically modulated early in life by exposure to infectious agents.[50]

In contrast to these findings, however, increased rates of asthma have been found among children and adults who reside near CAFOs.[50–54] Radon et al,[54] for example, surveyed nearly 7 000 individuals in 4 German towns with a high density of CAFOs between 2002 and 2004. The authors measured specific IgE antibodies to common and farm-specific allergens, lung function, and bronchial hyperresponsiveness to methacholine challenge and found that the number of farm animal production facilities near the residence was a predictor of self-reported wheezing and decreased forced expiratory volume in 1 second, but not a predictor of allergic rhinitis or specific sensitization. Self-reported asthma and nasal allergies increased along with self-reported odor annoyance.[54]

Merchant et al[50] studied a cohort of 1 000 rural Iowa families to evaluate the relationship among asthma and farm and other environmental exposures. Four types

of asthma outcomes were assessed, including doctor-diagnosed asthma and doctor-diagnosed asthma/medication for wheeze, current wheeze, and cough with exercise. The authors found a high rate of asthma; the prevalence of doctor-diagnosed asthma was 12%, and at least 1 of the 4 outcomes was found in more than one-third of the study population. A particularly high prevalence of asthma outcomes was identified among children living on farms that raise pigs (44.1%, $P = 0.01$) and raise pigs and add antibiotics to feed (55.8%, $P = 0.013$).[50]

Mirabelli and colleagues[55] assessed respiratory symptoms related to air pollution from CAFOs in 58 169 children attending schools in North Carolina, the second leading state for both turkey and pig production.[56] Exposure was estimated by utilizing publicly available data about pig production operations and their proximity to public schools. The authors found that the prevalence of wheezing during the previous year was slightly higher among students who may have been exposed to airborne contaminants from CAFOs. In addition, regarding students who reported allergies, the prevalence of wheezing within the previous year was 5% higher for those attending schools located within 3 miles of a CAFO than those students at schools located beyond 3 miles and was 24% higher for those students at schools where farm animal odor was reported to be noticeable indoors twice per month.[52] In another study of the same cohort by the same authors, odor from farm animals was noticeable both outside ($n = 47$, 21%) and inside ($n = 19$, 8%) the schools.[55]

Sigurdarson and Kline conducted a cross-sectional study of children from kindergarten through fifth grade in 2 rural Iowa schools. One school was located approximately $^1/_2$ mile from a CAFO, while the control school was not sited near any CAFOs or other large-scale agricultural operations. The authors found that children who attended the school near the CAFO had a significantly increased prevalence of physician-diagnosed asthma (adjusted odds ratio, 5.71; $P = 0.004$). There was no difference in terms of severity of asthma between the 2 study populations.[53]

Other health outcomes in addition to respiratory illnesses have been associated with CAFO-related exposures, including odor-related illnesses. Odorant compounds produced at CAFOs can affect health in a number of ways. At high concentrations, these chemicals can produce significant irritation of the nose, throat, and eyes and induce symptoms such as vomiting, headaches, and nausea. In addition, mixtures with nonodorant chemicals can produce inflammation as well as obstruct airflow.[57]

Avery et al[58] assessed the physiological impacts related to malodor from pig CAFOs and found that there was an immunosuppressive effect of malodor on mucosal immunity.

Wing and Wolf evaluated the health status of residents living near CAFOs in North Carolina. The researchers examined 3 rural communities: 1 in the vicinity of a pig CAFO, 1 in the vicinity of 2 intensive cattle operations, and 1 in a rural agricultural area without farm animal production operations with liquid waste management systems. The authors found elevated rates of mucous membrane irritation and respiratory and gastrointestinal problems, as well as higher reporting of headaches, runny noses, sore throats, excessive coughing, diarrhea, and burning eyes among residents living near the pig CAFO than among those whose residence was not near a CAFO.[59]

Pregnant women and children are susceptible populations who may be at particular risk for exposures related to CAFO operations. In a 2008 study by Sneeringer[60] that assessed the impact of industrial farm animal operations on infant health, the author found that doubling of production could lead to a 7.4% increase in infant mortality, deaths driven by elevated levels of respiratory diseases.

Excess nitrates in water have also been implicated in a number of health outcomes in these susceptible populations. For instance, the Centers for Disease Control and Prevention noted that excess nitrates in groundwater due to contamination from a pig CAFO may

have been linked to miscarriages reported in 1993 and 1994.[25] Other studies have found an association between high nitrate levels in water used in infant formula and development of methemoglobinemia, or blue-baby syndrome.[61]

The presence of a CAFO in or near a community can negatively impact the social structure of local residents. Wing and Wolf also assessed measures of "quality of life," as indicated by the number of times residents reported that they were prevented by odor emanating from CAFOs from opening their windows or going outside even in favorable weather. Findings were similar in the control and the community in the vicinity of the cattle CAFO, but quality of life was greatly diminished among residents near the pig CAFO.[59]

Wing et al evaluated the strength of odors from farmed pigs in the homes of 101 participants from 16 neighborhoods in eastern North Carolina sited near pig CAFOs. Study participants reported odor outside on more than half the study days in 9 of the neighborhoods, and nearly one-third of all study participants reported having their daily activities affected (either changing or ceasing the activities) due to the odor.[57]

Schiffman and colleagues studied mood disturbance related to exposure to malodorous compounds in 44 individuals residing near North Carolina CAFOs and 44 control participants who did not live near these facilities. The authors found that those living near CAFOs had higher rates of depression, anger, tension, and fatigue than those of the control population.[62] Indeed, the Pew Commission report noted that "[r]educed civic participation rates, higher levels of stress, and other less tangible impacts have all been associated with high concentrations of industrial farm production."[7(p59)]

Studies have also shown that property values can decline substantially when residences are near a CAFO.[63–65] According to an article in the journal of the Appraisal Institute, an international association of professional real estate appraisers, case studies demonstrate that "diminished marketability, loss of use and enjoyment, and loss of exclusivity can result in a diminishment ranging from 50% to nearly 90% of otherwise unimpaired value."[63(p306)] Researchers in Pennsylvania have found that neighboring house prices decrease once the total live weight of confined animals exceeds 200 000 pounds.[66] In rural Iowa, which leads the United States in both egg[67] and pig[68] production, a 2003 survey found that the development of pig CAFOs was equally or less desirable than construction of prisons, solid waste landfills, slaughter plants, and sewage treatment plants.[69]

CONCLUSION

There are inherent limitations to studies assessing health outcomes in residents of communities situated near large-scale farm animal production facilities, including the inability to control for confounders, such as non–CAFO-related exposures, the complicated nature of the disease etiology, and the role of socioeconomic status in susceptibility. In addition, most studies rely on limited exposure assessment—for example, basing exposure estimates on the distance between a residence or school and a CAFO—which does not capture specific individual-level exposures, such as specific doses or how contaminants were dispersed. It is also likely that individuals may be exposed to multiple contaminants, which compounds the ability to perform accurate assessments due to the paucity of information about health outcomes related to exposure to mixtures.

The available data on the attendant risks, however, are concerning enough to warrant precautionary action. Recommendations by the Pew Commission on Industrial Farm Animal Production included the following:

- A phase out and subsequent ban on the nontherapeutic use of antibiotics, defined as any use of antimicrobials in animal agriculture in the absence of clinical disease or documented disease exposure.
- A phase out, within 10 years, of intensive confinement systems that restrict natural movement and behavior, including veal

crates for calves, gestation crates for pregnant pigs, and battery cages for egg-laying hens.

- Developing and implementing "a new system to deal with farm waste (that will replace the inflexible and broken system that exists today) to protect Americans from the adverse environmental and human health hazards of improperly handled IFAP [industrial farm animal production] waste."[7(p77)] Specifically, a combination of enclosed tanks for manure storage and municipal-style waste treatment has been suggested to limit microbial efflux.[70]
- Improved enforcement of existing federal, state, and local regulations to improve siting and protect the health of those who live near these operations.
- Local control and public input for the siting of new facilities, as well as access to redress for neighbors when these operations fail to comply with standards.[7] The issuance of permits could be contingent upon the bonding of manure storage reservoirs to ensure spill clean-up and proper consideration of watershed-level animal density and airshed emission dispersion.[41]

The American Public Health Association has gone further, issuing a policy statement that urges federal, state, and local governments and public health agencies to impose a moratorium on the construction of new CAFOs.[23]

Studies have indicated that residents of communities situated near CAFOs may be at increased risk of developing certain adverse health outcomes, including respiratory illnesses. Community members may also be more susceptible than CAFO workers due to the healthy worker effect—that is, the working population tends to be healthier than does the general population, as the latter may be more likely to be afflicted with chronic health conditions. More research is needed to better understand exposures and health outcomes related to large-scale CAFO operations.

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An Agricultural Economist's Public Concerns About CAFOs

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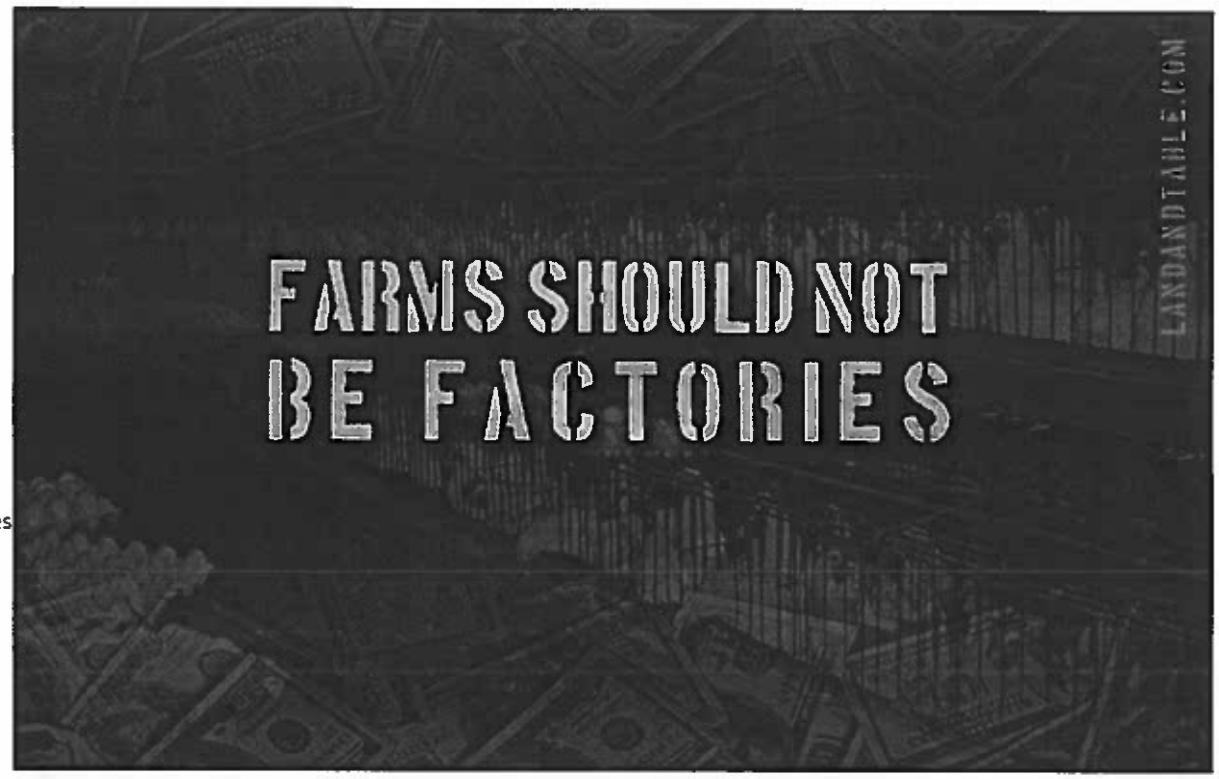

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Once the independent producers were eliminated from the mainstream food system, consumers were left without alternatives to CAFOs. That's the reason why alternatives such as organic, free-range, and natural food products are now emerging: To give consumers a real choice.

Here is one of several talks I will be posting related to factory farming and CAFOs (concentrated animal feeding operations) by John Ikerd, Professor Emeritus of Agricultural Economics, University of Missouri, Columbia.

"John was raised on a small dairy farm in southwest Missouri and received his BS, MS, and Ph.D. degrees in agricultural economics from the University of Missouri. He worked in private industry for a time and spent thirty years in various professorial positions at North Carolina State University, Oklahoma State University, University of Georgia, and the University of Missouri before retiring in early 2000. Since retiring, he spends most of his time writing and speaking on issues related to sustainability with an emphasis on economics and agriculture." (source)

Going Public with Concerns about CAFOs

Finally, the promoters of concentrated animal feeding operations, or CAFOs, are on the defensive – after many years of persistent opposition. The general public is beginning to awaken to the problems and perils of CAFOs. The war against CAFOs may be far

from won, but the tide of the battle seems to be turning. As might be expected at this point, the defenders of CAFOs have mounted major counteroffensives all across the country. For example, the US Farmers and Ranchers Alliance (USFRA) is a new national public relations initiative defending so-called modern, industrial agriculture. It is supported by a multi-million dollar annual budget provided by major agricultural commodity organizations and agribusiness corporations.[i] Bob Stallman who is president of the American Farm Bureau Federation, a major promoter of CAFOs, also serves as chairman of the USFRA.

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The primary objective of the organization is to defend modern industrial agriculture against a growing wave of public concerns, as the public relations firm in charge of USFRA propaganda readily admits. Several states have formed "Farmers Care" organizations with similar missions and are collaborating with USFRA to portray a positive public image for industrial agriculture, which includes a series of public forums or "Food Dialogues."[ii] "Breakfasts on the Farm" have become popular events where the public is invited to visit local farms for breakfast.[iii] These groups claim to be advocates for all types of farms, which is but a thinly-disguised effort to obscure their obvious pro-corporate/industrial agriculture bias.

Naturally, CAFOs are highlighted in the current "defense of farming" initiatives, since CAFOs are the epitome of so-called modern, industrial agriculture. Young families who own CAFOs are featured in videos as the faces of modern agriculture. These families talk about their love of farming, concern for their communities, and their commitments to caring for their animals and protecting the environment. CAFOs are touted as the only means many multi-generational farmers have for continuing the family tradition of farming.

The USFRA website defines "food safety, animal welfare, water quality, and consumer prices and choices" as their major lines of defense.[iv] With respect of animal welfare, the propaganda claims animals in CAFOs are actually treated more humanely than in previous non-confinement facilities. They claim confinement buildings are well-ventilated to keep animals cool in the summer and can be closed in the winter to protect animals from the cold. Baby pigs are provided a warmer environment during winter farrowing and farrowing crates protect them from accidental crushing by their mothers. They claim slotted concrete floors provide a much cleaner environment that do open lots or pastures, and efficient ventilation systems provide animals with plenty of clean, fresh air. CAFOs are portrayed as veritable pork palaces where happy pigs lead peaceful lives of perpetual comfort.

Proponents also claim that CAFOs are actually better for water quality, and the environment in general, than were the pastures or open feed lots. They tout the effectiveness of modern manure management systems, with comprehensive manure plans that include details of where and when manure will be spread. Modern manure storage facilities that allow manure to be spread only one or two times a year are replacing open manure "lagoons," thus minimizing any odor problems for neighbors. CAFO proponents claim that neighbors who continue to complain about odors or water quality problems are people from cities who have moved into rural areas and don't understand the environmental realities of farming. After all, CAFOs are subjected to strict U.S. and state environmental regulation, so they claim.

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CAFO proponents respond to food safety concerns with proclamations that Americans have the safest, most healthful food system in the world. They tout the biosecurity and other sanitation measures taken by CAFOs as a reflection of commitment by modern agriculture to ensuring food safety as well as minimizing diseases. Organic, free-range, pasture-based, and other systems of livestock and poultry production are touted as means of providing consumers with choices. The clear message is that other producers should reciprocate by not saying anything derogatory about CAFOs. Whenever food safety concerns break through into headlines, however, CAFO advocates are quick to direct public scrutiny to organic production practices or to smaller, less-regulated operations, such as farmers markets and direct sales of raw milk. Laws against criticizing industrial food products (veggie libel laws) have been largely ineffective, so industrial agriculture has turned to public relations as a means of silencing criticism. Continuing concerns regarding a variety of public health risks associated with CAFOs are brushed aside as being anecdotal and lacking in scientific credibility.

In an attempt to seal their case, proponents claim CAFOs are the only means of providing consumers with adequate quantities of meat, milk, and eggs at affordable prices. The groups point to the growth in CAFOs as clear and compelling evidence that CAFO are simply a rational producer response to consumer demand. They argue that CAFOs could not have displaced the smaller livestock and poultry operations if CAFOs were not more economically efficient in providing the products that consumers need and want. Even if some consumer have concerns about animal welfare, the environment, and food safety, proponents claim that such concerns are small prices to pay for the economic benefits of CAFOs. Nothing worthwhile in life is ever without some risks. Obviously, more people are concerned about keeping prices low than about any added risks associated with CAFOs; otherwise we wouldn't have CAFOs.

In general, CAFO proponents blame growing public concerns for animal welfare and environment issues on radical "animal rights" and environmental groups that are more concerned about funding their organizations than protecting animals or the environment. Those who are concerned about food safety and the demise of family farms are labeled as "Luddites" or "idealists" who resist progress or long to return to some idealistic past that never really existed. After all, farmers depend on healthy animals and fertile soil for their livelihood, they say. Voluntary compliance with industry-defined standards of good management practices is all that is needed. The impersonal forces of a free-market economy has chosen CAFOs: Case closed!

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Most long-time veterans of the CAFO wars know the fallacies of such claims, but proponents are banking on being able to sell their pro-CAFO propaganda to a largely-uninformed general public. This means that CAFO opponents must to be willing to move their battles beyond the concerns of rural communities and into the larger arena of general public opinion. Although CAFO opponents lack the corporate funding of those who promote CAFOs, we have one important advantage: We don't have to rely on false propaganda; we only need to tell the truth.

First, we need to continually remind the public that opponents of CAFOs are not opponents of "real agriculture" or "real farming." Although there are many "bad actors" among CAFO owners and operators, in truth, many others are simply "good people" who have become entrapped in a "bad system." In fact, most *opponents* of CAFOs are actually *proponents* of animal agriculture. We oppose CAFOs because they are the epitome of everything that is wrong about large-scale, specialized, standardized, corporately-controlled *industrial* agriculture.

We also need to admit that it may be *theoretically* possible to plan, construct, and operate a CAFO in a manner that would not threaten the natural environment or public health. The problem is that CAFOs don't operate in a theoretical world; they must cope with the vagaries of an unpredictable reality. CAFOs operators can host "breakfasts on the farm" and visits by various dignitaries because, for at least for a few days, they can clean up their act and operate responsibly when it's needed for good public relations. While some CAFOs may not harm the environment some of the time, the hard, cold truth is that whenever a significant number are located in a given area, one or more of the CAFOs will be polluting the environment at any given time, and any one of them will be polluting at least some of the time.

If CAFOs are models of environmental stewardship, why has the US EPA found 35,000 miles of rivers and groundwater in 17 states polluted by CAFOs?[v] Why have the

number of waterways labeled as "impaired" by the Iowa DNR jumped from 215 in 1987 to 642 in 2012, as CAFOs took over the Iowa hog industry?[vi] The fact that some streams are still clean and some water wells are still not contaminated, is not a logical defense. If such pollution is a result of irresponsible management, then irresponsible management obviously is widespread and ongoing among CAFO operators. The pollutants originating from CAFOs include nitrogen, phosphorus, antibiotics, pesticides, and heavy metals. Municipalities along these streams have been forced to add costly waste treatment facilities to mitigate the effects of CAFOs on their drinking water.

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Why have massive "dead zones" have been created in the Gulf of Mexico, Chesapeake Bay, and elsewhere by CAFOs and the large-scale, chemical-intensive, industrial corn and soybean operations that provide their feed grains. These consequences are not the result of a "few bad actors;" these are characteristic of an *under-regulated* "industry." The environmental regulation of CAFOs has been largely ineffective because CAFO proponents have convinced lawmakers that CAFOs are farms, not factories, and farming is exempted from many environmental regulations. Meanwhile, the "right to farm" has resulted in about 800 officially reported manure spills in Iowa since 1995, and numbers of polluted steams and water wells continue to grow.[vii] These are facts, not propaganda.

If CAFOs are havens for humane care of animals, why have CAFO proponents promoted "Ag Gag Laws" in virtually every significant livestock producing state? These laws make it a crime for anyone, including employees of CAFOs, to take pictures that document animal abuse or environmental violations. There would be no motive for Ag Gag Laws if animals in CAFOs were treated as well every day as they are when the public is invited for "breakfast on the farm" or when visiting politicians are bought through on public relations tours. Real farmers should be proud to have scenes from their farms video recorded and shown on YouTube. The cold, hard truth is that while animals may appear to be well-treated in some CAFOs some of the time, some animals are horribly abused in some operations some of the time, and all suffer from "unnatural confinement" all of the time.

Admittedly, major anti-CAFO initiatives have been mounted by mainstream animal protection organizations, such as the Humane Society of the United States and the Farm Sanctuary. These initiatives have focused on providing more space for animals in confinement systems. However, there is simply no way that massive numbers of animals can be treated humanely while in the large confinement facilities that typify CAFOs. Farm animals did not evolve to live in confinement any more so than humans

evolved to live in prisons. There is simply no opportunity to afford farm animals the dignity and respect that must precede humane treatment when the animals are confined in large-scale concentrated feeding operations. Animals are sentient, feeling, living organisms or beings, not inanimate mechanisms. Real farmers treat animals with dignity and respect – even when they ultimately are to be used for human food.

CAFO proponents respond to food safety and other public health concerns with platitudes rather than facts concerns, because *public health* may well be the Achilles' heel of CAFOs. CAFOs have been linked to numerous illnesses and even deaths caused by chemical and biological contamination of streams and groundwater. The odors from CAFOs are not just an obvious and obnoxious nuisance but also contain chemical compounds that are known to contribute to a variety of respiratory illnesses. CAFOs are also natural breeding grounds for a variety of harmful pathogens. Massive recalls of contaminated foods have become almost commonplace in the U.S. One such recall involved billions of eggs as a result of contamination with salmonella. A deadly version of the common E. coli bacteria, E-Coli 0157:H7, has caused illness and death and has resulted in a number of nationwide food recalls. This pathogen has resulted from feeding high-energy grain rations to animals that have evolved to eat forages. Other organisms originating in CAFOs, including campylobacter and cryptosporidium,contribute to illnesses of millions of Americans each year.

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Perhaps most significant among the public health risks associated with CAFOs is the dramatic increase in instances of antibiotic resistant bacteria, such as *multidrug-resistant Staphylococcus aureus* or MRSA, which reportedly kills more Americans than AIDS. An estimated 80 percent of all antibiotics produced in the United States are used in animal agriculture, many of which are also used to treat diseases in humans. Numerous studies by reputable public health institutions have documented that antibiotics use in CAFOs has contributed to the development of antibiotic resistance in disease-causing pathogens.[viii] CAFO operators routinely give sub-therapeutic or small doses of antibiotics to animals to make them grow faster and prevent disease outbreaks among the animals in close confinement. The small doses are not sufficient to kill all members of a given strain of bacteria, which allows the most resistant organisms to multiply and eventually dominate the bacteria strain. CAFOs are degrading the entire health-care system of the United States.

In spite of growing concerns, CAFOs have continued to grow. Contrary to the claims of proponents, however, the growth in CAFOs is not a response to consumer demands. CAFOs are not more economically efficient than many of the well-managed independent farming operations they have forced out of business. CAFOs need only be

more efficient than the least-efficient one-third to one-half of independent producers to gain a sufficient share of the market to displace the remaining more-efficient producers. Most corporations that produce through CAFOs are "vertically integrated," meaning they control more than one stage in the production process. Vertically-integrated corporations can keep retail and wholesale prices high during periods of cyclical oversupply and thus keep live animal prices low enough for long enough to force even the most-efficient of independent producers out of business. Once CAFOs dominate a market, periodic oversupply situations are addressed by manipulating or cancelling contracts with growers, which keeps retail prices high and corporate margins at highly profitable levels for stockholders. As a result, CAFOs would not necessarily result in lower prices for meat, milk, and eggs for consumers, even if they were more economically efficient than independent producers.

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This is not anti-CAFO propaganda. USDA statistics clearly show that retail prices for meat, milk, and eggs have continued to rise, in some cases rise dramatically, as animal production was moving off of independent family farms and into contract CAFOs.[ix] As the market power of corporate contractors grows, the price spreads between farm-level prices and retail prices widen, leaving retail prices even higher than before. In addition, much of the recent increases in meat produced in CAFOs in going to export markets rather than to reduce food costs for American consumers. As if to punctuate this trend, the largest Chinese meat packing company is in the process of buying Smithfield Foods, the largest U.S. meat packer. CAFOs are designed to benefit corporate investors – not farmers, not rural communities, and not consumers. Once the independent producers were eliminated from the mainstream food system, consumers were left without alternatives to CAFOs. That's the reason why alternatives to CAFOs, such as organic, free-range, and natural food products are now emerging: To give consumers a real choice.

When all else fails to silence consumer concerns, CAFOs proponents point out that a certain amount of risk to the environment and public health is inherent in any worthwhile economic activity, including CAFOs. Admittedly, there are inevitable and necessary risks in life. However, there are "no economic benefits" from CAFOs to offset their obvious environmental, animal welfare, or public health risks. These conclusions are not based on idealism or emotion. The pendulum of "good science" has swung in opposition to CAFOs. There are reams of scientific studies that confirm the growing public concerns about CAFOs. [x] The proponent's only defense is an ambitious program of pro-CAFO propaganda designed to mask the cold, hard truth.

In response to the propaganda, we must stress that we are not opposed to farmers or ranchers, but we are opposed to any system of production that threatens the health and well-being of both rural and urban Americans. The CAFO promoters are using "good people" to protect a "bad system." Until now, most of our efforts have focused on issues of greatest concern to people in rural communities. To confront the new propaganda campaign, we must expand the perimeter of the battleground to embrace the growing concerns about broader issues, such an animal protection and public health. These are issues that affect everyone. These are the issues that have spurred CAFO proponents into their defensive strategies. These are the issues on which we can ultimately win the war against CAFOs. To win, we will need to build bridges between rural and urban America and go public with the growing concerns about CAFOs.

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That said, we must not falter or fade in our battle to help people in rural communities defend themselves from the continuing onslaught of CAFOs. The defenders of CAFOs are relentless in their arguments that CAFOs are essential for the economic viability of family farms and rural communities, regardless of public concerns about the environment, animal welfare, or public health. The USDA, state departments of agriculture, and major agricultural universities are all promoting CAFOs as the future of animal agriculture and the economic foundation of rural America. It's difficult to blame people who listen to those they should be able to trust.

So, we must continue to emphasize that CAFOs are not a logical strategy for rural economic development, regardless of what those in our public institutions may claim. CAFOs are not the future of farming. They are not real farms and are in fact destroying the future of farming. Between 1980 and 2008, years of major growth in CAFOs, the U.S.D.A. statistics indicate the number of beef cattle operations fell by 41%, the total number of hog farms declined by 90%, and the number of dairy farms fell by 80%.[xi] Between 1992 and 2004 alone, the number of hog farms fell by more than 70 percent, whereas the inventory of total hog numbers remained stable.[xii] The CAFOs weren't producing more hogs; they were just producing a similar number of hogs with far fewer hog farmers. This is not propaganda but fact: CAFOs drive real farmers out of business.

The number of independent producers displaced by CAFOs is inevitably greater than the number of people employed by CAFOs. CAFOs gain their economic advantage by specializing in specific phases of livestock or poultry production, which allows production processes to be standardized, routinized, and mechanized. As a result CAFOs can be operated without skilled labourers and each worker can oversee more animals and each owner/investor can control more CAFO operations. CAFOs are factories, not farms. Any economic advantages of CAFOs result from reducing labor

costs and spreading management costs over more animals. As a result, CAFOs inevitably employ fewer people at lower levels of compensation in the process of producing a given number of animals than do non-factory operations.

As a result of the low-pay and poor working conditions, most people employed in CAFOs are not local residents but immigrants into rural areas who are desperate for work. These immigrants may be good, hard-working people, but they create increased needs for education, health care, law enforcement, and other public services – at least proportionate to their numbers. Increased traffic of heavy trucks on local roads and bridges also add economic burdens to local governments. CAFOs typically add little to local tax revenues, as they often receive preferential tax assessments. In addition, CAFOs tend to do business with companies in major trade centers rather than with local businesses. Perhaps most telling, no community in the U.S. that relies on CAFOs as its economic foundation is looked to as a model for rural economic development.

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The impacts of CAFOs are a bit different for each community, but the basic issues are the same. Invariably, some few people in CAFO communities benefit economically, while others suffer the inherently negative ecological, social, and economic consequences of CAFOs. Perhaps no single issue has been as disruptive of life in rural America as when local proponents and opponents of CAFOs confront each other and the rest of the community is forced to choose sides. Regardless of the ultimate outcomes, communities invariably suffer from these conflicts.

Rural people have the same basic democratic rights as other Americans, including the rights of self-determination and self-defense. These rights are being systematically denied when rural people are told they must rely on so-called experts to decide when their health is threatened – that rural people are incapable of reading scientific reports and drawing their own conclusions. The rights of rural people are being systematically denied when rural people are told they must trust public officials with obvious economic and political ties to CAFOs to protect them from the threats CAFOs inevitable pose to the overall well-being of people in rural communities. We must continue to defend the democratic rights of rural Americas to protect themselves from CAFOs, even as we expand our efforts to refute the current barrage of pro-CAFO propaganda with truth.

End Notes

[1] Prepared for presentation at *CAFO Conference*, sponsored by Peach Bottom Concerned Citizens Group, York, PA; September 7, 2013.

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Article written by J. D. Fowler

J.D. Fowler is the organizer of the monthly Land and Table potluck gatherings with a vision to cultivate a regional network of sustainable farmers, organic gardeners, homesteaders, healthy-eaters, and local food advocates. His views expressed here are his alone.

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Community Health and Socioeconomic Issues Surrounding Concentrated Animal Feeding Operations.

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Community Health and Socioeconomic Issues Surrounding Concentrated Animal Feeding Operations

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A consensus of the Workgroup on Community and Socioeconomic Issues was that improving and sustaining healthy rural communities depends on integrating socioeconomic development and environmental protection. The workgroup agreed that the World Health Organization's definition of health, "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity," applies to rural communities. These principles are embodied in the following main points agreed upon by this workgroup. Healthy rural communities ensure *a*) the physical and mental health of individuals, *b*) financial security for individuals and the greater community, *c*) social well-being, *d*) social and environmental justice, and *e*) political equity and access. This workgroup evaluated impacts of the proliferation of concentrated animal feeding operations (CAFOs) on sustaining the health of rural communities. Recommended policy changes include a more stringent process for issuing permits for CAFOs, considering bonding for manure storage basins, limiting animal density per watershed, enhancing local control, and mandating environmental impact statements. *Key words:* animal confinements, environmental impact, livestock, mental health, odor, poultry, right-to-farm legislation, swine. *Environ Health Perspect* 115:317–320 (2007). doi:10.1289/ehp.8836 available via *http://dx.doi.org/* [Online 14 November 2006]

Background and Recent Developments

The agricultural community in areas of large-scale livestock production. The rural and agricultural community has changed dramatically over the past half century. The trends include an overall reduction in the number of farms, an increase in size of the farms, and economic concentration in the industries that supply inputs and purchase commodities from farms. The structure of the pork industry has also changed dramatically during the past three decades. The number of hog producers in the United States was more than 1 million in the 1960s but fell to about 67,000 by 2005 [U.S. Department of Agriculture (USDA) 2005]. Although the total inventory of hogs has changed little over the years, the structural shift toward concentration has been dramatic with the 110 largest hog operations in the country, each of which has over 50,000 hogs, now constituting 55% of the total national inventory (USDA 2005). The swine industry includes the following types of producers: small independent "niche" operators who often market organic pork to local markets, traditional independent operators, and large family or unaffiliated corporations. Former independent operators are increasingly raising livestock on contract for larger corporations. According to the U.S. Government Accountability Office, in 1999 contract production constituted more than 60% of total hog output and 35% of the cattle market (U.S. Government Accountability Office 2005), while poultry is produced almost entirely via contracts. Corporate producers or incorporated family-based operations employ from a few individuals to several hundred. Most often upper management and many of the workers in such operations do not come from or live in the vicinity of concentrated animal feeding operations (CAFOs).

The community of people living in the region of large-scale livestock production consists of residents of small family farms (that may or may not produce pork), workers at the production facilities, rural nonfarm residents, and the residents of neighboring towns. The challenges CAFOs place on neighbors were extensively reviewed in 1996 (Thu 1996) and again in a 2002 report accompanied by a number of consensus recommendations for the future of the hog industry in Iowa (Iowa State University and University of Iowa 2002). A number of additional scientific reviews and symposia summaries have been issued (Centers for Disease Control and Prevention 1998; Cole et al. 2000; Donham 2000; National Academy of Sciences 2002; Schiffman et al. 2000; Thu 2002).

Economic health. Economic concentration of agricultural operations tends to remove a higher percentage of money from rural communities than when the industry is dominated by smaller farm operations, which tend to circulate money within the community. Goldschmidt (1978) documented this as early as 1946 in California, one of the first states where industrialized agriculture developed. Specifically, he compared two agricultural communities, one dominated by larger industrialized farms with absentee ownership and a high percentage of hired farm labor, and the other community was dominated by smaller owner-operated farms. The latter community was found to have a richer civic and social fabric with more retail purchases made locally and with income more equitably distributed. A similar study by MacCannell (1988) of comparable types of communities found that the concentration and industrialization of agriculture were associated with economic and community decline locally and regionally. Studies in Illinois (Gomez and Zhang 2000), Iowa (Durrenberger and Thu 1996), Michigan (Abeles-Allison and Conner 1990), and Wisconsin (Foltz et al. 2002) demonstrated decreased tax receipts and declining local purchases with larger operations. A Minnesota study (Chism and Levins 1994) found that the local spending decline was related to enlargement in scale of individual livestock operations rather than crop production. These findings consistently show that the social and economic well-being of local rural communities benefits from increasing the number of farmers, not simply increasing the volume of commodity produced (Osterberg and Wallinga 2004).

Physical health. There have been more than 70 papers published on the adverse health effects of the confinement environment on swine producers by authors in the United States, Canada, most European countries, and Australia (Cormier et al. 1997; Donham 2000; Donham et al. 1977, 1982, 1986, 1990, 2002; Kirkhorn and Schenker 2002; Kline et al. 2004; Preller et al. 1995; Reynolds et al. 1996; Rylander et al. 1989; Schiffman

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et al. 1995; Schwartz et al. 1992; Thu et al. 1997; Wing and Wolf 2000). It is clear that at least 25% of confinement workers suffer from respiratory diseases including bronchitis, mucus membrane irritation, asthmalike syndrome, and acute respiratory distress syndrome. Recent findings substantiate anecdotal observations that a small proportion of workers experience acute respiratory symptoms early in their work history that may be sufficiently severe to cause immediate withdrawal from the work place (Dosman et. al. 2004). An additional acute respiratory condition, organic dust toxic syndrome, related to high concentrations of bioaerosols in livestock buildings occurs episodically in more than 30% of swine workers.

Environmental assessments of air quality inside livestock buildings reveal unhealthful concentrations of hydrogen sulfide, ammonia, inhalable particulate matter, and endotoxin (Iowa State University and University of Iowa 2002; Schenker et al. 1998). While there is less information on adverse effects among residents living in the vicinity of swine operations, that body of literature has been growing in recent years (Avery et al. 2004; Bullers 2005; Centers for Disease Control and Prevention 1998; Kilburn 1997; Merchant et al. 2005; Mirabelli et al. 2006a; Reynolds et al. 1997; Schiffman et al. 1995, 2000; Thu 2002; Thu et al. 1997; Wing and Wolf 2000).

Thu et al. (1997) documented excessive respiratory symptoms in neighbors of large-scale CAFOs, relative to comparison populations in low-density livestock-producing areas. The pattern of these symptoms was similar to those experienced by CAFO workers. Wing and Wolf (2000) and Bullers (2005) found similar differences in North Carolina. A case report associated with hydrogen sulfide exposure from a livestock processing facility in South Sioux City, Nebraska, revealed excessive diagnoses of respiratory and digestive disturbances in people living nearby (Campagna et al. 2004). Schiffman and colleagues reported that neighbors of confinement facilities experienced increased levels of mood disorders including anxiety, depression, and sleep disturbances attributable to exposures to malodorous compounds (Schiffman et al. 1995, 2000). Avery et al. (2004) found lower concentration and secretion of salivary immunoglobulin A among swine CAFO neighbors during times of moderate to high odor compared with times of low or no odor, suggesting a stress-mediated physiologic response to malodor (Shusterman 1992).

Community environmental air quality assessments have shown concentrations of hydrogen sulfide and ammonia that exceed U.S. Environmental Protection Agency (U.S. EPA) and Agency for Toxic Substances and Disease Registry recommendations (Reynolds et al. 1997). A recent study revealed that children living on farms raising swine have an increased risk for asthma, with increasing prevalence of asthma outcomes associated with the increased size of the swine operation (Merchant et. al. 2005). Children in North Carolina attending middle schools within 3 miles of one or more swine CAFOs and children attending schools where school staff report CAFO odors in school buildings were found to have a higher prevalence of wheezing compared with other middle school children (Mirabelli et al. 2006a, 2006b). It should be noted that these studies (although controlled) lack contemporaneous exposure assessment and health outcomes ascertainment. Additional research to include environmental exposure data related to biomarkers of response is needed.

Mental health. Living in proximity to large-scale CAFOs has been linked to symptoms of impaired mental health, as assessed by epidemiologic measures. Greater self-reported depression and anxiety were found among North Carolina residents living near CAFOs (Bullers 2005; Schiffman et al. 1995). This finding was not corroborated in a small study by Thu et al. (1997) of depression among people living near to or far from CAFOs. However, it should be noted that the study of Thu et al. differed in that residents were not asked to report on their mental state during an actual odor episode as was the case in the study by Schiffman et al. (1995).

Greater CAFO-related posttraumatic stress disorder (PTSD) cognitions have been reported among Iowans living in an area of CAFO concentration compared with Iowans living in an area of a low concentration of livestock production (Hodne CJ, unpublished data). PTSD cognitions were consistent with interviewees' multiple concerns about the decline in the quality of life and socioeconomic vitality caused by CAFOs, in areas of CAFO concentration with declining traditional family farm production.

Social health. One of the most significant social impacts of CAFOs is the disruption of quality of life for neighboring residents. More than an unpleasant odor, the smell can have dramatic consequences for rural communities where lives are rooted in enjoying the outdoors (Thu 2002). The encroachment of a large-scale livestock facility near homes is significantly disruptive of rural living. The highly cherished values of freedom and independence associated with life oriented toward the outdoors gives way to feelings of violation and infringement. Social gatherings when family and friends come together are affected either in practice or through disruption of routines that normally provide a sense of belonging and identity—backyard barbecues and visits by friends and family. Homes are no longer an extension of or a means for enjoying the outdoors. Rather, homes become a barrier against the outdoors that must be escaped.

Studies evaluating the impacts of CAFOs on communities suggest that CAFOs generally attract controversy and often threaten community social capital (Kleiner AM, Rikoon JS, Seipel M, unpublished data; 2000; Ryan VD, Terry Al, Besser TL, unpublished data; Thu 1996). The rifts that develop among community members can be deep and long-standing (DeLind 1998). Wright et al. (2001), in an in-depth six-county study in southern Minnesota, identified three patterns that reflect the decline of social capital that resulted from the siting of CAFOs in all six rural communities they studied: *a*) widening gaps between CAFO and non-CAFO producers; *b*) harassment of vocal opponents of CAFOs; and *c*) perceptions by both CAFO supporters and CAFO opponents of hostility, neglect, or inattention by public institutions that resulted in perpetuation of an adversarial and inequitable community climate. Threats to CAFO neighbors have also been reported in North Carolina (Wing 2002). Clearly, community conflict often follows the siting of a CAFO in a community. What is not known is if community conflict resulting from the siting or presence of CAFOs has an impact on the ability of communities to act on other issues.

Environmental injustice. Disproportionate location of CAFOs in areas populated by people of color or people with low incomes is a form of environmental injustice that can have negative impacts on community health (Wing et al. 2000). Several studies have shown that a disproportionate number of swine CAFOs are located in low-income and nonwhite areas (Ladd and Edwards 2002; Wilson et al. 2002; Wing et al. 2000) and near low-income and nonwhite schools (Mirabelli et al. 2006a, 2006b). These facilities and the hazardous agents associated with them are generally unwanted in local communities and are often thrust upon those sectors with the lowest levels of political influence. CAFOs are locally unwanted because of their emissions of malodor, nutrients, and toxicants that negatively affect community health and quality of life. Low-income communities and populations that experience institutional discrimination based on race have higher susceptibilities to CAFO impacts due to poor housing, low income, poor health status, and lack of access to medical care.

Failure of the political process. In 2005 the U.S. Government Accountability Office issued a report on the effectiveness of U.S. EPA efforts in meeting its obligations to regulate concentrated animal feeding operations (U.S. Government Accountability Office 2005). The report identified two major flaws:

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a) allowing an estimated 60% of animal feeding operations in the United States to go unregulated, and *b*) lack of federal oversight of state governments to ensure they are adequately implementing required federal regulations for CAFOs. Additionally, many states have not taken a proactive stance to comply with the U.S. EPA regulations. Therefore, the concentration of livestock production, most noted by CAFO-style production, has continued to expand in most states. This has resulted in many rural communities and individuals taking action on their own, through local ordinances or litigation, as they have not been able to find access through usual governmental channels.

Several studies have found that property values decrease when CAFOs move into a community (Abeles-Allison and Conner 1990; Hamed et. al. 1999; Herriges et al. 2003; Palmquist et al. 1997). Neighbors of CAFOs are interested in preventing loss of property value, loss of their homes and land, forced changes in their life style, adverse changes in their communities, and threats to their health (Thu and Durrenberger 1998). The democratic process offers citizens access to lawmakers, to the courts, and to direct action to redress their grievances. However, the legislative process in many states has often been unresponsive to citizen wishes concerning CAFOs (Cantrell et al. 1996). For example, 13 states have enacted laws that inhibit citizens from speaking freely about agriculture if it is disparaging. A representative example can be seen in a South Dakota law that defines disparagement as

> dissemination in any manner to the public of any information that the disseminator knows to be false and that states or implies that an agricultural food product is not safe for consumption by the public or that generally accepted agricultural and management practices make agricultural food products unsafe for consumption by the public. (South Dakota Codified Laws 2006)

All 50 states have some form of right-to-farm legislation. This legislation serves to protect farming operations from zoning laws or lawsuits that would overly restrict the ability of farmers to do business (Chapin et al. 1998; Hamilton 1998). Right-to-farm legislation varies from state to state but may include laws that prevent zoning from limiting farm practices that have substantial detrimental effects on neighbors, such as CAFO production. Right-to-farm laws may also include preemption of other actions of local government that normally could limit what businesses are allowed to do, known as home rule. For example, the Iowa Supreme Court has ruled that county governments cannot use home rule powers or protection of public health to promulgate laws that are more restrictive than state laws currently in force (Worth County Friends of Agriculture v. Worth County, Iowa, 2004). Although local governmental action has been limited by the bias toward agricultural producers, individual actions have not. Courts in several states have ruled that right-to-farm laws give only limited protection from nuisance action. The Iowa Supreme Court in June 2004 found that CAFO immunity provisions written in Iowa statutes were unconstitutional (Gacke v. Pork XTRA 2004). A district court in Illinois granted a temporary injunction stopping the construction of a nearby CAFO based on an anticipatory nuisance premise (Nickels et al. vs. Burnett 2002) that such a facility would constitute reasonable interference with neighbors' quality of life.

Most states have enacted some forms of environmental laws aimed at protecting the environment from agricultural discharges or emissions. One form of these laws requires establishment of manure management plans. Typically, these laws call for certain sizes of operations to apply for permits. These permits may include the filing of a manure management plan, which calls for a plan for CAFO operators to manage their manure in a manner to prevent water and soil pollution. However, there is little if any performance inspection or enforcement of these plans (Jackson et al. 2000). Nonenforcement is primarily due to the lack of personnel and technical resources at state environmental agencies. For example, some states may have 2,000 or more such operations but not enough staff to efficiently process permit applications, much less get out into the field to inspect performance of these operations.

Workshop Recommendations

Priority research needs. Community health studies. Although sufficient research supports actions to protect rural residents from the negative impacts of CAFOs on community health, additional research could be conducted to further delineate mechanisms of effects and impacts on susceptible subgroups. These areas include psychophysiologic impacts of malodor; impacts of malodor on mental health and quality of life; and respiratory impacts of bioaerosol mixtures, especially among asthmatics, children, and the elderly. Wider and more effective application of community-based participatory research will be important to advance research in these areas.

Sustainability of livestock production. Federal funding for agricultural research should be reoriented to promote innovation in sustainable livestock production.

Translation of science to policy. Requirements for issuing permits for CAFOs should include increased protections for health and the environment including the following:

- CAFOs should be sited and issued permits on the basis of total animal density allowed in a given watershed as determined by the carrying capacity.
- Environmental impact statements should be mandated for all new CAFOs. These should include environmental health, social justice, and socioeconomic issues.
- Decisions to issue permits for CAFOs should be considered in public meetings and decided at the local level.
- CAFOs should be regulated using standards applied to general industry based on the level of emissions and type of waste handling.
- Permits for manure storage basins should require bonding for performance and remediation.
- The current state of knowledge of community impacts of CAFOs warrants support for the American Public Health Association recommendation for a moratorium on all new CAFO construction.

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Health Effects of Airborne Exposures from Concentrated Animal Feeding Operations

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Toxic gases, vapors, and particles are emitted from concentrated animal feeding operations (CAFOs) into the general environment. These include ammonia, hydrogen sulfide, carbon dioxide, malodorous vapors, and particles contaminated with a wide range of microorganisms. Little is known about the health risks of exposure to these agents for people living in the surrounding areas. Malodor is one of the predominant concerns, and there is evidence that psychophysiologic changes may occur as a result of exposure to malodorous compounds. There is a paucity of data regarding community adverse health effects related to low-level gas and particulate emissions. Most information comes from studies among workers in CAFO installations. Research over the last decades has shown that microbial exposures, especially endotoxin exposure, are related to deleterious respiratory health effects, of which cross-shift lung function decline and accelerated decline over time are the most pronounced effects. Studies in naïve subjects and workers have shown respiratory inflammatory responses related to the microbial load. This working group, which was part of the Conference on Environmental Health Impacts of Concentrated Animal Feeding Operations: Anticipating Hazards—Searching for Solutions, concluded that there is a great need to evaluate health effects from exposures to the toxic gases, vapors, and particles emitted into the general environment by CAFOs. Research should focus not only on nuisance and odors but also on potential health effects from microbial exposures, concentrating on susceptible subgroups, especially asthmatic children and the elderly, since these exposures have been shown to be related to respiratory health effects among workers in CAFOs. *Key words:* air quality, asthma, biological agents, endotoxin, inflammation, odor, poultry, swine. *Environ Health Perspect* 115:298–302 (2007). doi:10.1289/ehp.8835 available via *http://dx.doi.org/* [Online 14 November 2006]

Background and Recent Developments

Gases and vapors. A number of toxic gases and vapors are emitted by concentrated animal feeding operations (CAFOs) into the work and general environments. In particular, occupational studies have yielded information about exposure levels of ammonia (NH_3), hydrogen sulfide (H_2S), and carbon dioxide (CO_2). The characteristic odor of a CAFO is the result of a complex mixture of these gases and many volatile and semivolatile organic compounds. Odor emissions are especially associated with quality of life issues for exposed populations. Specific gases such as H_2S are being used as proxies to estimate or regulate exposure to the whole complex mixture. Although this approach has the advantage of simplicity and exposure estimates can be compared with guideline exposure values, it also has several limitations. Situations may arise where the surrogate compound does not co-vary with other toxicants in the mixture. The issue of which specific community health effects may result from CAFO emissions is open and controversial. There is limited evidence that symptom patterns may be the result of CAFO exposures in individuals living in their vicinity. Changes in immunoglobulin A responses have been observed in individuals and associated with exposure to odor, suggesting that psychophysiologic responses can occur (Avery et al. 2004). The underlying mechanistic explanation is that these physiologic changes are most likely stress related; however, other mechanisms including sensitization may also contribute.

Very little information exists about lung function changes among populations living in the vicinity of CAFOs. Emission studies, in combination with modeling approaches, are helpful but not sufficient to relate exposures to health effects because the exposure depends on personal activity patterns and time spent near different sources. A recent report from Germany found that people residing in proximity to many CAFOs (> 12 within a 500-m radius) experienced significantly increased prevalence of self-reported wheezing and decreased forced expiratory volume in 1 sec (FEV_1) indicative of inflammatory effects of CAFO emissions in the lungs (Radon et al. 2005). However, a problem with the interpretation is that clear differences existed in sensitization rates between rural participants and the urban comparison population. In addition, it can be expected that differences existed within the rural population associated with childhood exposure patterns to animals on these farms compared with those experienced with CAFOs. This raises methodologic issues regarding appropriate comparison populations and confounders or effect-modifying variables that need to be included in multiple regression models to make accurate comparisons. Nevertheless, the results from this study are of interest and similar studies need to be undertaken in other populations with more subjects living in proximity to CAFOs.

Most information on potential health effects comes from working populations. Gases seem to play a limited role in the explanation of work-related respiratory symptoms in CAFO workers, but this may not be true for humans living in the surrounding areas. The distribution of adverse effects by age is different, and susceptibility may be an important issue, with children and elderly individuals belonging to the most vulnerable populations. Also, socioeconomic relationships between workers and companies, as opposed to neighbors and companies, are different, and this will have an impact on the willingness to tolerate hazardous exposures, and bear an increased burden of ill health.

Exposure inside CAFOs. In early studies on respiratory health of CAFO workers, several constituents of dust have been considered. Exposure to allergens from pigs and storage mites has received some attention, but most studies have shown that sensitization rates to swine urine proteins among farmers are relatively low and cannot explain the high symptom rates in CAFO workers (Brouwer et al. 1990; Cormier et al. 1991; Crook et al. 1991;

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Harries and Cromwell 1982; Katila et al. 1981). Similarly, responses against storage mites seem to be explained mainly by cross-reactivity to house dust mites.

Early studies have shown that the CAFO industry environment is rich in microbial life. Kiekhaefer et al. (1995) made detailed microbial characterizations of the environment in various types of CAFOs across seasons and showed that moderately elevated culturable mold levels exist with an overall mean concentration of 5.3×10^3 colony-forming units/m^3 and mean total organisms (orgs) concentrations of 1.1×10^8 orgs/m^3. The predominant fungal types were *Cladosporium* and *Alternaria* in the summer and fall and yeasts *Penicillium* and *Fusarium* in the winter and spring. Mainly gram-positive bacteria are found in CAFOs, but gram negatives play an important role as well. As a result, endotoxin levels are clearly elevated. Although microbial markers other than endotoxin have been associated with respiratory health and specific respiratory inflammation (Zhiping et al. 1996), endotoxin has been most extensively studied in experimental studies with naïve subjects and epidemiologic studies using a range of study designs.

Endotoxin exposure. Particulate exposure in the environs surrounding CAFOs occurs but has not received much attention to date. Considerable information exists about workplace exposure to dust from CAFOs (Schenker et al. 1998), and since the 1980s, endotoxins have been identified as important causal and toxic agents (Attwood et al. 1987; Donham et al. 1984).

Endotoxin is composed of lipopolysaccharides (LPS) and is a nonallergenic cell-wall component of gram-negative bacteria with strong proinflammatory properties. Endotoxins are ubiquitous and commonly present inside CAFOs, the general environment, and house dust (Douwes et al. 1998, 2000; Michel et al. 1991; Peterson et al. 1964; Schenker et al. 1998; Thorne et al. 2005). Very high endotoxin exposure occurs in farming, particularly livestock farming (Kullman et al. 1998; Schenker et al. 1998). Elevated endotoxin levels are present in homes where children have regular contact with farm animals and in homes where pets are present (Douwes et al. 2000; Thorne et al. 2003; von Mutius et al. 2000). Larger numbers of family members, poverty, and roach infestation are also associated with higher endotoxin in homes (Thorne et al. 2003, 2005). Inhalatory endotoxin exposure has been associated with a range of respiratory health effects in both the work and the domestic environment (Douwes and Heederik 1997; Douwes et al. 2002). Because results of research on respiratory health effects of endotoxin exposure were focused on different aspects for the occupational and domestic environments, overall results are reviewed briefly here for both environments.

Work environment exposures and adult onset allergy and asthma. Early studies on endotoxin exposure and farming activities began in about 1982. Swine production facilities have especially been studied since that period. Endotoxin exposure is high for workers in these industries, and several large-scale studies suggest that the mean exposure varies between a few hundred up to 15,000 endotoxin units (EU)/m^3 of air in situations where ventilation is limited because of extreme climatic conditions (Douwes and Heederik 1997). These exposures have been associated with increased symptoms, both respiratory and systemic (Rylander et al. 1989), across-shift lung function changes (Donham et al. 2000), reduced lung function in cross-sectional studies and accelerated decline in lung function in longitudinal studies (Vogelzang et al. 1998). Neutrophil-mediated inflammation has been observed in naïve subjects and swine confinement workers after exposure that is limited to periods of a few hours (Jagielo et al. 1996; Sandström et al. 1992; Von Essen and Romberger 2003). The exact pathophysiology is not clear, but it is well established that it is mediated by an acute inflammatory response involving a variety of cytokines, including interleukin (IL)-1, IL-6, IL-8, and tumor necrosis factor (TNF)-α, and the subsequent massive recruitment and activation of neutrophils in the lower and upper airways. The inflammatory reactions are orchestrated by alveolar macrophages that carry specific endotoxin binding receptors [LPS binding protein, CD14, MD2, toll-like receptor (TLR) 4], which play a crucial role in the activation of these cells and the subsequent inflammatory processes (Gioannini et al. 2003). Considerable interindividual variability in response to endotoxin has been observed in endotoxin provocation experiments with naïve subjects (Kline et al. 1999).

Recent studies suggest that environmental endotoxin exposure might protect against the development of atopy and possibly allergic asthma (Gereda et al. 2000a, 2000b; Liu and Leung 2000; Martinez and Holt 1999; von Mutius et al. 2000). A low prevalence for atopy, hay fever, and to a lesser extent, asthma has been observed in the children and adolescents of farming families and first-year university students with a farming background (Braun-Fahrländer et al. 1999; Ernst and Cormier 2000; Kilpeläinen et al. 2000; Portengen et al. 2002; Riedler et al. 2000; von Ehrenstein et al. 2000). Contact with livestock in the first year of life appeared to be one underlying determinant of this reduced risk. These observations are usually referred to as the "hygiene hypothesis." Hence, exposure to endotoxin may reflect two sides of a coin: *a*) producing a protective effect with regard to atopy, and *b*) inducing inflammation that leads to nonallergic asthma. Two recent studies of adult farmers are in agreement with this hypothesis (Douwes et al. 2002). In the European Community Respiratory Health Survey, which investigates occupational asthma in 15,637 randomly selected people 20–44 years of age, the highest risk of asthma was shown for farmers [odds ratio (OR) = 2.6; 95% confidence interval (CI), 1.3–5.4] and agricultural workers (OR = 1.8; 95% CI, 1.0–3.2) (Kogevinas et al. 1999). An increased risk of asthma morbidity and mortality for farmers has been reported in several other studies as well (Fishwick et al. 1997; Neijari et al. 1996; Toren et al. 1991). Farmers involved in animal production seem to have the highest risk for asthma compared with subjects not involved in animal production (Melbostad et al. 1998). In the same study population, asthma in the absence of atopic sensitization to common allergens was associated with an increased exposure to endotoxin (Eduard et al. 2004). Other studies have reported conflicting results for the association of endotoxin exposure and asthma in farmers (Kimpbell-Dunn et al. 1999; Omland et al. 1999; Vogelzang et al. 1999). A study among Dutch pig farmers showed that the prevalence of atopic sensitization decreased sharply with increasing occupational endotoxin exposure, with the lowest prevalence at levels above 750 EU/m^3 (Portengen et al. 2005). A study from Iowa showed an increased prevalence of childhood asthma on farms with increasing numbers of swine (Merchant et al. 2005). This raises the question as to whether exposures that begin in adulthood may lead to lowered risk for atopic sensitization as well, as opposed to the prevailing belief that a healthy worker selection is responsible for this phenomenon.

Domestic endotoxin exposure and allergy and asthma in children. Most research on domestic endotoxin exposures has focused on the question of whether this exposure can explain the observations made in several studies describing a protective effect related to the development of atopy and allergic asthma in children who have grown up on small, traditional farms (Braun-Fahrländer et al. 1999; Klintberg et al. 2001; Portengen et al. 2002; Riedler et al. 2000; von Ehrenstein et al. 2000). It was indicated that contact with livestock reduced the risk of atopic asthma in children (von Ehrenstein et al. 2000) and young adolescents (Portengen et al. 2002). Although no specific protective factors were determined in these studies, it has been suggested that respiratory exposure to endotoxin may play an important role (Klintberg et al. 2001; von Ehrenstein et al. 2000), as it is well known, especially from occupational studies, that animal husbandry is associated with high

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exposures to bacterial endotoxin. However, exposures to other bioaerosol components such as fungi, gram-positive and gram-negative bacteria, bacterial DNA motifs, storage mites, and allergens from crops and animals are expected to be higher on farms and could also play a role.

The immune system is known to be skewed toward a proatopic direction during fetal and perinatal life. It has been proposed that proinflammatory microbial products, such as bacterial endotoxin, prokaryotic DNA, and glucans, markedly modulate the response of the immune system away from its tendency to develop atopic immune responses (Liu and Leung 2000; Martinez and Holt 1999). This may be a dose-dependent phenomenon, with low doses of these compounds providing some protective effects (as accounted for in the hygiene hypothesis of allergic asthma and atopy) and higher doses leading to a skewed and harmful response. Bacterial endotoxin and prokaryotic DNA can strongly induce IL-12 production by antigen-presenting cells, leading to the elaboration of interferon (IFN)-γ, IL-18, and other mediators. These mediators, many of which are transduced through one of the conserved TLR, are well recognized as promoting T helper (Th)1 (counter to Th2) responses. It has also been shown that the protective effect of farming exposure is regulated by a TLR2 response, as only children with the wild type of this gene were protected from allergy, given they were born on a farm (Eder et al. 2004). More recently, however, the promotion of "regulatory" responses (e.g., regulatory $CD4^+$ T-cells and antigen-presenting cells such as dendritic cells and macrophages) has received prominent attention. These cells, when activated by microbial products referred to as pathogen-association molecular patterns (PAMPs) use IL-10 and TGF-β to mediate their attenuation effects; regulatory responses can downregulate both Th1 and Th2 immune responses. This category of inflammation may account for the observations that both Th1-mediated diseases (e.g., diabetes mellitus) and Th2-mediated diseases (asthma and atopic disorders) have been rising in industrialized countries over the past several decades where children are exposed to lower levels of microbial products and infections than in the past or in preindustrialized or agricultural societies. Further infections associated with eosinophilia (e.g., helminth infestations), that promote both Th2 and regulatory responses, can protect against asthma and atopy (Kline et al. 1998; Shirakawa, 1997; Yazdanbakhsh et al. 2002).

To date few studies have produced direct *in vivo* evidence that endotoxin exposure may protect against the development of atopy by enhancing Th1 responses. A U.S. study of infants with documented wheezing episodes showed that endotoxin levels were correlated with IFN-γ–producing T cells (Th1) but not with IL-4–, IL-5–, or IL-13–producing cell proportions (Th2) (Gereda et al. 2000b). A Swiss–German study of farm children showed a decreased capacity to release IFN-γ, TNF-α, IL-10, and IL-12 in peripheral blood leucocytes upon stimulation with LPS, with increasing endotoxin load in the beds (Braun-Fahrländer et al. 2002), which could be a consequence of "exhaustion" of the atopic immune system as proposed in association to atopy by Kruger et al. (2004). Animal experimental studies with ovalbumin and endotoxin have not yielded consistent results.

Studies that found a consistent protective effect of farming exposure against atopy (Braun-Fahrländer et al. 2002; von Mutius et al. 2000) have shown only a weak protective effect against asthma itself, or they have shown a dual response in children with atopic asthma and allergy to be lower with increasing LPS exposure, and contrary to this, an increased prevalence of nonatopic wheeze with increasing LPS exposure (Braun-Fahrländer et al. 1999). There is considerable evidence that endotoxin exposure may both exacerbate preexisting asthma and induce new asthma. Several studies have also shown that endotoxin in house dust is associated with exacerbations of preexisting asthma in children and adults (Michel et al. 1991, 1996, 1997). A cohort study in 499 infants with a familial predisposition to asthma or allergy showed that early indoor endotoxin exposure was associated with an increased risk of repeated wheeze during the first year of life rather than a decreased risk (relative risk = 1.6; 95% CI, 1.03–2.38) (Shirakawa et al. 1997). A recent study of endotoxin in 831 homes across the United States demonstrated that indoor endotoxin was a significant risk factor for asthma symptoms, medication use, and wheezing. The adjusted OR for households with both bedding and bedroom floor endotoxin exceeding 19.6 EU/mg compared with those below was 2.83 (95% CI, 1.01–7.87). This effect was seen regardless of allergy status (Thorne et al. 2005).

Thus, for asthma alone, there is consistent evidence that endotoxin is both a secondary and primary cause of asthma, and that this occurs through nonatopic (i.e., nonimmunoglobulin E–mediated) mechanisms.

Because of the health effects related to environmental exposures, exposure standards have been suggested (Rylander 1997). The Health Council of the Netherlands proposed a health-based occupational exposure limit of 50 EU/m^3 over 8 hr for the working environment, which has been modified to 200 EU/m^3 because of feasibility issues. The introduction of this standard has been postponed because agricultural industries cannot meet this level, but exposure reduction action plans are being implemented so that this level can be met in a few years.

Workshop Recommendations

Priority research needs.

- Candidate agents: Most research has been focused on specific gases, organic dust, or on bioaerosols containing endotoxins. Occupational studies indicate that exposures occur to other agents, such as antibiotics and disinfectants, and that these agents may be related to increased risks for respiratory disease.
- Odor: There is a need to investigate in greater detail psychophysiologic responses related to malodor exposures in people living in proximity to swine CAFOs, exploring different potential mechanisms. The influence of factors such as mood and coping styles on perceived responses to odors and physiologic responses has been minimally investigated in relation to CAFO exposures.
- CAFO mixed exposures: CAFO exposures involve, by definition, exposure to complex mixtures. These include pulmonary irritants, inflammatory agents, odoriferous compounds, allergens, and antibiotics. Problems of the interaction in mixtures need to be addressed.
- Environmental particulate matter exposures: Studies of particulate-matter exposure in rural areas are needed because of the huge gap in knowledge. Exposure mechanisms for particulates are expected to be different than those for gases because particulates from CAFOs are biologically active and are known to be relatively large. Therefore, sedimentation out of the air is expected to be considerable at short distances. Resuspension in the air, walk-in, and take-home exposures are important candidate mechanisms of transfer leading to exposure indoors. Finally, exposures arising from the handling and distribution of manure to the fields as primary aerosol and secondary re-suspension need to be addressed.
- Analytical techniques: International harmonization of methods for bioaerosol exposure assessment is needed. In the case of harmonization of endotoxin assay, the United States should give serious consideration to adoption of the existing European Committee for Standardization protocol.
- Susceptibility and genetics: Only scarce information is available for evaluating the susceptibility of groups to the effects of organic dust exposure. The candidate genes responsible for changes in the reactions to specific agents have been only sporadically investigated.
- Susceptibility and gender: Recent studies from Canada suggest that women are more prone than men to develop asthma from

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working in CAFOs. This points to the need for renewed investigations regarding gender effects in workers exposed to high concentrations of organic dust.

- Outcome assessment: There is a need to collect information regarding respiratory health in people living in proximity to CAFOs. Respiratory symptom status and lung function should be measured, as has been done in confinement workers in the last decades. Information on sensitization rates to common allergens and presence of allergic responses is crucial, as clear differences exist with nonrural populations and within rural populations, depending on early childhood exposure to animals. Recent developments in outcome assessment include more sensitive markers of inflammation, for example, IL-1β, IL-8, TNFα, C-reactive protein, and new sources to be studied by noninvasive approaches such as tear fluid, nasal lavage, exhaled breath condensate, and whole blood. These markers can elucidate the nature of the inflammatory response and facilitate a more detailed interpretation of the available information.
- Design: Panel studies have been shown to be powerful tools in air pollution research and should be pursued in studies of communities exposed to organic dust and CAFO emissions. They enroll sensitive individuals as a starting point and consider exacerbations of disease over time as the end point of interest. Exposure assessment in these studies requires combinations of exposure modeling, use of time-activity patterns and personal exposure assessment to calibrate the modelling. Alternatively, large-scale studies using hospital admission data in combination with spatial analysis to map the patients' homes and schools to CAFOs may be a cost effective and useful additional approach.

Translation of science to policy.

- Surveillance studies of workers in agricultural industries and panel studies in communities are warranted.
- The livestock industry should promote good housekeeping practices locally and worldwide and develop hygienic strategies to reduce exposure in the workplace and emissions to the general environment. Occupational health and hygiene expertise is scarce in these industries and should be improved. The cost effectiveness of various technological solutions should be established.
- Exposure standards should be promulgated for some key agents, including endotoxin, and where they exist, exposure levels should be maintained below the current standards. International guidelines for occupational and community health are needed for specific toxicants.

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LEVELING THE FIELD – ISSUE BRIEF #2

Environmental and Health Problems in Livestock Production:

Pollution in the Food System

Over the last thirty years, the livestock production system in the United States has undergone an industrial revolution. The number of animals raised for meat has been steady or growing, even as the number of farms raising animals has declined. Today, we have only a quarter the number of hog farms we had in 1982, but the number of hogs sold has gone up. How is that possible? Only because of a major change in the way livestock are produced—a change that affects farmers, consumers, businesses, and our communities.

In the industrial model of livestock production, animals are housed in close quarters inside massive climate-controlled buildings or on feedlots. Each confined animal feeding operation, or CAFO, may house tens or even hundreds of thousands of animals. To prevent disease, many livestock companies require their growers to feed animals low doses of antibiotics. CAFOs store the waste these animals generate in massive lagoons on the property and sometimes spread or spray the manure on available land.

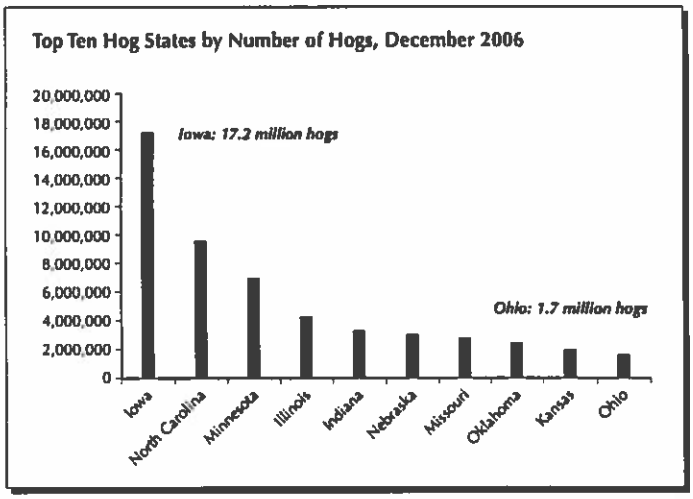
Even if you've never seen a CAFO, you can probably understand why many communities and researchers are worried about their impact on the environment and public health. Workers in confinement buildings and residents of the communities where these operations are located feel the impacts most acutely, but we are all affected by health and environmental problems in the food system. The vitality of our food system is dependent on healthy rural communities and a clean rural environment. If they're compromised by air pollution, water pollution, odor, or antibiotic resistance, then we all need to be concerned.

This issue brief is the second in a series that maps the impacts of industrial livestock production and outlines the creative, innovative responses of individuals, organizations and communities. We'll begin with a summary of major health and environmental concerns; then we'll look at what groups all across the country are doing to address them. We can learn from their experience and use the tools available to build a healthier, safer, and more vibrant food system.

When Manure Multiplies

In every way—within confinement barns and feedlots and within the communities and regions where animals are raised for meat—livestock production has become more concentrated. In the hog sector, the 110 largest operations, which each house over 50,000 animals, account for 55% of the national hog inventory.[1] In two North Carolina counties alone, the number of hogs has increased by 2 million since 1990, and the counties now average 2,185 hogs per square mile.[2] Three counties in northern Iowa experienced a nearly three-fold increase in the number of hogs between 1992 and 1997—from 600,000 to over 1.6 million—while the number of farms raising hogs declined by almost 40 percent.[3]

When CAFOs housing thousands of animals are geographically concentrated, their environmental and health impacts are concentrated too. Workers, area residents, and the communities located downstream or down-wind of the animals may find themselves with a lot of problems on their hands. The greatest environmental and health challenges are odor, air pollution, surface and ground water pollution, and antibiotic resistance. Let's take a look at these problems in more detail.



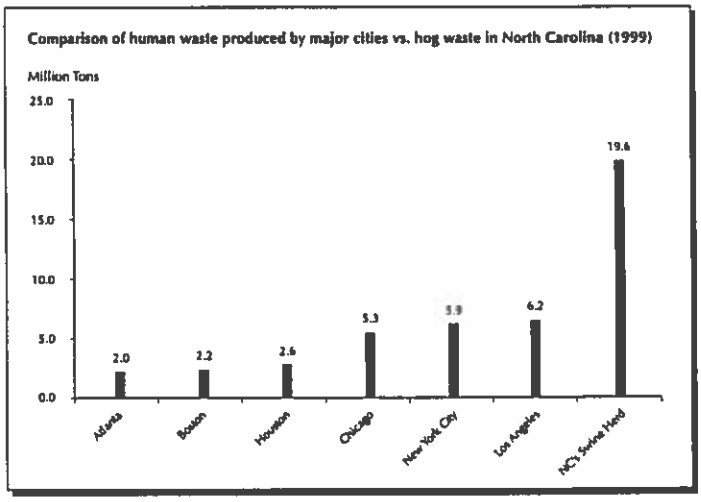
The top ten hog producing states housed a combined total of 52.6 million hogs in 2006. A high concentration of animals magnifies their impacts on health and the environment.
Source: USDA/NASS (2007)

Water Pollution from Manure

Animals generate waste. While many traditional crop and livestock operations use manure as a fertilizer, letting animals roam on land after harvest to build up organic matter,[4] industrial operations have far too much waste (and far too little land) to use this method. Most industrial operations store waste in massive lagoons that can hold millions of gallons of liquid manure. They may spread or spray some of the manure on available land. When it is spread in excessive quantities, or when the lagoons leak, problems result.

Hog CAFOs are often cited as the most problematic with respect to waste storage and removal, but there are numerous examples of pollution problems originating in cattle feedlots, industrial dairies, and poultry operations.[5] On Maryland's eastern shore, 6,000 broiler houses turn out 750,000 tons of chicken manure each year, more waste than is produced by a city of 4 million people.[6] A state-wide study in California conducted by the Environmental Protection Agency estimates that each dairy cow produces almost 44,000 pounds of manure per year. California is now home to over 1.5 million dairy cows. Many of the operations are located in the San Joaquin Valley, which is struggling to deal with the manure problem and related pollution issues.[7]

Meanwhile, as visible in the chart below, hog CAFOs in North Carolina alone produce nearly 20 million tons of waste a year—more than the human residents of New York, Chicago, and Los Angeles combined.[8]



Cochran et al. (2000).

The careful management and removal of this amount of waste is crucial to preserving environmental and human health. Raw manure can contain up to 100 million fecal coliform bacteria per gram, as well as

ammonia, phosphorus, and other nutrients and microbes that can contaminate soil and water in high concentrations.[9] E. Coli bacteria have been found in the manure of a quarter of the beef cattle on large feedlots.[10] Unfortunately, evidence suggests that pollution problems from CAFO manure are large and spreading.

Nitrogen and phosphorus can aid plant growth when applied in reasonable amounts, but are dangerous in high concentrations. The EPA has identified poultry manure as the largest source of excess phosphorus and nitrogen in the Chesapeake Bay and found that the nutrients have created a dead zone as plants and aquatic life are smothered from lack of oxygen. One-third of all wells in Maryland's chicken-producing areas have been found to have concentrations of nitrate, which is created by the breakdown of nitrogen by microbes, that exceed EPA standards for drinking water.[11]

Another study found that nitrates were responsible for contamination in 3/4 of all wells surveyed in central and western Kansas.[12] High nitrate concentrations in drinking water can cause blue baby syndrome and may contribute to developmental defects in fetuses or miscarriages in pregnant women.[13]

Manure gets into surface and ground water when lagoons spill or break, or when the CAFO operator spreads or sprays too much manure on the land around the operation.[14] Spills and leaks occur quite frequently.[15] In just one example, researchers at Kansas State University acknowledged that 87 million gallons of waste had leached into groundwater over the 15-year life of a large Kansas hog CAFO.[16] Another study found that over half of Iowa's 5600 manure storage structures leaked at rates above the legal limit.[17]

Nitrogen and other pollution from CAFOs becomes an even greater public concern when the effects of manure contamination spread from the operation outward into the community and beyond. The EPA reported in 1998 that CAFOs were a contributing source of water pollution in 20% of impaired water sources in the United States.[18]

Manure contamination can spread in groundwater aquifers or on products washed with contaminated water. In an era of national and even global food distribution, we are all at risk when the rural environment is compromised.

Air Pollution from Waste

"Piling up too much 'stuff' in one place causes problems. If you spread out the animals and let manure lay where it falls in a pasture, it doesn't bother anyone very much. But if you start collecting it, flushing it, spreading and spraying it around—all normal practices in confinement operations—it becomes air pollution."

– Dr. John Ikerd, University of Missouri, 2001

Another method used by livestock production facilities to dispose of waste is the spray application of liquefied manure to fields surrounding the operation.

Spraying large amounts of manure sends dust particles into the air that can penetrate the lungs of humans nearby. The particles carry toxic gases such as ammonia, which can impede the lungs from clearing dust particles, and hydrogen sulfide, which can prevent cells from using oxygen and causes loss of consciousness, coma, or death at high exposure levels.[19] One study found that residents living downwind from CAFOs emitting hydrogen sulfide at fairly low levels were suffering from permanent nervous system impairment.[20] Exposure to persistent,

Thousands of cows produce a lot of waste.
Photo courtesy factoryfarm.org

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low levels of hydrogen sulfide can cause fatigue, short-term memory loss, headaches, and other symptoms.[21] Air pollution from CAFOs is poorly regulated under the federal Clean Air Act, so the harm to residents living near the facilities from air pollution goes largely unaddressed.[22]

Risk to Workers, CAFO Owners and Their Families

Workers, CAFO owners, and their families face some of the greatest risks from livestock pollution.[23] Many spend their days inside these operations and are exposed regularly to dust, gases and odor.

Epidemiological studies have compared CAFO workers to workers involved in jobs that do not bring them in contact with livestock. The studies show significantly higher incidences of chronic bronchitis, asthma, flu-like symptoms, and lower respiratory tract inflammation in CAFO workers than in other workers. Ammonia, toxins, and dust are the biggest health threats. CAFO workers have been found to have higher incidences of infection with and illness from salmonella, leptospirosis, and hepatitis E than non-CAFO workers.[24]

The families of CAFO owners and the owners themselves are also at risk. One particularly horrific story retold by researcher Marlene Halverson involved five members of a CAFO-owning family who died from methane asphyxiation after entering a 10-foot deep liquid manure pit on their farm in Michigan. One family member had climbed down a ladder in the pit to make a repair, was overcome by fumes, and fell in. Four others followed him and perished as each tried to save the last.[25]

When Animals Stop Smelling and Start Stinking

Much of the damage caused by livestock pollution is subtle. Community members may not realize that their health problems are related to a nearby CAFO unless tests are conducted and the results are publicized. But anyone who has ever been near an industrial livestock facility can tell you that there is one major impact that is definitely not subtle: the smell.

Odor is more than an inconvenience. Studies show that chronic bad odor can have significant health effects. Odor also compromises the quality of life of rural residents.

One study in North Carolina compared residents living within 2 miles of a CAFO to residents not living near a CAFO. The CAFO community reported significantly greater frequency of headaches and burning eyes than the other group, which researchers attributed to the concentrated odor. These residents also reported significantly more times during the day when they could not open windows or enjoy the outdoors. Residents of communities down-wind from animal facilities often report significant mood disturbance, tension, depression, anger, fatigue, and confusion.[26]

Odor also affects the rural economy. Would you want to live next to an operation so smelly that you couldn't open your windows? A 2001 study by a national property appraisal firm found that property values around CAFOs could decline by anywhere from 50% to 90% due to "diminished marketability, loss of use and enjoyment, and loss of exclusivity."[27] State tax tribunals in Michigan reduced the assessed values of residential properties adjacent to CAFOs by between 50 and 66% because of flies and odor.[28]

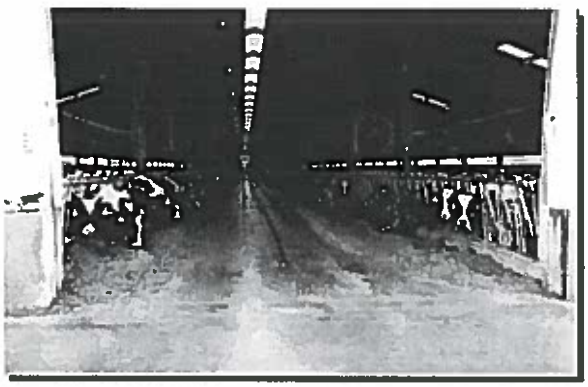

Photo courtesy factoryfarm.org

Encouraging Monoculture

Researchers also note that industrialized livestock production promotes a system where feed crops are grown on large, specialized farms and feed is shipped considerable distances to reach the CAFO.

Soybeans as far as the eye can see.
Photo by Elanor Starmer

Large-scale, input-intensive grain and oilseed farming can have significant environmental impacts of its own, including soil depletion and water contamination from pesticide and fertilizer runoff. Transportation imposes environmental costs as well in the form of greenhouse gas emissions from semis carrying feed. And as we saw above, separating crop and livestock production creates numerous problems when the manure cannot be properly used or disposed of. The specialized, industrial model of production has reduced the presence of diversified farms and ranches where reasonable quantities of manure are used to build soil health—the kinds of farms and ranches that produced the majority of our meat and milk until the last third of the 20th century. The eventual disappearance of these small- and mid-sized farms would be a significant environmental—not to mention social and economic—blow to our society and food system.[29]

Antibiotic Resistance

Industrial livestock production may be threatening the effectiveness one of the mainstays of our health system: antibiotics. Animals living so closely together are at risk for spreading disease, so many livestock companies require their growers to feed animals low doses of antibiotics as a preventative measure. In fact, some 70% of antibiotics used in the United States are fed to animals who are not sick.[30] Many in the scientific community have expressed concern that the system will increase antibiotic resistance and put human health at risk. A 2002 study found antibiotics in 1/3 of ground and surface water samples taken near hog CAFOs and in 2/3 of samples near poultry CAFOs. Studies show that manure lagoons can leach antibiotic-resistant bacteria along with other contaminants.[31] Antibiotic resistance should be a major concern for us all: doctors report a growing number of illnesses that no longer respond to antibiotic treatment, resulting in prolonged illness or death in patients with resistant strains of an illness.[32] The American Medical Association now opposes the use of antibiotics in farm animals that are not sick.[33]

Hogs are packed tightly together in this industrial facility, increasing their risk of spreading disease.

Photo courtesy Institute for Agriculture and Trade Policy:
The Price we Pay for Corporate Hogs

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What Can We Do? Strategies for Protecting Health and the Environment

Communities mobilize against the health and environmental impacts of CAFOs for many reasons. They are spurred to act because of harm done to their property; because they resent the community strife that corporate livestock production creates as it pits CAFO owners and their non-CAFO-owning neighbors against each other; or because they believe that corporations have violated basic standards of fairness, foisting costs on the community even as they receive large tax relief packages, low-interest finance, and limited liability agreements from state or local governments.[34] Their resistance takes many forms and happens on local, state, and national levels:

This young advocate says no to CAFOs in Tennessee.
Photo courtesy factoryfarm.org

Fighting CAFO Pollution to Protect Health and the Environment

- **Keep control at the local level.** Communities in states with local control have passed county planning or zoning regulations to keep large-scale livestock facilities out. The ordinances can set limits on the number of animals allowed in a facility or set acreage requirements; dictate "setback" regulations that require facilities to be a certain number of feet from a road, waterway, or property line; or require prospective CAFO operators to apply for environmental permits or livestock waste permits before the county will issue a zoning permit.[35]
- In communities where CAFOs are already operating, local environmental and public health ordinances have helped mitigate their effects. In Missouri, local groups passed health ordinances in twelve counties to keep swine facilities further from residential or public land.[36]
- In states that do not allow local control, community members have used public comment periods for CAFO licenses to express their concerns to local policymakers. If residents can prove a CAFO will negatively impact their land, a construction permit can be turned down.[37]
- Communities may be able to buy time to consider proposals for new CAFO construction by enacting a moratorium on new CAFOs until appropriate planning and zoning regulations can be put in place.[38]
- **Work on the state level.** Communities can pressure state enforcement agencies through formal complaints and letters to the state agency in charge of monitoring and enforcement for CAFOs (often the Department of Natural Resources). Most CAFOs must also apply for permits with the state under the Clean Water and Clean Air Acts, so community members can organize to attend public permit meetings with state lawmakers. As a last resort, citizens are allowed to formally request the involvement of the federal Environmental Protection Agency by filing a citizen suit under the Clean Water Act.
- State-wide ballot initiatives are another option. In 1998, Colorado voters succeeded in passing Amendment 14, which placed stricter regulations on large swine CAFOs and mandated the use of lagoon covers for odor control.[39]
- **Lobby on the federal level.** The Clean Water Act and the Clean Air Act must be strengthened to better address CAFO pollution and odor. Permitting requirements should be more strict, and the public review process for CAFOs must be thorough.
- **Support alternative livestock producers** through your purchases and by lobbying for government support for smaller-scale, diversified livestock operations.

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For more information:

CAFO Pollution and Environmental and Health Effects:

- **The Institute for Agriculture and Trade Policy** has put out a series of detailed fact sheets on the problems of air and water pollution from CAFOs, health impacts, and impacts on workers. IATP also has information on how to make safer, more sustainable food choices. Access them at www.iatp.org/foodandhealth/issues_factoryfarms.cfm.
- IATP researcher **Marlene Halverson's** excellent report on the impacts of hog CAFOs is available at www.iatp.org/hogreport/index.html.
- Read a comprehensive report on CAFOs and air quality by researchers at the **U. of Iowa and Iowa State**: www.public-health.uiowa.edu/ehsrc/CAFOstudy.htm

Antibiotics:

- Read Antibiotics, Agriculture, and Resistance, a report by the **Land Stewardship Project**. www.landstewardshipproject.org/pr/ 2002/newsr_021218.html
- **Union of Concerned Scientists** is one of the leading groups working on the overuse of antibiotics in livestock production. Access their resources at www.ucsusa.org/food_and_environment/antibiotics_and_food/
- **Keep Antibiotics Working** is a coalition of health, environmental, agriculture and consumer groups with excellent information on the use of antibiotics in livestock production. www.keepantibioticsworking.com/

Take Action on CAFO pollution:

- Read a guide by **Diane Hatz**, former director of the GRACE factory farm project, on how to confront a CAFO: www.factoryfarm.org/guide/docs/guide.pdf
- The **Sierra Club** has resources on challenging CAFO pollution, including "Five Local Strategies to Keep CAFOs Out." www.sierraclub.org/factoryfarms/resources/strategies.asp.
- Find out about federal policy proposals from the website of the **Sustainable Agriculture Coalition** (http://www.sustainableagriculturecoalition.org/) and sign up for action alerts from the **National Campaign for Sustainable Agriculture** (www.sustainableagriculture.net) to find out how you can take action.
- Visit the website of **Food and Water Watch** for more information on the impacts of factory farming and how consumers can act to change it. http://foodandwaterwatch.org/food.
- Support sustainable, smaller scale livestock producers by finding alternative retail outlets in your area. Visit farmers' markets or make connections on-line through resources like the **Eat Well Guide** (http://www.eatwellguide.org/) and **Farm to Table** (http://www.farmtotable.org/).

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Adverse Health Effects Of Hog Production
A Literature Review

Ammonia emissions from hog farms pose a serious public health threat.

- Ammonia emissions from hog farms react with other gases in the air to form fine particle pollution, a public health threat linked to decreased lung function, cardiovascular ailments and most seriously, premature death.[1]
- Recent analysis by NC State University (NCSU) researchers shows that fine particulate pollution is higher in Raleigh (and likely for all of the Triangle area) when air masses cross the high density hog counties on the way to Raleigh.[2] This analysis also found fine particulate levels in a rural town (Kenansville) in a high density hog county were very high relative to what would be expected.
- The 2003 National Academy of Sciences[3] report identified atmospheric ammonia nitrogen emissions as the most significant public health threat from Animal Feeding Operations[4] on a regional scale.
- Reducing ammonia emissions from Animal Feeding Operations makes sense not only for the obvious public health benefits, but also for economic reasons. The Benefit Cost Analysis conducted by Research Triangle Institute for the NCSU hog waste management evaluations found that a 50% reduction in ammonia emissions from hog farms in eastern NC will provide an estimated $190 million a year in benefits from avoided health impacts.[5]

Air emissions from lagoons, sprayfields and hog houses have been linked to neurological and respiratory problems.

- Subjects in a controlled exposure chamber who were exposed to air from hog operations for one hour reported headaches, eye irritation and nausea.[6]
- Unpleasant odors have been found to be a nuisance and emotional stressor on neighbors,[7] and are known to contain irritants that can cause damage to mucosal linings in the nose, throat and respiratory tract.[8]
- The 2003 National Academy of Sciences report identified odor as the most significant concern for local communities among the suite of air emission problems from Animal Feeding Operations.
- Researchers from the UNC School of Public Health and Duke University found that neighbors exposed to odors from hog operations showed evidence of reduced immune system function.[9]
- Evidence is also emerging that indicates that the health of citizens living near hog operations is negatively affected.[10] Research in Iowa and North Carolina showed that neighbors living within three miles of hog operations experience elevated levels of respiratory complaints relative to those living near other animal production operations or crop production.[11,12]
- Abhorrent odors can be exacerbated by the smell and sight of rotting flesh from hog carcasses that are often stored in "dead boxes" close to neighbors' property lines. "Dead trucks" that transport hog carcasses to rendering facilities also emit odor

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Hydrogen Sulfide Emissions

- Hydrogen sulfide (H_2S) is a colorless gas with a strong odor of rotten eggs that is detectable at concentrations as low as 0.5 ppb (0.0007 mg/m^3). Acute exposures to H_2S at 2 – 10 ppm have been associated with respiratory and cardiovascular effects, and people with asthma appear to be more sensitive to H_2S reporting headaches following 30 minute exposures to 2 ppm.[13] The EPA also reports that acute occupational exposures have been associated with a variety of central nervous system (CNS) transitory symptoms, such as dizziness, nausea, headache, and at higher exposure concentrations, serious conditions such as "abrupt physical collapse" and pulmonary edema.[14]
- The 2003 National Academy of Sciences report, noting hydrogen sulfide's risks to public health, recommended that the EPA and USDA should develop process-based mathematical models for atmospheric emissions of hydrogen sulfide, along with ammonia and methane, to identify management changes that decrease emissions.
- Of particular concern is the susceptibility of children to neurological effects associated with H_2S exposure.[15]
- The EPA Office of Air Quality Planning and Standards is in the process of re-evaluating H_2S toxicity to determine if it requires specific regulation.[16] The neurotoxicity has been cited as one of the principle reasons for increased scrutiny.
- In light of these efforts by the EPA Office of Air Quality Planning and Standards, it would seem reasonable and practical to continue to collect emissions data, and use this information in the evaluation of potential health impacts that can be used to inform the decision-making process by the Office of Air Quality Planning and Standards. It is premature to cease collecting this information at a time when an analysis of the exposure conditions is warranted.

Hog waste contains disease-causing pathogens & increases antibiotic resistance.

- Hogs and humans share many of the same disease organisms. Large quantities of antibiotics, many closely related to those used to treat humans, are used by pork and other livestock and poultry producers.[17]
- Environment Defense reported in 2005[18] that North Carolina's animal production industry, which is largely comprised of hog and poultry production, is estimated to use three million pounds of antibiotics annually. This is approximately the same amount of antibiotics that is estimated to be used *nationally* to treat humans.
- The vast majority of antibiotics are administered not to treat disease but rather to promote growth or to compensate for the crowded, stressful and often unhygienic conditions in industrial-scale livestock operations. An expanding body of evidence[19,20] links this frequent exposure of antibiotics to the development of antibiotic-resistant pathogens, contributing to the problem of reduced antibiotic effectiveness in humans, a growing health concern in the United States.
- There are also concerns about the exposure of workers or neighbors to antibiotics in the dust generated in the hog confinement facilities, which are vented to the outdoors.[21,22]

Evidence indicates adverse impacts on workers' and children's health.

- An enormous amount of research exists to document the serious negative impacts to swine confinement house workers.[23] Effects include respiratory symptoms, reductions in pulmonary function and increased bronchial responsiveness.
- Researchers in Iowa found a high prevalence of asthma in children living on hog farms, especially farms that added antibiotics to feed.[24,25]
- A North Carolina study of 58,169 children found a 23% higher prevalence of asthma symptoms among students attending schools where staff noticed livestock odors indoors twice a month or more.[26]

Manure land application rates at hog Animal Feeding Operations result in high levels of pollutants in groundwater and pose risks for drinking water wells.

- Ground water nitrate levels beneath animal waste sprayfields are typically found to range from 10 to 50 parts per million (ppm).[27] The drinking water standard for nitrate is 10 ppm. Even wells drilled to clean aquifers below surface contaminated groundwater aquifers are at risk because well casing construction flaws can allow leaks of highly contaminated groundwater into drinking water wells.
- Results from a free well-testing program for people living adjacent to hog farms in North Carolina in 1996 found more that 10% of the wells tested failed to meet drinking water standards for nitrate. Three wells had nitrate concentrations in the 70 – 100 ppm range. The NC Department of Health and Human Services found that the results of the well testing program "*...illustrate a potentially serious groundwater problem to the people utilizing wells near Industrial Livestock Operations in five counties in eastern North Carolina.*"[28]

Community health experts are recommending safeguards to protect the health of rural residents.

- Based on the 2003 American Public Health Association's review of evidence of the health and economic impacts of concentrated animal feeding operations (CAFOs)[29] [30] and "evidence, albeit less certain, indicating impacts on children and CAFO neighbors from exposure to large concentrations of manure and their subsequent emissions of dust, toxins, microbes, antibiotics and pollutants in the air and water," the Association resolved that it would:

> *[U]rge federal, state, and local governments, and public health agencies to impose a moratorium on new Concentrated Animal Feed Operations until additional scientific data on the attendant risks to public health have been collected and uncertainties resolved.*

Community health experts are recommending safeguards to protect the health of rural residents. (continued)

- The American Public Health Association's recommendations were recently endorsed by a collection of American and European environmental scientists brought together in a symposium and workshop organized by the University of Iowa's Environmental Health Science Research Center and sponsored by the National Institutes of Environmental Health Sciences. The endorsement emerged from an expert community health workgroup assembled at the workshop in 2004, the results of which were recently published.[31] The workgroup found that "*...sufficient research exists to support action to protect rural residents from the negative community health effects of CAFOs....*" Furthermore, the expert workgroup recommended that permitting of CAFOs should include: consideration of total animal density in a watershed; environmental impact statements; public meetings and local decision making; regulation with standards applied to general industry with similar levels of emissions and type of waste handling; and bonding for manure-storage basins for performance and remediation.

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Neighbor Health and Large-scale Swine Production

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Introduction

The 1989 report "Agriculture at Risk: A Report to the Nation" played a central role in elevating agricultural health issues to national prominence. The cast of agricultural health issues laid forth in the report set the stage for shaping priority research issues. However, the rapid pace of agricultural industrialization resulted in tremendous change in the agricultural sector between the time of the report in 1989 and the present. No where is this more evident than in the livestock sector, particularly the swine industry. The rapid structural shift in the swine sector towards concentration and consolidation created environmental and public health problems largely unforeseen in the 1989 report, or even in the Surgeon General's Report on Agricultural Safety and Health issued three years later (Myers, et al.1992). Specifically, the swift growth of large-scale Confined Animal Feeding Operations (CAFOs) in the 1990s has resulted in the emergence of whole new agricultural health issues previously unmentioned.

In this paper I focus on emergent agricultural health concerns related to CAFOs, namely public health concerns for neighbors exposed to CAFO emissions. Concerns have been directed at a broad spectrum of CAFOs, including dairy, cattle, and poultry. However, the swine industry has received the most attention from both a public health and public policy standpoint. In addition, considerable research on occupational health challenges among swine confinement workers was in fact present at the time of the "Nation at Risk Report" and numerous subsequent conferences which provide a backdrop for consideration of CAFO neighbor health issues. Consequently, this paper will focus most directly, though not exclusively, on reviewing research and concomitant agricultural and public health issues related to CAFO emissions and neighbor health concerns in the swine sector.

Background

The industrialization of agriculture dates back to at least the previous century and is characterized, in part, by the substitution of fossil fuels and capital intensive production technology for human labor (Thu and Durrenberger, 1998). The substitution of fossil fuel based technology in place of farmers has resulted in the consolidation of production into fewer hands and the attendant growth of large-scale production operations. The swine industry is a classic example of this industrialization process. As illustrated in Figure 1, there is very little difference between the number of hogs produced in the U.S. in the year 2000 compared with the number of hogs produced over 80 years earlier in 1915.

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[Figure 1. U.S. Hog Production in 1915 and 1999 (USDA NASS)]

While overall production volume has changed little, the structure of the industry has shifted radically. As revealed in Figure 2, the number of hog producers in the U.S. declined precipitously from the 1960s to the present. Notable in this regard is the rapid rate of decline and concurrent emergence of relatively large production operations. For example, in a mere six-year period from 1993 to 1999, there was a 250% increase in

[Figure 2. Total U.S. Hog Farmers from 1965 to 1999 (USDA NASS)]

the total U.S. hog inventory concentrated in operations with 5,000 or more hogs each (USDA NASS).

The structural shift in the hog industry paralleled technological changes. Most notable among these is the transformation from pasture-based and open lot hog production to totally confined production beginning in the 1970s. Movement to totally confined production provided a seeming advantage to the bulk of hog farmers in the Midwest by providing an antidote to harsh climatic conditions which impeded growth rates and time to market. Moreover, enclosed production units provided an opportunity for stricter control over feed rationing and reproduction. However, as is so often the case, technological changes produced unforeseen costs.

Worker Health Problems and Swine CAFOs

One of the principles underlying confined animal production is to control the climatic elements, particularly in temperate regions, that hinder swine growth. To accomplish this, an enclosed environment is created to keep outdoor conditions, most notably the frigid cold, from coming indoors. This also means that elements inherent to hog production will, to varying extents, be confined to the inside. Soon after confinement production emerged in the 1970s, studies began to reveal that confining pigs also meant confining airborne elements injurious to both workers and pigs alike. In a 25-year period beginning in the 1970s, nearly 30 published studies consistently reveal a variety of health problems among swine confinement workers, the most notable of which are a series of respiratory problems (see reviews in Thorne et al. 1996; Cole, Todd and Wing, 2000). These problems include a series of overlapping conditions such as chronic bronchitis, occupational asthma, and organic dust toxic syndrome, that have been documented to occur in nearly 30 percent of swine confinement workers. More detailed research identified the concentration levels of interior ambient airborne elements, including their interactive dynamics, which put exposed worker populations at risk. For example, recommended gas (7 ppm ammonia), dust (2.5 mg/m3 total dust; .23mg/m3 respirable dust), and endotoxin (100 EU/3) levels have been developed for interior swine confinement operations based on dose-response research (Donham et al., 1995; Reynolds et al., 1996).

At the time of the "Nation at Risk" report, occupational health problems among swine confinement workers were clearly recognized. The occupational health research over the past ten years has resulted in further clarification of exposures and the connections to health symptomologies and defined medical conditions. However, virtually unknown in 1989 was the

existence of health problems among neighbors exposed to swine CAFOs. Since the mid-1990s, research examining the health of neighbors of large-scale swine production has opened a new chapter concerning the health costs of confined swine production.

An Emergent Public Health Issue: Swine CAFO Neighbors

There is no indication in the earliest occupational health literature that swine CAFOs posed any real or potential health problems among neighbors. This is understandable since the relatively modest size of an early generation of swine CAFOs simply did not seem likely to pose an air quality challenge beyond nuisance odor. Indeed, an entire cottage research industry developed among agricultural engineers to understand and control emissions from livestock facilities as an odor problem largely devoid of any heath reference (Hobbs, 1995; Miner, 1975; O'Neill and Phillips, 1992). Nonetheless, a close examination of early odor literature does provide clues that a lingering health issue was present.

For example, early agricultural engineering reports (Overcash et al., 1984) indicated the possibility that livestock odors could elicit deleterious physiological responses, including nausea, vomiting and headaches, coughing, and irritation of eyes, nose and throat. In addition, health science literature showed odor exacerbating pre-existing conditions such as asthma (Change and Williams, 1986). Within the tradition of livestock odor research, Warner, Sidhu, and Chadzynski (1990) examined emissions from a swine facility in Michigan in order to assess the intensity and distance odor traveled in creating a nuisance, or quality of life, problem. However, embedded in this work was a health survey which recorded health symptoms among neighbors as an early indication that something beyond an unpleasant nuisance was involved. These early works reveal that odor has a tangible physical property that elicits a physiological response. Moreover, odor is only one dimension of the panoply of swine CAFO emissions that include over 160 identified compounds (see Ritter, 1989; and overview odor discussion in Melvin et al., 1996).

Consequently, this early research may have mistakenly assumed that odor was the primary constituent of CAFO emissions exposure responsible for reported health symptoms.

In 1995, Susan Schiffman and colleagues from Duke University published the first research specifically focused on the negative neighbor health effects of exposure to emissions from swine CAFOs. The results were based on of a matched control study examining the psychological effect of odors from commercial swine operations in North Carolina (Schiffman et al., 1995). They administered a standardized mood states (POMS) and total mood disturbances (TMD) scale to 44 neighbors of commercial swine operations and 44 matched controls not living near such operations. Results showed that the neighbors subjected to odors scored significantly higher on both scales, exhibiting higher rates of tension, depression, anger, and fatigue than did the control group. Elsewhere, Schiffman describes a variety of mechanisms that explain how odor can have a deleterious human health effect, including a physiological pathway between the olfactory lobe and the immune system which directly implicate odor as a health risk (Schiffman et al., 1998).

As a follow-up to the Schiffman study, Thu et al. published the results of a control study (1997) based on physical and psychological health data from 18 neighbors living within a two-mile

radius of a 4,000 sow swine confinement production facility. They compared the results with data from 18 demographically comparable rural residents who lived near minimal livestock in Iowa. Results indicated that the neighbors of the swine operation reported significantly higher rates of four clusters of symptoms previously documented to represent toxic or inflammatory effects of the respiratory tract. Most notable is the fact that for the first time the configuration of respiratory symptoms among neighbors were documented to be consistent with the well-established pattern of respiratory health problems among swine confinement workers evident in the occupational health literature.

In 1998 the National Center for Environmental Health, Centers for Disease Control and Prevention, responded to growing nation-wide concerns expressed through state health agencies about the environmental and public health consequences of CAFOs by sponsoring a workshop, "Public Health Issues Related to Concentrated Animal Feeding Operations." The workshop brought together over 35 experts and divided them into two groups to focus on water and air contamination from CAFOs. It is noteworthy that the group of scholars who focused on CAFO air contamination agreed that "adequate evidence currently exists to indicate airborne emissions from large-scale swine facilities constitute a public health problem" (CDC, NCEH, 1998:30).

In 1999, a landmark study funded by the North Carolina Department of Health and Human Services, Division of Public health, was released. This was the largest study to date examining the health and quality of life of residents living in proximity to large swine operations. Later published in Environmental Health Perspectives (Wing and Wolf, 2000), researchers examined three different rural communities to include residents living near a 6,000 swine CAFO, residents living near two intensive cattle operations, and a control area where residents lived at least two miles from any livestock operation that used a liquid manure system. Controlling for age, gender, smoking, and work, the findings among the 155 participants were consistent with Thu, et al. (1997) and Schiffman (1995) in revealing elevated health problems among residents living in proximity to the swine CAFO. There were significantly elevated rates of headaches, runny nose, sore throat, excessive coughing, diarrhea, and burning eyes among neighbors of the swine operation.

The results of the Wing and Wolf study are notable for two fundamental reasons. First, the results indicate reporting bias was not a problem. It is clear that participants in this study, as well as the comparable study by Thu, et al. (1987), could be subject to reporting bias because residents may simply want to provide negative responses to the pork industry that they may disagree with. However, if that is the case, it is extremely difficult to explain away the highly selective nature of reported symptoms and the fact that participants chose not to report elevated rates of all symptoms when given the opportunity. That did not occur in either the Thu et al. (ibid) study or the Wing and Wolf research (2000). Indeed, in the Wing and Wolf research, many of the symptoms reported were similar in all three groups. Second, the configuration of reported symptoms are consistent with well-documented symptoms among swine confinement workers. It appears highly unlikely that two cohorts of swine CAFO neighbors could accidentally stumble upon selecting a consistent set of symptoms that match symptoms among swine confinement workers.

Further evidence for swine CAFO neighbor health problems comes from the Bureau of

Epidemiology within the Utah Department of Health (Keller and Ball, 2000). In 1993, one of the largest hog operations in the country began construction near the town of Milford (population 1,305) in Beaver County, southern Utah. In the following two years, the facility was populated with pigs whose sow base reached 44,000 sows (with a reported target of 120,000 total sows). At the request of the Southwest Utah District Health Department, Utah's Bureau of Epidemiology within the Utah Health Department, responded to concerns about increases in diarrheal and respiratory disease among nearby Milford residents. A retrospective approach utilizing hospital discharge records from nearby Milford was used and compared with two comparison populations in the region, in addition to statewide averages for Utah as a whole. The investigation examined whether hospital discharge records from Milford indicated higher rates of respiratory and diarrheal illness during the years 1992 to 1998 (when the swine CAFO was constructed and became operational) compared to other communities in the region and the state as a whole. Findings demonstrate an increase in both diarrheal and respiratory illness cases in Milford during the period from 1992 to 1998 when the swine CAFO became operational. For example, Milford experienced a quadrupling of hospital diarrheal case rates from 88 per 10,000 in 1992, to 409 per 100,000 in 1997. During the same period, Milford reflected a tripling of hospital cases involving respiratory illness, from 159 cases per 10,000 in 1992, to 517 cases per 10,000 in 1997. Moreover, the incidence rates were significantly higher than those found in comparison populations and the state as a whole, leading the authors to conclude: "The results of this investigation found evidence that suggests elevated incidence of diarrheal and respiratory in Milford as compared to Parowan, Panuitch, and the State of Utah during the time period of 1992 through 1998" (Keller and Ball, 2000:7). The investigators do not ascribe causation to the neighboring swine CAFO, but the implication is clear.

The evidence is mounting that swine CAFO workers are not the only ones experiencing health problems, a public health problem appears to be present (Thu, 1998).
These studies, as well as federal and state reports, independently and consistently show that neighbors, including farmer neighbors, of large-scale swine production are experiencing abnormally high rates of health problems compared with other populations. Moreover, the health symptoms being experienced by neighbors are consistent with, and similar to, the types of health symptoms well-documented among interior confinement workers. However, in contrast to occupational health research among CAFO workers, comparable exposure studies investigating potential toxicants and their relationship to neighbor health problems are notably lacking.

There are clues from the occupational health literature, the odor research, and investigations in other industries which suggest direction for future human exposure research. Among the airborne elements to examine are hydrogen sulfide, volatile organic compounds (VOCs), dusts, endotoxin, and perhaps ammonia, in addition to the irritant dimension of odors. While the likely culprit is some combination of emission constituents, exposure to hydrogen sulfide merits particularly attention. Hydrogen sulfide is a known toxic gas produced by the anaerobic digestion of protein in swine CAFOs. Chronic or acute occupational exposure to hydrogen sulfide concentrations near or above 500 ppm (parts per million) is known to result in Acute Respiratory Distress Syndrome (ARDS) or pulmonary edema among swine confinement workers which can be fatal. However, less attention has been devoted to examining the consequences of longer-term exposure to low levels of hydrogen sulfide. In the oil refinery industry exposure to low levels of hydrogen sulfide produces symptoms such as shortness of breath, headache, eye irritation, small-

airway obstruction, and diarrhea (Kilburn and Warshaw, 1995). Moreover, longer-term exposure to low levels of hydrogen sulfide can result in permanent neurological dysfunction with accompanying physiological damage (Kilburn, 1993 and 1997). This threat has resulted in six states establishing hydrogen sulfide or reduced sulfur standards. Hydrogen sulfide monitoring data from swine CAFOs in Minnesota by the Minnesota Pollution Control Agency (MPCA) confirm the relevance of research on chronic exposure to low levels of hydrogen sulfide (Sullivan, 1999). MPCA data reveal that swine CAFOs can emit hydrogen sulfide onto neighboring property at levels that exceed World Health Organization recommended standards (Roth, 1993).

Discussion

Research to date indicates that neighbors of swine CAFOs can experience health problems at significantly higher rates than controlled comparison populations. This fact has been recognized in legal cases, such as an Appelate Court decision in Missouri, that have upheld local government authority to establish public health based ordinances to influence the siting of CAFOs in order to protect the health of its citizenry based on established science. Such local health board activity has already occurred in North Carolina and Missouri, with comparable efforts underway in a number of other states. In addition, nuisance lawsuits leveled by farmer and non-farmer neighbors against CAFOs will most certainly make increasing use of public health problems from both an air emissions and water quality premise.

In 1998, the President of the United States released the Clean Water Action Plan (CWAP) which provided a blueprint for restoring and protecting water quality across the Nation. The CWAP called for the development of a USDA/EPA Unified Strategy to minimize the water quality and public health impacts of animal feeding operations. This effort has resulted in a comprehensive set of rules to be enforced via the National Pollution Discharge Elimination System (NPDES) permits for CAFOs which are currently in the Federal Register for public comment. However, this effort has focused primarily on water quality, with little attention to air quality. Comparable research and policy attention to exterior air quality problems, human exposures, and health conditions resulting from CAFOs is necessary.

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Public Health Concerns for Neighbors of Large–Scale Swine Production Operations

K. M. Thu

Abstract

This article provides a review and critical synthesis of research related to public health concerns for neighbors exposed to emissions from large–scale swine production operations. The rapid industrialization of pork production in the 1990s produced a generation of confined animal feeding operations (CAFOs) of a size previously unseen in the U.S. Recent research and results from federally sponsored scientific symposia consistently indicate that neighbors of large–scale swine CAFOs can experience health problems at significantly higher rates than controlled comparison populations. Symptoms experienced by swine CAFO neighbors are generally oriented toward irritation of the respiratory tract and are consistent with the types of symptoms among interior confinement workers that have been well documented in the occupational health literature. However, additional exposure assessment research is required to elucidate the relationship of reported symptoms among swine CAFO neighbors and CAFO emissions.

Keywords. *Swine, CAFOs, Public health, Neighbors.*

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health challenges among swine confinement workers was in fact present at the time of the "Agriculture at Risk" report, and numerous subsequent conferences provide a backdrop for consideration of CAFO neighbor health issues. Consequently, this article will focus directly, though not exclusively, on reviewing research and concomitant agricultural and public health issues related to CAFO emissions and neighbor health concerns in the swine sector.

Background

The industrialization of agriculture dates back to at least the previous century and is characterized, in part, by the substitution of fossil fuels and capital intensive production technology for human labor (Thu and Durrenberger, 1998). The substitution of fossil fuel–based technology in place of farmers has resulted in the consolidation of production into fewer hands and the attendant growth of large–scale production operations. The swine industry is a classic example of this industrialization process. There is very little difference between the total U.S. inventory of hogs in the year 2000 (59.3 million) compared with the total inventory of hogs produced over 80 years earlier in 1915 (60.6 million) (USDA NASS). However, while overall production volume has changed little, the structure of the industry has shifted radically. As revealed in figure 1, the number of hog producers in the U.S. declined precipitously from the 1960s to the present. Notable in this regard is the rapid rate of decline and concurrent emergence of relatively large production operations. For example, in a mere six–year period from 1993 to 1999, there was a 250% increase in the total U.S. hog inventory concentrated in operations with 5,000 or more hogs each (USDA NASS).

The structural shift in the hog industry paralleled technological changes. Most notable among these is the transformation from pasture–based and open–lot hog production to totally confined production beginning in the 1970s. Movement to totally confined production provided a seeming advantage to the bulk of hog farmers in the Midwest by providing an antidote to harsh climatic conditions that impeded growth rates and time to market. Moreover, enclosed production units provided an opportunity for stricter control of feed rationing and reproduction. However, as is so often the case, technological changes produced unforeseen costs.

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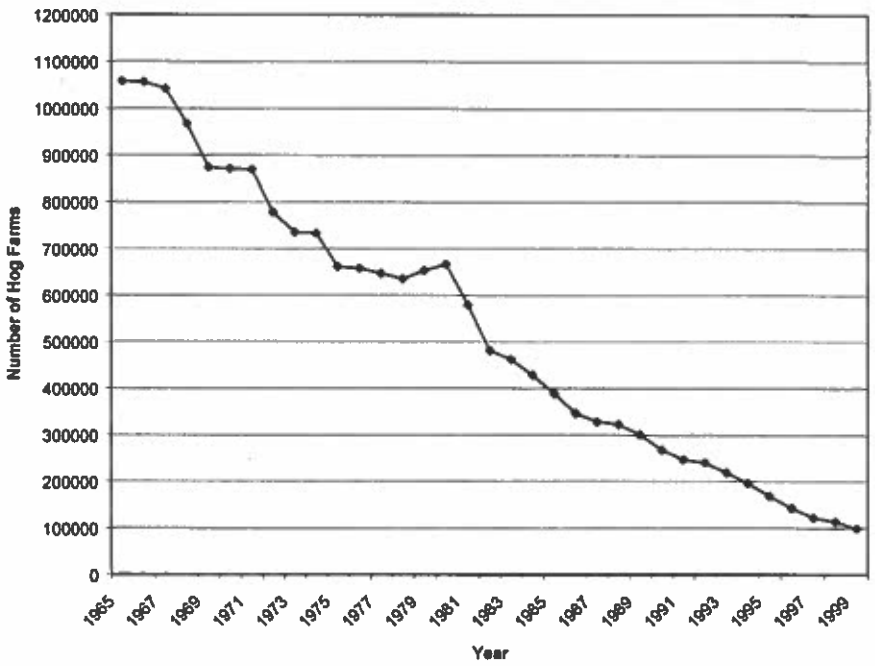

Figure 1. Total U.S. hog farmers from 1965 to 1999 (USDA NASS).

Respiratory problems include a series of overlapping conditions such as chronic bronchitis, occupational asthma, and organic dust toxic syndrome that have been documented to occur in up to 30% of swine confinement workers. Symptomatic signals of chronic problems include nagging cough with production of phlegm persisting for more than three months in a year, chest tightness and/or wheezing associated with work in a confinement, persistent fatigue in conjunction with headaches and difficulty breathing, symptoms of a cold that won't go away (stuffy nose, sore throat, and "popping" ears), and decreases in pulmonary function (Thorne et al., 1996, p. 163–164). Six or more years of exposure heightens the potential for chronic problems, while a minimal two–hour exposure inside a confinement may result in shorter–term acute symptoms such as itchy, watery eyes and chest tightness. Moreover, many of these symptoms and overarching conditions can co–occur, making them difficult to discern and assess. It is reasonably clear that persons with medical pre–conditions, such as asthma, are more susceptible to these constellations of problems. It has also been suggested that some of these conditions may result in irreversible lung damage (Thorne et al., 1996, p. 164).

More detailed research identified the concentration levels of interior ambient airborne elements, including their interactive dynamics, which put exposed worker populations at risk. For example, recommended gas (7 ppm ammonia), dust (2.5 mg/m^3 total dust; 0.23 mg/m^3 respirable dust), and endotoxin (100 EU/m^3) levels have been developed for interior swine confinement operations based on dose–response research (Donham et al., 1995; Reynolds et al., 1996). Researchers have also noted that when these elements combine (e.g., ammonia attached to small dust particles), they may have an added negative health consequence.

At the time of the "Agriculture at Risk" report, occupational health problems among swine confinement workers were clearly recognized. The occupational health research over the past ten years has resulted in further clarification of exposures and the connections to health symptomologies and defined medical conditions. However, virtually unknown in 1989 was the existence of health problems among neighbors exposed to swine CAFOs. Since the mid–1990s, research examining the health of neighbors of large–scale swine production has opened a new chapter concerning the health costs of confined swine production.

An Emergent Public Health Issue: Swine CAFO Neighbors

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In 1995, Dr. Susan Schiffman and colleagues at Duke University published the first research specifically focused on the negative health effects of exposure to emissions among neighbors of swine CAFOs. The results were based on a matched control study examining the psychological effect of odors from commercial swine operations in North Carolina (Schiffman et al., 1995). Researchers administered a standardized mood states (POMS) and total mood disturbances (TMD) scale to 44 neighbors of commercial swine operations and 44 controls not living near such operations who were matched based on age, gender, education, and race. Results showed that the neighbors subjected to odors scored significantly higher on both scales, exhibiting higher rates of tension, depression, anger, and fatigue than did the control group. Elsewhere, Schiffman describes a variety of mechanisms that explain how odor can have a deleterious human health effect, including a physiological pathway between the olfactory lobe and the immune system, which directly implicate odor as a health risk (Schiffman et al., 1998).

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As a follow–up to the Schiffman study, Thu et al. (1997) published the results of a control study based on physical and psychological health data from 18 neighbors living within a two–mile radius of a 4,000–sow swine confinement production facility. They compared the results with data from 18 demographically comparable rural residents who did not live near concentrations of livestock in Iowa. The results indicated that the neighbors of the swine operation reported significantly higher rates of four clusters of symptoms previously documented to represent toxic or inflammatory effects of the respiratory tract among confinement workers. One cluster reported by swine CAFO neighbors includes symptoms such as coughing, sputum production, breath shortness, chest tightness, and wheezing. A second cluster includes symptoms of nausea, weakness, and feelings of dizziness. A third cluster consists of headaches and plugged ears, while a fourth cluster encompassed symptoms of a runny nose, scratchy throat, and burning eyes. Most notable is the fact that for the first time the configuration of respiratory symptoms among neighbors was documented to be consistent with the scientifically well–established pattern of respiratory health problems among swine confinement workers discussed previously.

In April of 1998, a scientific workshop on odors and health problems was held at Duke University and spearheaded by Dr. Susan Schiffman. The workshop, in which I participated, was sponsored by Duke University, the Environmental Protection Agency, and the National Institute on Deafness and Other Communication Disorders and brought together nearly 50 experts from a broad array of scientific fields to assess the current state of scientific knowledge concerning the health consequences of odor exposures, particularly odors generated by large livestock operations. The results, published two years later (see Schiffman et al., 2000), revealed three general paradigms whereby ambient odors can indeed produce health problems: (1) physiological irritation from emission levels causing toxicological effects in which odor is simply a marker, (2) symptoms produced by malodors but without concomitant toxicological irritation, and (3) odors as part of a mixture of co–pollutants. In paradigms one and three, the odor serves as a signal that other ambient emission elements are creating the health symptoms. The over–riding conclusion of the workshop was that odors and their interconnected airborne emission partners can cause health problems:

> "Our current state of knowledge clearly suggests that it is possible for odorous emissions from animal operations, wastewater treatment, and recycling of biosolids to have an impact on physical health. The most frequently reported symptoms attributed to odors include eye, nose, and throat irritation, headache, nausea, hoarseness, cough, nasal congestion, palpitations, shortness of breath, stress, drowsiness, and alterations of mood" (Schiffman et al., 2000, p. 57).

In June of 1998, the same year as the Duke conference, the National Center for Environmental Health, Centers for Disease Control and Prevention, responded to growing nationwide concerns expressed through state health agencies about the environmental and public health consequences of CAFOs by sponsoring their own scientific workshop, "Public Health Issues Related to Concentrated Animal Feeding Operations," in which I also participated. The scientific workshop brought together over 35 experts and divided them into two groups to focus on water and air contamination. The CDC workshop produced a report consistent with the Duke results, indicating that exposure to odor–related emissions from large–scale livestock facilities can result in health problems for neighbors. The group of scientists focusing

on CAFO–related air contamination agreed that "adequate evidence currently exists to indicate airborne emissions from large–scale swine facilities constitute a public health problem" (CDC, 1998, p. 30).

In 1999, a landmark study funded by the North Carolina Department of Health and Human Services, Division of Public Health, was released and later published in *Environmental Health Perspectives* (Wing and Wolf, 2000). This was the largest study to date examining the health and quality of life of residents living in proximity to large swine operations. The researchers examined three different rural communities, which included residents living near a 6,000–swine CAFO, residents living near two intensive cattle operations, and a control area where residents lived at least two miles from any livestock operation that used a liquid manure system. After controlling for age, gender, smoking, and work, the findings among the 155 participants were consistent with Thu et al. (1997) and Schiffman et al. (1995), as well as with the two 1998 scientific workshops, in revealing elevated health problems among residents living in proximity to the swine CAFO. There were significantly elevated rates of headaches, runny nose, sore throat, excessive coughing, diarrhea, and burning eyes among neighbors of the swine operation.

The results of the Wing and Wolf (2000) study are notable for two reasons. First, the results indicate that reporting bias was not a problem. It is clear that participants in this study, as well as in the comparable study by Thu et al. (1997), could be subject to reporting bias because residents may simply want to provide negative responses to the pork industry. However, if that is the case, then it is extremely difficult to explain the highly selective nature of reported symptoms and the fact that participants chose not to report elevated rates of all symptoms when given the opportunity. That did not occur in either the Thu et al. (1997) study or the Wing and Wolf (2000) research. Indeed, in the Wing and Wolf research, many of the reported symptoms were similar in all three of their research groups in North Carolina. Second, the configuration of reported symptoms is consistent with well–documented symptoms among swine confinement workers. It appears highly unlikely that two groups of swine CAFO neighbors would stumble upon a consistent set of symptoms that match symptoms among swine confinement workers.

Further evidence for health problems among swine CAFO neighbors comes from the Bureau of Epidemiology within the Utah Department of Health (Keller and Ball, 2000). In 1993, one of the largest hog operations in the country began construction near the town of Milford (population 1,305) in Beaver County, southern Utah. In the following two years, the facility was populated with pigs whose sow base reached 44,000 (with a reported target of 120,000 total sows). At the request of the Southwest Utah District Health Department, Utah's Bureau of Epidemiology responded to concerns about increases in diarrheal and respiratory disease among nearby Milford residents. A retrospective study of hospital discharge records from nearby Milford was compared with two comparison populations in the region, in addition to statewide averages for Utah as a whole. The investigation examined whether hospital discharge records from Milford indicated higher rates of respiratory and diarrheal illness during the years 1992 to 1998 (when the swine CAFO was constructed and became operational) compared to other communities in the region and the state as a whole. The findings demonstrated an increase in both diarrheal and respiratory illness cases in Milford during the period from 1992 to 1998 when the swine CAFO became operational. For example, Milford experienced a quadrupling of hospital diarrheal case rates, from 88 per 10,000 in 1992, to 409 per 10,000 in 1997. During the same period, Milford reflected a tripling of hospital cases involving respiratory illness, from 159 cases per 10,000 in 1992, to 517 cases per 10,000 in 1997. Moreover, the

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incidence rates were significantly higher than those found in comparison populations and in the state as a whole, leading the authors to conclude: "The results of this investigation found evidence that suggests elevated incidence of diarrheal and respiratory illness in Milford as compared to Parowan, Panuitch, and the State of Utah during the time period of 1992 through 1998" (Keller and Ball, 2000, p. 7). The investigators do not ascribe causation to the neighboring swine CAFO, but the implication is clear.

The evidence is mounting that a public health problem appears to be present for not only swine confinement workers but for neighbors of swine CAFOs as well (Thu, 1998). These studies, as well as federal and state reports, independently and consistently show that neighbors, including farmer neighbors, of large-scale swine production are experiencing abnormally high rates of health problems compared with other populations. Moreover, the health symptoms experienced by neighbors are consistent with, and similar to, the types of health symptoms that have been well documented among interior confinement workers. However, in contrast to occupational health research among CAFO workers, comparable exposure studies investigating potential toxicants and their relationship to neighbor health problems are notably lacking.

There are clues from the occupational health literature, the odor research, and investigations in other industries that suggest the direction for future human exposure research. Among the airborne elements to examine are hydrogen sulfide, volatile organic compounds (VOCs), dusts, endotoxin, and perhaps ammonia, in addition to the irritant dimension of odors (see Reynolds et al., 1997). It should be noted that many of these ingredients have an interactive and synergistic effect, such as gas molecules attaching to dust particles.

While the likely culprit is some combination of emission constituents, exposure to hydrogen sulfide merits particularly attention. Hydrogen sulfide is a known toxic gas produced by the anaerobic digestion of protein in swine CAFOs. Chronic or acute occupational exposure to hydrogen sulfide concentrations near or above 500 ppm is known to result in Acute Respiratory Distress Syndrome (ARDS) or pulmonary edema among swine confinement workers, which can be fatal. However, less attention has been devoted to examining the consequences of longer-term exposure to low levels of hydrogen sulfide. In the oil refinery industry, exposure to low levels of hydrogen sulfide produces symptoms such as shortness of breath, headache, eye irritation, small-airway obstruction, and diarrhea (Kilburn and Warshaw, 1995). Moreover, longer-term exposure to low levels of hydrogen sulfide can result in permanent neurological dysfunction with accompanying physiological damage (Kilburn, 1993, 1997). This threat has resulted in six states establishing hydrogen sulfide or reduced sulfur standards. Hydrogen sulfide monitoring of swine CAFOs in Minnesota by the Minnesota Pollution Control Agency (MPCA) confirms the relevance of research on chronic exposure to low levels of hydrogen sulfide (Sullivan, 1999). The MPCA data reveal that swine CAFOs can emit hydrogen sulfide onto neighboring property at levels that exceed World Health Organization recommended standards (Roth, 1993). Moreover, recent work prepared in conjunction with Minnesota policy planning provides a comprehensive review of livestock emission constituents and their potential human health consequences (Earth Tech, Inc., 2001).

Discussion

The decade following the release of "Agriculture at Risk: A Report to the Nation" (Merchant et al., 1989) witnessed a dramatic change in the structure of the livestock industry, particularly the swine sector. The rapid industrialization of pork production produced a generation of confined production facilities at a scale never before experienced in the U.S. The enormous size of these operations has given rise to the necessity of moving beyond a traditional odor–based research paradigm and toward a more encompassing public health research paradigm. Nearly three decades of research on the interior environment of swine CAFOs and the well–documented exposure consequences for confinement workers provide important direction for research on external emissions to better understand the health consequences for CAFO neighbors. Recent research and results from federally sponsored scientific symposia consistently indicate that neighbors of swine CAFOs can experience health problems at significantly higher rates than controlled comparison populations. Moreover, such problems can be created by several different CAFO emission constituents acting alone or synergistically. It should be noted that odor is but one component of emissions and can both create problems by itself and act as a marker for the presence of irritant toxins. Symptoms experienced by swine CAFO neighbors are generally oriented toward irritation of the respiratory tract and are consistent with the types of symptoms that have been well documented among swine confinement workers. However, additional exposure assessment research is required to elucidate the relationship of reported symptoms among swine CAFO neighbors and emissions from CAFOs.

Research is currently underway and progress is being made toward identifying emission elements potentially responsible for health problems. However, much research continues to be technically focused, with lesser attention on the people involved, particularly from the neighbors' standpoint. Many of these issues involve rural quality of life expectations and considerations that can and should be investigated in concert with technical research. Indeed, common law nuisance and state air pollution statutes may focus more directly on the experiences, expectations, and quality of life norms of neighbors than technical measurements of various emission constituents. Hence, we need not only additional epidemiological and exposure assessment research, we also need additional anthropological and social science research to more fully understand quality of life norms and expectations among rural residents.

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Original Investigation

High-Density Livestock Operations, Crop Field Application of Manure, and Risk of Community-Associated Methicillin-Resistant *Staphylococcus aureus* Infection in Pennsylvania

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IMPORTANCE Nearly 80% of antibiotics in the United States are sold for use in livestock feeds. The manure produced by these animals contains antibiotic-resistant bacteria, resistance genes, and antibiotics and is subsequently applied to crop fields, where it may put community members at risk for antibiotic-resistant infections.

OBJECTIVE To assess the association between individual exposure to swine and dairy/veal industrial agriculture and risk of methicillin-resistant *Staphylococcus aureus* (MRSA) infection.

DESIGN, SETTING, AND PARTICIPANTS A population-based, nested case-control study of primary care patients from a single health care system in Pennsylvania from 2005 to 2010. Incident MRSA cases were identified using electronic health records, classified as community-associated MRSA or health care–associated MRSA, and frequency matched to randomly selected controls and patients with skin and soft-tissue infection. Nutrient management plans were used to create 2 exposure variables: seasonal crop field manure application and number of livestock animals at the operation. In a substudy, we collected 200 isolates from patients stratified by location of diagnosis and proximity to livestock operations.

MAIN OUTCOMES AND MEASURES Community-associated MRSA, health care–associated MRSA, and skin and soft-tissue infection status (with no history of MRSA) compared with controls.

RESULTS From a total population of 446 480 patients, 1539 community-associated MRSA, 1335 health care-associated MRSA, 2895 skin and soft-tissue infection cases, and 2914 controls were included. After adjustment for MRSA risk factors, the highest quartile of swine crop field exposure was significantly associated with community-associated MRSA, health care-associated MRSA, and skin and soft-tissue infection case status (adjusted odds ratios, 1.38 [95% CI, 1.13-1.69], 1.30 [95% CI, 1.05-1.61], and 1.37 [95% CI, 1.18-1.60], respectively); and there was a trend of increasing odds across quartiles for each outcome ($P \leq .01$ for trend in all comparisons). There were similar but weaker associations of swine operations with community-associated MRSA and skin and soft-tissue infection. Molecular testing of 200 isolates identified 31 unique *spa* types, none of which corresponded to CC398 (clonal complex 398), but some have been previously found in swine.

CONCLUSIONS AND RELEVANCE Proximity to swine manure application to crop fields and livestock operations each was associated with MRSA and skin and soft-tissue infection. These findings contribute to the growing concern about the potential public health impacts of high-density livestock production.

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The US Food and Drug Administration reports that 80% of antibiotics in the United States are used in food animals, mainly to promote growth of livestock in high-density production.[1,2] In this industrial model, thousands of livestock animals are housed together and fed subtherapeutic doses of antimicrobial agents.[3] This can select for antibiotic-resistant bacteria like methicillin-resistant *Staphylococcus aureus* (MRSA).[4] About 75% of administered antibiotics are not absorbed by the animal and end up in manure.[5] In addition to antibiotics, antibiotic-resistant bacteria and resistance genes have been isolated from manure and are known to persist in the environment.[6] Application of manure to crop fields close to human dwellings may lead to increased risk of antibiotic-resistant infections.[7]

High prevalence of MRSA colonization among pig farmers was first noted in the Netherlands in 2005.[8] Transmission of MRSA among cows, calves, and humans has also been reported.[9,10] A US study reported that 45% of swine workers were colonized, which is 30 times the national average.[11,12] Few studies have assessed risk of MRSA infection. A Danish case-control study (21 cases) found that living or working on a farm was a risk factor for MRSA infection.[13] Other studies of MRSA infection have described the spread of infection within pig farming families.[14,15] To our knowledge, the impact of proximity to high-density livestock production on risk of MRSA infection has not been evaluated. Two studies assessed community livestock density and found no association with MRSA colonization.[16,17] Most studies have implicated clonal complex 398 (CC398) as the most common variant harbored by swine.[9,12-15,17,18]

In the United States, community-associated MRSA (CA-MRSA) now accounts for more than half of all noninvasive MRSA infections.[19-22] CA-MRSA often occurs as a skin and soft-tissue infection (SSTI) in young, otherwise healthy individuals who lack common health care risk factors.[23-25] In contrast, health care-associated MRSA (HA-MRSA) generally occurs in older individuals with comorbidities. Now, the epidemiology and microbiology of 2 epidemics previously considered distinct are merging.[26-28]

The possible contribution of high-density livestock production to these epidemics has been inadequately studied.[29] US data are needed to evaluate which livestock species pose risk, what aspects of the operations and manure handling are involved, and the magnitude of the risk. We conducted a population-based, nested case-control study using electronic health record (EHR) data from the Geisinger Health System, an integrated health services organization with 4 hospitals and 41 outpatient clinics. We evaluated residential proximity to swine and dairy/veal high-density livestock operations and manure-applied crop fields in relation to CA-MRSA, HA-MRSA, and SSTI (without a history of MRSA infection or colonization) case status.

Methods

Data Sources

To select cases and controls, we used EHR data from January 1, 2005, to February 9, 2010, from 446 480 patients with a Geisinger primary care provider. Geisinger's primary care patients represent the general population in the region.[30] The study area comprised the health system's primary care market and bordering counties totaling 38 counties in Pennsylvania (Figure 1); approximately 3.8 million people resided in these counties according to the 2000 US Census. The study was approved by institutional review boards at the Geisinger Health System and the Johns Hopkins Bloomberg School of Public Health.

Pennsylvania Act 38 of 2005 requires high-density livestock operations to develop and implement nutrient management plans (NMPs) for manure handling. We defined *high-density livestock operations* as agricultural operations where animal density exceeded 2 animal equivalent units (AEUs, 1000 pounds of live weight) per acre and where total AEUs exceeded 8; or operations that exceeded 300 AEUs. When livestock operations have insufficient land for manure application, manure is exported to other areas and applied to crop fields. We focused on swine and dairy/veal operations because of previously identified links with MRSA.[8-10,13-15] The NMPs provided data on livestock operation location, animal type, livestock quantity (AEUs), amount of manure applied to crop fields by season, and crop field area and location. We obtained NMPs from the Pennsylvania Department of Environmental Protection and County Conservation Districts.

Case Ascertainment and Control Selection

Incident MRSA cases were identified primarily using laboratory cultures and secondarily by diagnosis codes (eg, *International Classification of Diseases, Ninth Revision* [*ICD-9*]) that indicated MRSA infection, as previously described.[22] Cases were then classified as either CA-MRSA or HA-MRSA based on presence of health care risk factors (eg, hospitalization, surgery, dialysis, nursing home residence, indwelling device)[22,31] or diagnosis more than 2 days after hospital admission using *ICD-9* codes[21,23,32] and *Current Procedural Terminology* codes. We then randomly selected patients with SSTI but no history of MRSA using 29 *ICD-9* codes (eg, carbuncle, furuncle, abscess)[22] and controls with no history of MRSA, and we frequency matched both groups with case patients by age (0-6, 7-18, 19-45, 46-62, 62-74, ≥75 years), sex, and diagnosis or an outpatient encounter in the same year as MRSA diagnosis. The SSTI cases were evaluated as a separate case group because some SSTIs occurring during the study period were likely to have been caused by MRSA but not diagnosed as such, and high-density livestock production could cause SSTIs from other bacteria. Therefore, we selected patients with SSTIs without reference to any specific pathogen. If a control had multiple outpatient encounters during the year, a single encounter was randomly selected as the date for exposure assignment.

Geographic Location of Patients, Livestock Operation, and Crop Fields

We identified the latitude and longitude of patient addresses using ArcGIS, version 10 (Esri),[33] and calculated MRSA rates by community (Figure 1). The latitude and lon-

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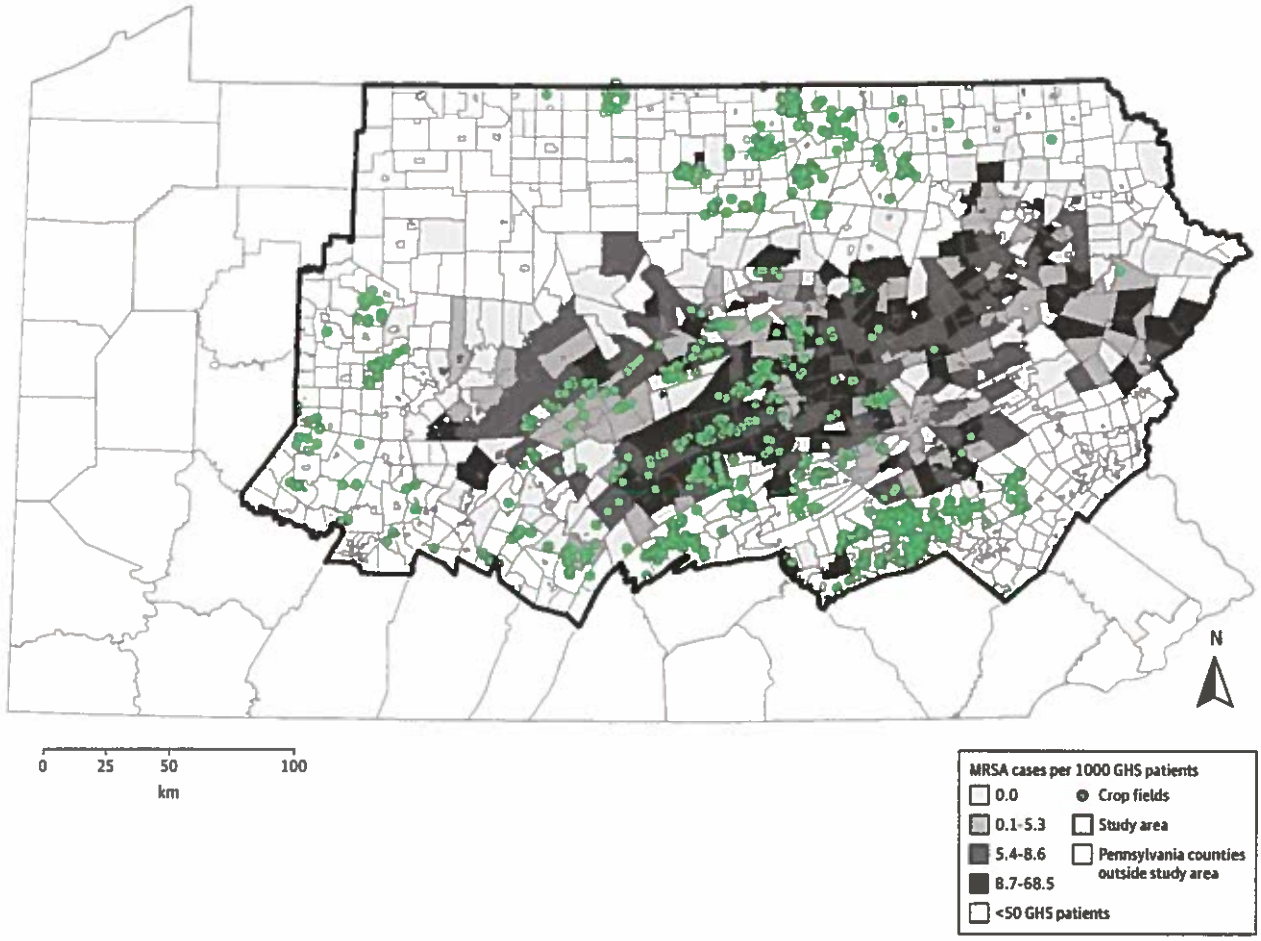
Figure 1. Crop Field Locations and Methicillin-Resistant *Staphylococcus aureus* (MRSA) Rates



Crop field locations and rates of MRSA per 1000 Geisinger Health System (GHS) primary care patients in townships, boroughs, and cities. Rates in communities with fewer than 50 GHS patients were not estimated. The map demonstrates that crop fields were often located in areas with a range of human population densities.

gitude of livestock operation addresses were located using Google Earth with visual confirmation of the presence of a barn at the address. Three different methods were used to locate crop fields because 131 fields (17.3%) were missing address data (**Figure 2**). In the absence of an address, we used the county and community of the field from the NMP to locate the crop field.

Exposure Assessment

We estimated each individual's exposure to livestock operations and to manure-applied crop fields, for swine and dairy/veal, using an inverse distance-squared approach[34] in R, version 2.14.2 (R Foundation for Statistical Computing). For livestock operations, we used the equation

$$\text{Exposure for patient j} = \sum_{i=1}^{n} \frac{a_i}{d_{ij}^2}$$

where n is the number of operations, a_i is AEUs of livestock at operation I, and d_{ij}^2 is the squared distance (in meters) between the operation centroid i and patient j. This resulted in exposure units of AEUs per square meter (m^2). For manure-applied crop fields, we used the equation

$$\text{Exposure for patient j} = \sum_{i=1}^{n} \frac{c_i}{d_{ij}^2}$$

where n is the number of crop fields, c_i is the concentration of manure (gallons per square meter) applied during the season of diagnosis or visit at field i, and d_{ij}^2 is the squared distance (in meters) between the crop field centroid i and patient j. This resulted in exposure units of gallons per quartic meter (m^4). For missing seasonal application data (40% of fields), we used the regional seasonal average. Exposure variables were modeled as quartiles because they were not normally distributed.

Genetic Typing of MRSA Isolates

In a prospective substudy that occurred from January to December 2012, we identified all primary care patients with a culture-confirmed MRSA infection. We then randomly selected isolates from patients stratified by location of diagnosis (in-

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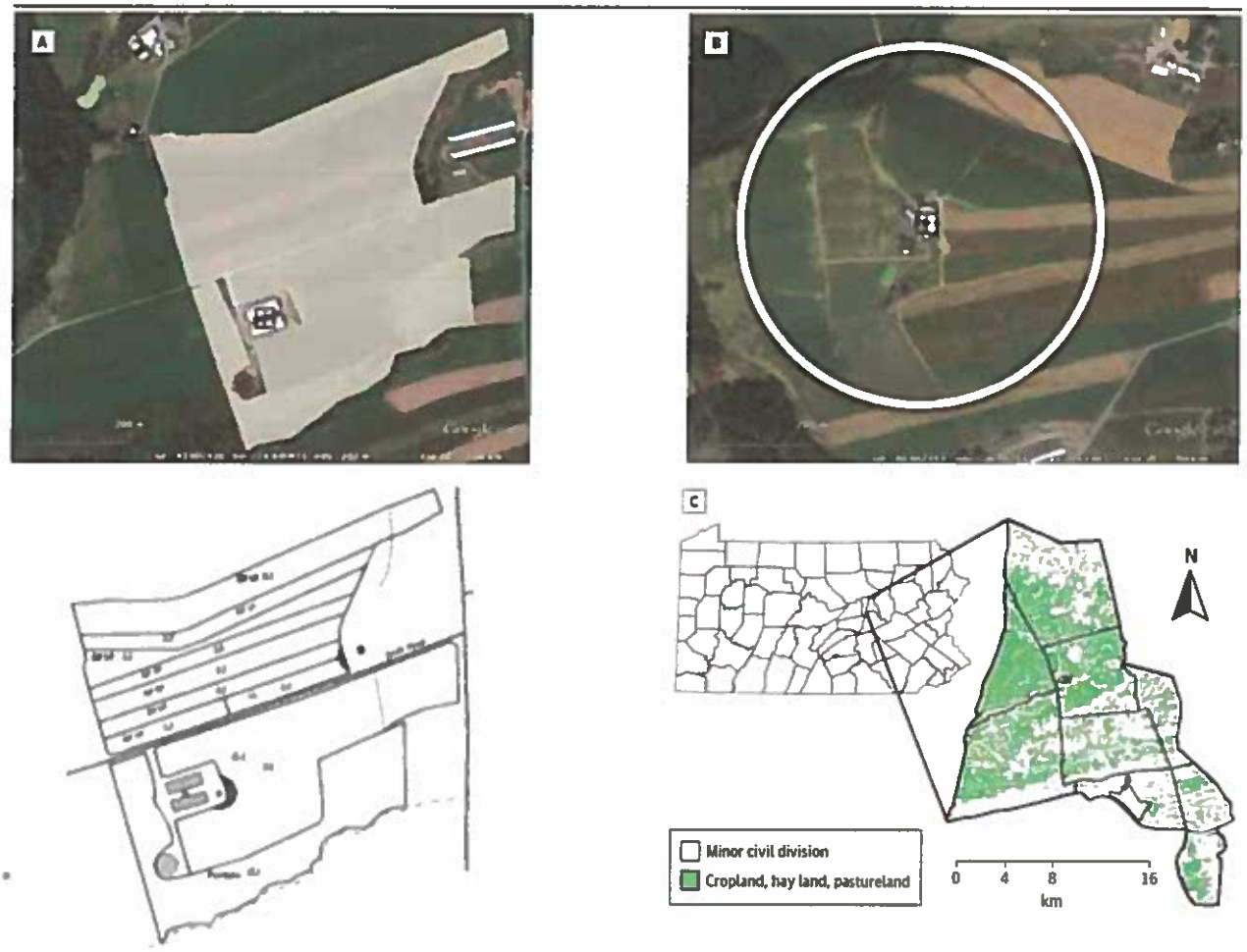
Figure 2. Three Methods Used to Identify and Locate Crop Fields



A, Aerial photograph (top) or map (bottom) were located using Google Earth (n = 135). B, Operation addresses known and located using ArcGIS, version 10 (Esri) (n = 420). C, County and township known and addresses were located by identifying cropland, hay land, and pastureland on a land use map and randomly selecting a point within the eligible land use types (n = 131).

patient or outpatient) and presence or absence of a livestock operation or crop field in their zip code of residence. We oversampled outpatient isolates from zip codes with high-density livestock production. All isolates were characterized by DNA sequence analysis of the protein A gene variable repeat region (*spa* typing).[35] The *spa* types were also assigned a Ridom StaphType, using the Ridom SpaServer database (available at http://www.spaserver.ridom.de).[36] Panton-Valentine leukocidin (*PVL*) genes were detected by polymerase chain reaction.[37]

Statistical Analysis

To compare the 4 study groups, we used Kruskal-Wallis tests for comparisons of means and χ^2 tests for comparisons of proportions. We used multilevel multinomial (2 MRSA groups and controls) and multilevel logistic regression (SSTI cases and controls) to assess the association between exposure and case status. We adjusted models for predictors obtained from the EHR: age, sex, race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, and other); ever-smoking status using *ICD*-9 codes[22]; antibiotic order in the 2 years preceding diagnosis; and Medical Assistance for health insurance, residential community (city, borough, or township), and community socioeconomic deprivation.[33] *Medical Assistance* is a means-tested program, which we used as a surrogate indicator for low socioeconomic status.[38,39] It was identified for each encounter by 1 of 24 codes and modeled as ever received (if received for >2 encounters) vs never received. The livestock operation model was additionally adjusted for season of infection or visit. Final models were selected based on associations reported in our group's earlier article,[22] and adequate model fit was confirmed using Pearson goodness-of-fit tests and likelihood ratio tests. Semivariograms were used to determine that spatial autocorrelation did not account for the results.[40] We used a 2-sided type 1 error rate of 0.05 as the threshold for statistical significance and made no adjustments for multiple comparisons. Logistic and multinomial logistic regression analyses were completed using Stata statistical software version 11.2 (StataCorp Inc) and the GLLAMM program (www.gllamm.org).

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We calculated population attributable fraction (PAF) for CA-MRSA and SSTI cases by using the adjusted odds ratios (AORs) for the third and fourth quartile of crop field swine manure exposure obtained from the final multivariable logistic regression model using the formula PAF = (AOR - 1)/AOR × (proportion of cases exposed to risk factor).[41] The PAF for the third and fourth quartiles were summed to calculate the final PAF. Confidence intervals were computed using the delta method with the postestimation command *nlcom* in Stata.

We performed several sensitivity analyses. First, we evaluated 2 other time windows for crop field manure exposures: a 1-year and a 30-day window before either the date of MRSA diagnosis or the date of a preceding SSTI diagnosis. Second, models were repeated using different methods to identify crop fields (Figure 2). Third, we evaluated effect modification by community type and season. Fourth, analysis was performed to evaluate whether distance to nearest crop field, independent of manure application, was associated with disease outcomes. Finally, we repeated analyses using only culture-confirmed MRSA cases.

Results

Patients, Farms, and Crop Fields Included in the Study

A total of 1734 CA-MRSA and 1519 HA-MRSA cases were identified between January 2005 and February 2010. Most cases (72.3%) were identified by a positive MRSA culture. We frequency matched 3336 SSTIs and 3336 controls to the cases. Of the 9925 patients, we were able to identify latitude and longitude coordinates for home addresses for 87.5%. Thirty-one patients (0.35%) were excluded because they did not reside in counties for which we collected NMPs. This resulted in a total of 1539 CA-MRSA, 1335 HA-MRSA, and 2895 SSTI cases and 2914 controls with residences in 32 counties and 574 communities defined by *minor civil divisions*, ie, census-designated divisions of a county.

We collected NMPs and identified the location of 326 high-density livestock operations, 123 swine and 203 dairy/veal operations, in 27 counties and 168 townships. Ninety-eight of the swine operations (79.7%) and 71 of the dairy/veal farms (35.0%) exported at least a portion of their manure to a total of 424 crop fields. Crop fields were located in 29 counties, 8 boroughs, and 218 townships, for an average of 3.4 crop fields per township. A reported 637 266 595 gallons of manure was applied to crop fields annually. Among those in the highest quartiles of swine livestock operation exposure and swine crop field manure exposure, the median (IQR) distance to the nearest farm or field was 4.6 km (3.1-6.7 km) and 4.0 km (2.6-7.5 km), respectively. The Pearson *r* correlation between the individual-level exposure assignments from the 2 models was 0.59 (both log transformed).

Demographic Characteristics of Cases and Controls

There were no differences in demographic characteristics between patients included in the study and those excluded because we could not map their home address (n = 1211), except that patients with SSTIs who were included were significantly more likely to have ever smoked than were those who were excluded (eTable 1 in the Supplement). Compared with controls, patients in the CA-MRSA group were significantly younger; they were more likely to be black, to smoke, and to receive Medical Assistance; and they lived in communities with greater socioeconomic deprivation (Table 1). White race/ethnicity (95.3% of the study population) was associated with higher levels of swine and dairy/veal crop field manure exposure (Table 2). Exposures to manure were also the lowest among those who had not received an antibiotic prescription in the 2 years prior to diagnosis or visit, those who had received Medical Assistance, and those residing in cities.

Association of Crop Field Manure Exposure With Case Status

After adjusting for potential confounding variables, we found a significantly increased odds of CA-MRSA, HA-MRSA, and SSTI with higher swine manure exposure (fourth vs first quartile AORs, 1.38 [95% CI, 1.13-1.68], 1.30 [95% CI, 1.05-1.61], and 1.37 [95% CI, 1.18-1.60], respectively; $P = .01$, $P < .001$, and $P < .001$ for trend, respectively) (Table 3). The fourth quartile (vs first quartile) of dairy/veal exposure was also associated with increased odds of CA-MRSA (AOR, 1.24 [95% CI, 1.01-1.52]). The PAFs (95% CI) for the highest 2 quartiles of swine crop field manure exposure for CA-MRSA infection and SSTI were 10.7% (5.0-16.4%) and 11.5% (7.0-16.0%), respectively.

Association of High-Density Livestock Operations With Case Status

The fourth quartile vs first quartile of swine livestock operation exposure was associated with increased odds of CA-MRSA and SSTI (AORs, 1.25 [95% CI, 0.99-1.58] and 1.27 [95% CI, 1.08-1.50], respectively; $P = .04$ and $P = .002$, respectively) but not HA-MRSA (Table 3). No associations were seen with dairy/veal operations. Receipt of Medical Assistance remained independently associated with MRSA and SSTI outcomes in all adjusted analyses.

MRSA Isolate Substudy

A total of 200 isolates were randomly selected from 1128 patients with isolates (Table 4). Of these, 133 (66.5%) were common community strains (*spa* types t008, t024, t064, t206, t211); 33 (16.5%) were common health care strains (t002, t010, t062, t105); and the remainder were divided among 22 additional types. Notably, none was a *spa* type associated with CC398. A total of 27 community-onset isolates were *PVL*-negative.

Sensitivity Analyses

Evaluation of the 2 other time windows for manure application revealed slightly attenuated but otherwise similar results, except in the case of annual dairy/veal exposure, where the association strengthened for both CA-MRSA and SSTI cases (fourth vs first quartile AORs, 1.41 [95% CI, 1.13-1.77] and 1.26 [95% CI 1.08-1.48], respectively; $P = .01$ and $P = .02$, respectively) (eTable 2 in the Supplement). Exclusion of crop fields without aerial photographs and/or addresses, including interaction terms for community type

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Table 1. Patient Demographic and Clinical Characteristics

Characteristic	Study Participants, No. (%)			
	CA-MRSA (n = 1539)	HA-MRSA (n = 1335)	SSTI With No History of MRSA (n = 2895)[a]	Control (n = 2914)
Male	715 (46.5)	673 (50.4)	1412 (48.8)	1430 (49.1)
Age at infection or visit, median (IQR), y	23.5 (10-47)[b]	60.9 (39-77)[b]	41.5 (16-66)	41.9 (16-66)
Race/ethnicity[c]				
Non-Hispanic white	1446 (94.0)	1285 (96.5)	2772 (95.8)	2770 (95.1)
Non-Hispanic Black	49 (3.2)[d]	26 (2.0)	46 (1.6)	57 (2.0)
Hispanic	31 (2.0)	13 (1.0)[d]	52 (1.8)	52 (1.8)
Other	13 (0.8)	7 (0.5)[d]	25 (0.9)	34 (1.2)
Smoking[e]				
Never	1288 (83.7)[b]	952 (71.3)[b]	2334 (80.6)[b]	2649 (90.9)
Season of onset[f]				
Winter	352 (22.9)[g]	327 (24.5)	683 (23.6)[g]	786 (27.0)
Spring	269 (17.5)[b]	292 (21.9)	646 (22.3)	702 (24.1)
Summer	412 (26.8)[d]	342 (25.6)	819 (28.3)[b]	686 (23.5)
Fall	506 (32.9)[b]	374 (28.0)	747 (25.8)	740 (25.4)
Any antibiotic prescription in 2 years prior[h]	1125 (73.1)[b]	1024 (76.7)[b]	2018 (69.7)[b]	1499 (51.4)
Medical assistance[i]				
Never	1056 (68.6)[b]	1067 (79.9)[g]	2307 (79.7)[b]	2450 (84.1)
Community type				
City	250 (16.2)[b]	238 (17.8)[b]	371 (12.8)[d]	316 (10.8)
Borough	550 (35.7)[b]	393 (29.4)	870 (30.1)	839 (28.8)
Township	739 (48.0)[b]	704 (52.7)[b]	1654 (57.1)[d]	1759 (60.4)
Community socioeconomic deprivation[j]				
Quartile 1	347 (22.6)[b]	269 (20.1)[b]	723 (25.0)[g]	835 (28.7)
Quartile 2	392 (25.5)	316 (23.6)	741 (25.6)	725 (24.9)
Quartile 3	395 (25.7)	361 (27.0)[d]	722 (24.9)	691 (23.7)
Quartile 4	405 (26.3)[c]	389 (29.1)[b]	709 (24.5)	663 (22.8)

Abbreviations: CA-MRSA, community-associated methicillin-resistant *Staphylococcus aureus*; *CPT*, *Current Procedural Terminology*; HA-MRSA, health care-associated MRSA; *ICD-9*, *International Classification of Diseases, Ninth Revision*; IQR, interquartile range; SSTI, skin and soft-tissue infection.

[a] Based on 29 *ICD-9* codes: 680.0-680.9, 681.00-681.02, 681.9-681.11, 682.0-682.9, 035, 684, and 686.9.

[b] $P < .001$ vs control.

[c] Race/ethnicity was missing for 4 HA-MRSA cases and 1 control.

[d] $P < .05$ vs control.

[e] Based on presence of *ICD-9* codes 305.1 (tobacco use disorder), V15.82 (history of tobacco use), or 649.0 (tobacco use complicating pregnancy) or *CPT* codes 99406 or 99407 (smoking cessation counseling).

[f] Spring, March through May; summer, June through August; fall, September through November; and winter, December through February.

[g] $P < .01$ vs control.

[h] Indicates receipt of antibiotic prescription in the 730 to 14 days prior to diagnosis or visit.

[i] Based on the health insurance carrier for each encounter; identified with 24 separate codes, and "ever" was defined as more than 2 encounters with Medical Assistance.

[j] Community socioeconomic deprivation was assigned at the township, borough, or census tract level and was based on 6 indicators (all percentages) derived from US Census 2000 data: combined less than high school education, not in the labor force, in poverty, on public assistance, civilian unemployment, and does not own a car; a higher score represents a more deprived community; quartile 1 values, less than −2.22; quartile 2 values −2.23 through 0.46; quartile 3 values, 0.47 through 3.05; and quartile 4 values 3.06 or greater.

or season, and restricting analysis to culture-confirmed MRSA cases did not alter results. Distance to nearest crop field, independent of manure application, was not associated with MRSA or SSTI.

Discussion

High-density swine production was an independent risk factor for CA-MRSA and HA-MRSA infection and SSTI in patients without a history of MRSA. There was evidence that both a crop field manure application model that incorporated distance, swine manure volume, season of application, and field area, as well as a livestock operation model that incorporated distance and swine count, were each associated with increased risk of infection. Exposure assignments from these 2 models were moderately correlated, suggesting 2 independent sources of risk. Furthermore, while livestock operations are easily identifiable and fixed, manure-applied crop fields are not necessarily easily identifiable, are scattered, and may change from year to year. Associations with dairy/veal operations were less consistent and weaker than those for swine operations, which

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Table 2. Characteristics of CA-MRSA Group by Crop Field Manure Exposure Quartiles (n=1539)

Characteristic	Individual Seasonal Crop Field Exposure, gal/m⁴, No. (%)									
	Swine Quartiles[a]					Dairy/Veal Quartiles[b]				
	1	2	3	4	P Value[c]	1	2	3	4	P Value[c]
Sex										
Female	185 (51.0)	217 (55.8)	205 (54.1)	217 (53.2)	.61	176 (49.3)	206 (56.1)	203 (55.2)	239 (53.5)	.27
Male	178 (49.0)	172 (44.2)	174 (45.9)	191 (46.8)		181 (50.7)	161 (43.9)	165 (44.8)	208 (46.5)	
Race/ethnicity										
Non-Hispanic white	336 (92.6)	353 (90.8)	367 (96.8)	390 (95.6)	<.001	322 (90.2)	347 (94.6)	345 (93.8)	432 (96.6)	.005
Non-Hispanic black	17 (4.7)	18 (4.6)	5 (1.3)	9 (2.2)		21 (5.9)	9 (2.5)	8 (2.2)	11 (2.5)	
Hispanic	6 (1.7)	17 (4.4)	5 (1.3)	3 (0.7)		11 (3.1)	9 (2.5)	9 (2.5)	2 (0.5)	
Other	4 (1.1)	1 (0.3)	2 (0.5)	6 (1.5)		3 (0.8)	2 (0.5)	6 (1.6)	2 (0.5)	
Smoking[d]										
Never	291 (80.2)	326 (83.8)	320 (84.4)	351 (86.0)	.17	303 (84.9)	308 (83.9)	296 (80.4)	381 (85.2)	.26
Ever	72 (19.8)	63 (16.2)	59 (15.6)	57 (14.0)		54 (15.1)	59 (16.1)	72 (19.6)	66 (14.8)	
Age group, y										
<25	174 (47.9)	216 (55.5)	186 (49.1)	217 (53.2)	.13	198 (55.5)	187 (51.0)	198 (53.8)	210 (47.0)	.08
≥25	189 (52.1)	173 (44.5)	193 (50.9)	191 (46.8)		159 (44.5)	180 (49.1)	170 (46.2)	237 (53.0)	
Antibiotic order in prior 2 years										
No	108 (29.8)	120 (30.9)	102 (26.9)	84 (20.6)	.005	115 (32.2)	108 (29.4)	92 (25.0)	99 (22.2)	.007
Yes	255 (70.3)	269 (69.2)	277 (73.1)	324 (79.4)		242 (67.8)	259 (70.6)	276 (75.0)	348 (77.9)	
Medical Assistance[e]										
Never	245 (67.5)	246 (63.2)	278 (73.4)	287 (70.3)	.02	235 (65.8)	260 (70.8)	239 (65.0)	322 (72.0)	.08
Ever	118 (32.5)	143 (36.8)	101 (26.7)	121 (29.7)		122 (34.2)	107 (29.2)	129 (35.1)	125 (28.0)	
Community										
City	90 (24.8)	75 (19.3)	53 (14.0)	32 (7.8)	<.001	75 (21.0)	66 (18.0)	66 (17.9)	43 (9.6)	<.001
Borough	121 (33.3)	151 (38.8)	131 (34.6)	147 (36.0)		136 (38.1)	123 (33.5)	153 (41.6)	138 (30.9)	
Township	152 (41.9)	163 (41.9)	195 (51.5)	229 (56.1)		146 (40.9)	178 (48.5)	149 (40.5)	266 (59.5)	
Community socioeconomic deprivation[f]										
Quartile 1	75 (20.7)	64 (16.5)	105 (27.7)	103 (25.3)	.001	61 (17.1)	93 (25.3)	74 (20.1)	119 (26.6)	<.001
Quartile 2	99 (27.3)	91 (23.4)	95 (25.1)	107 (26.2)		73 (20.5)	99 (27.0)	84 (22.8)	136 (30.4)	
Quartile 3	108 (29.8)	117 (30.1)	83 (21.9)	87 (21.3)		111 (31.1)	90 (24.5)	95 (25.8)	99 (22.2)	
Quartile 4	81 (22.3)	117 (30.1)	96 (25.3)	111 (27.2)		112 (31.4)	85 (23.2)	115 (31.3)	93 (20.8)	

Abbreviations: CA-MRSA, community-associated methicillin-resistant *Staphylococcus aureus*; *CPT*, *Current Procedural Terminology*; *ICD-9*, *International Classification of Diseases, Ninth Revision*; IQR, interquartile range; m⁴, quartic meters; SSTI, skin and soft-tissue infection.

[a] Quartile 1 values, less than 7549 gal/m²/km²; quartile 2 values, 7650 through 18 846 gal/m²/km²; quartile 3 values, 18 847 through 39 047 gal/m²/km²; quartile 4 values, 39048 gal/m²/km² or greater.

[b] Quartile 1 values, less than 29 205 gal/m²/km²; quartile 2 values, 29 206 through 60 623 gal/m²/km²; quartile 3 values, 60 624-104 717 gal/m²/km²; quartile 4 values, 104 718 gal/m²/km² or greater.

[c] Calculated using χ^2 test.

[d] Based on presence of *ICD-9* codes 305.1 (tobacco use disorder), V15.82 (history of tobacco use), or 649.0 (tobacco use complicating pregnancy) or *CPT* codes 99406 or 99407 (smoking cessation counseling).

[e] Based on the health insurance carrier for each encounter; identified with 24 separate codes, and "ever" was defined as more than 2 encounters with Medical Assistance.

[f] Community socioeconomic deprivation was assigned at the township, borough, or census tract level and was based on 6 indicators (all percentages) derived from US Census 2000 data: combined less than high school education, not in the labor force, in poverty, on public assistance, civilian unemployment, and does not own a car; a higher score represents a more deprived community; quartile 1 values, less than −2.22; quartile 2 values, −2.23 through 0.46; quartile 3 values, 0.47 through 3.05; quartile 4 values, 3.06 or higher.

was not surprising, given the limited number studies on the topic. Our data also suggest that approximately 11% of CA-MRSA and SSTI cases in the study population could be attributed to crop field application of swine manure.

The association with SSTIs is notable because there were more than 50 000 such cases, compared with 4000 MRSA cases, in the region since 2001.[22] Crop field manure application may lead to SSTI either by causing MRSA infection that goes undiagnosed as such or by exposure to other bacteria that cause SSTI. We cannot attribute these infections to any single pathogen. Subanalysis of 258 SSTI cases (9%) identified from culture data as methicillin-susceptible *S aureus* (MSSA) revealed an association with swine livestock exposure (AOR, 1.70 [95% CI, 1.15-2.52]) that was stronger than for all SSTIs together. The public health burden of SSTIs[25,42] warrants future study of links to high-density livestock production. Concerning the association with HA-MRSA, this finding does not imply that livestock-associated strains are in hospitals. Rather, these older patients

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Table 3. Association of Seasonal Crop Field Manure Exposure and Livestock Operation Exposure With CA-MRSA, HA-MRSA, and SSTI From Full Multilevel Multivariate Model[a]

	Odds Ratio (95% CI)					
	CA-MRSA		HA-MRSA		SSTI	
Characteristic	Univariate	Adjusted	Univariate	Adjusted	Univariate	Adjusted
Seasonal Crop Field Manure Exposure						
Swine[b]						
Quartile 1	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
Quartile 2	1.11 (0.93-1.32)	1.09 (0.90-1.31)	1.15 (0.96-1.38)	1.21 (0.98-1.48)	1.03 (0.89-1.20)	1.03 (0.88-1.20)
Quartile 3	1.12 (0.94-1.33)	1.26 (1.04-1.52)	1.09 (0.90-1.31)	1.27 (1.03-1.57)	1.15 (1.00-1.33)	1.22 (1.05-1.41)
Quartile 4	1.34 (1.13-1.60)	1.38 (1.13-1.69)	1.26 (1.05-1.51)	1.30 (1.05-1.61)	1.34 (1.16-1.55)	1.37 (1.18-1.60)
P value[c]	.002	<.001	.04	.01	<.001	<.001
Dairy/veal[d]						
Quartile 1	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
Quartile 2	0.93 (0.78-1.12)	0.95 (0.78-1.16)	0.76 (0.64-0.92)	0.82 (0.67-1.02)	0.90 (0.78-1.04)	0.90 (0.77-1.05)
Quartile 3	0.94 (0.79-1.13)	0.90 (0.74-1.09)	0.94 (0.79-1.12)	0.92 (0.76-1.13)	0.84 (0.72-0.97)	0.85 (0.73-0.99)
Quartile 4	1.25 (1.05-1.48)	1.24 (1.01-1.52)	0.74 (0.62-0.90)	0.78 (0.62-0.98)	1.02 (0.88-1.18)	1.01 (0.87-1.19)
P value[c]	.01	.06	.03	.08	.96	.92
Livestock Operation Exposure						
Swine[e]						
Quartile 1	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
Quartile 2	0.85 (0.72-1.02)	0.96 (0.77-1.20)	0.78 (0.65-0.94)	0.96 (0.76-1.21)	0.91 (0.79-1.06)	1.00 (0.85-1.18)
Quartile 3	0.91 (0.77-1.09)	1.05 (0.84-1.32)	0.83 (0.69-0.99)	0.88 (0.70-1.12)	0.95 (0.82-1.10)	1.05 (0.89-1.23)
Quartile 4	1.03 (0.87-1.23)	1.25 (0.99-1.58)	1.04 (0.87-1.25)	1.18 (0.93-1.50)	1.19 (1.03-1.38)	1.27 (1.08-1.50)
P value[c]	.60	.04	.57	.19	.01	.002
Dairy/veal[f]						
Quartile 1	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
Quartile 2	0.80 (0.67-0.95)	0.90 (0.72-1.12)	0.79 (0.66-0.94)	0.83 (0.66-1.05)	1.02 (0.88-1.18)	1.10 (0.93-1.30)
Quartile 3	1.04 (0.88-1.24)	1.18 (0.94-1.48)	0.95 (0.79-1.13)	1.00 (0.79-1.26)	1.07 (0.92-1.24)	1.17 (0.99-1.39)
Quartile 4	0.86 (0.73-1.03)	1.07 (0.85-1.35)	0.62 (0.52-0.75)	0.80 (0.62-1.02)	0.99 (0.87-1.15)	1.12 (0.95-1.32)
P value[c]	.51	.21	<.001	.24	.97	.18

Abbreviations: AEU, animal equivalent unit; CA-MRSA, community-associated methicillin-resistant *Staphylococcus aureus*; HA-MRSA, health care-associated MRSA; SSTI, skin and soft-tissue infection.

[a] For multinomial models, n = 5783, and for binomial model, n = 5808; crop field model adjusted for sex, age, race/ethnicity, ever-smoking status, antibiotic prescription in the prior 2 years, receipt of Medical Assistance, residential minor civil division, and community socioeconomic deprivation; livestock model further adjusted for season of infection or visit.

[b] Quartile 1 values, less than 7549 gal/m^2/km^2; quartile 2 values, 7650 through 18 846 gal/m^2/km^2; quartile 3 values, 18 847 through 39 047 gal/m^2/km^2; quartile 4 values, 39 048 gal/m^2/km^2 or greater.

[c] *P* value for linear trend (quartiles included as a single variable with values 1, 2, 3, and 4).

[d] Quartile 1 values, less than 29 205 gal/m^2/km^2; quartile 2 values, 29 206 through 60 623 gal/m^2/km^2; quartile 3 values, 60 624 through 104 717 gal/m^2/km^2; quartile 4 values, 104 718 gal/m^2/km^2 or greater.

[e] Quartile 1 values, less than 6.3 AEU/km^2; quartile 2 values, 6.4 through 7.8 AEU/km^2; quartile 3 values, 17.9-34.7 AEU/km^2; quartile 4 values, 34.8 AEU/km^2 or greater.

[f] Quartile 1 values, less than 7.1 AEU/km^2; quartile 2 values, 7.2 through 21.0 AEU/km^2; quartile 3 values, 21.1 through 44.9 AEU/km^2; quartile 4 values, 44.9 AEU/km^2 or greater.

may have been colonized in the community with livestock strains and then had health care contact (eg, hospitalization, surgery, dialysis, indwelling device) before infection.

To our knowledge, no studies have examined the association between high-density livestock operations and MRSA infection in the community, and only 2 studies have assessed risk of colonization.[16,17] Study of colonization may not be useful when evaluating the risk of MRSA infection associated with industrial agriculture because, first, environmental exposure or direct contact may more often lead to CA-MRSA infection than does colonization[43] and second, MRSA colonization may not persist for more than 24 hours after livestock exposure.[44] Prior studies limited their ability to identify risk from high-density livestock exposure by including only patients with CC398,[13,45] by studying only people who lived or worked on farms,[9,12,46-48] and by not including crop field manure exposure.

A unique aspect of this study is the consideration of risk from manure application to crop fields. Sensitivity analyses across time (eg, annual, seasonal, and 30-day exposure) and across space (eg, restricting analysis to fields with aerial photographs or maps) did not substantively change results. Our findings are likely not an artifact of rural residents in the study popu-

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Table 4. Summary of MRSA Genetics

Characteristic	*spa* Types, No. (%)		Other Types, No. (%) (n = 34)[c]	*P* Value
	Community (n = 133)[a]	Healthcare (n = 33)[b]		
Age at infection, median (IQR), y	29 (13-48)	65 (45-77)	46 (14-61)	<.001
Location of onset				
Inpatient[d]	8 (6.0)	20 (60.1)	7 (20.6)	<.001
Outpatient[e]	125 (94.0)	13 (39.9)	27 (79.4)	
Community type				
City	18 (13.5)	1 (3.0)	5 (14.7)	.25
Borough	34 (25.6)	13 (39.4)	12 (35.3)	
Township	81 (60.9)	19 (57.6)	17 (50.0)	
PVL-positive	131 (98.5)	1 (3.0)	17 (50.0)	<.001
Swine operation exposure, fourth quartile[f]	27 (20.3)	10 (30.3)	13 (38.2)	.36

Abbreviations: AEU, animal equivalent unit; IQR, interquartile range; MRSA, methicillin-resistant *Staphylococcus aureus*; *PVL*, Panton-Valentine leukocidin genes.

[a] Includes *spa* types t008 (n = 123), t024 (n = 7), t064, t206, and t211.

[b] Includes *spa* types t002 (n = 27), t105 (n = 3), t010 (n = 2), and t062.

[c] Includes *spa* types t121 (n = 4), novel varieties (n = 3), t088 (n = 3), t622 (n = 3), t045 (n = 2), t068 (n = 2), t012, t125, t216, t304, t306, t316, t437, t539, t681, t692, t856, t948, t1154, t1610, t6614, t9964, and unknown.

[d] Inpatient isolates collected more than 2 days after hospital admission.

[e] Isolates collected in the outpatient setting or within the first 2 days of hospitalization.

[f] Quartile 4 values, 33.4 AEU/km^2 or greater.

lation because, while manure-applied crop fields were associated with risk, residence in a township (where 98.5% of crop fields are located) and distance to nearest crop field independent of manure application were not associated with the 3 outcomes.

Previous studies have used community-level livestock density as a marker of livestock exposure.[16,17,45] We estimated exposure at the individual level, incorporating several features of these operations and fields. Operation and field sites were confirmed using Google Earth rather than physical inspection of the area, which may have led to some misclassification. Additional exposure misclassification may have occurred since the exposure assessment did not capture all smaller farms. In Pennsylvania, only large operations, specifically concentrated animal feeding operations, or operations with greater than 2 AEUs per acre are required to produce NMPs. The 2007 US Census of Agriculture revealed that our exposure models included 89% of swine AEUs present in the study area. Because characteristics of high-density livestock practices differ by and within states, our results may not apply in full to other areas with these operations.

A limitation of this study is that we did not measure how livestock-associated pathogens may reach individuals in a community, but several ways have been considered in prior studies. Aerosolized MRSA has been isolated from the air up to 150 m downwind and from the soil up to 300 m downwind of swine operations.[49,50] Studies have also reported that tetracycline, the most commonly used antimicrobial agent used in food-producing animals in the United States,[1] was found at concentrations sufficient to select for resistant bacteria in both swine manure and manure-fertilized soil.[51] These studies provide biologic plausibility for our findings, but more research is needed to establish sources, media, routes, and behaviors that may lead to infection. Other animals,[52] slaughterhouses,[53] and meat consumption[54] may be involved.

We did not find any *spa* types associated with clonal complex CC398. Most MRSA found on farms or in farmers has been characterized as CC398, though other types have been identified.[9,12,13,45,55,56] However, few studies have assessed MRSA infection, instead focusing on MRSA carriage, and those that do come from Europe[14,15,57,58] and/or deal exclusively with CC398 MRSA.[58-60] The most common strains on US farms are not well known. In Ohio, the closest state to Pennsylvania for which there are data, common health care strains were most often isolated from swine; CC398 was secondary.[53] We were limited in that genetic data did not come from the same time period as the main study, and isolate strains could have changed over time.

We used *ICD-9* codes to classify MRSA cases as CA or HA and to derive the predictor variables used in the analysis. The primary HA epidemiologic factors[31] are well captured by the EHR. Ever-smoking status can also be effectively obtained using *ICD-9* codes.[61] Unfortunately, the EHR did not directly capture data on individual-level socioeconomic status or occupation, so our results could have been due to these variables. To evaluate this potential confounding, we adjusted the final models for 2 surrogates for socioeconomic status: Medical Assistance at the individual level and community socioeconomic deprivation at the community level. As expected, patients with CA-MRSA were more likely to receive Medical Assistance and more likely to live in more deprived communities than controls, associations that persisted in the adjusted models.[62,63] Previous literature has suggested increased prevalence of MRSA colonization in livestock workers.[8] However, given the low prevalence of this employment (1% of population in any agricultural work, according to US Census data) even in townships and boroughs in the study area, it seems unlikely that farming occupation could account for the reported associations. Moreover, inclusion of community-level percentage of agri-

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cultural workers in the multilevel model did not change associations.

In conclusion, proximity to and size of high-density livestock production were associated MRSA infection and SSTI, and the population-attributable fraction of crop field manure application exceeded 10% for CA-MRSA and SSTI. The findings contribute to the growing concern about the potential public health impacts of high-density livestock production.

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Exposure to Pig Farms and Manure Fertilizers Associated with MRSA Infections

Researchers from the Johns Hopkins Bloomberg School of Public Health have for the first time found an association between living in proximity to high-density livestock production and community-acquired infections with methicillin-resistant Staphylococcus aureus, commonly known as MRSA. Their analysis concluded that approximately 11 percent of community-acquired MRSA and soft tissue infections in the study population could be attributed to crop fields fertilized with swine manure. The study is the first to examine the association between high-density livestock operations and manure-applied crop fields and MRSA infections in the community. The results were published online September 16 in *JAMA Internal Medicine*.

According to the U.S. Food and Drug Administration, nearly 80 percent of antibiotics in the United States are sold for use in livestock feeds. The manure produced by these livestock and applied to crop fields contains antibiotic-resistant bacteria, resistance genes, and about 75 percent of the antibiotics consumed by the animals.

For the study, researchers identified patients with MRSA infections and skin and soft tissue infections reported in electronic medical records provided by Geisinger Health System. The two case groups were compared to patients who never had a MRSA infection. Patients received an exposure score based on their distance from the production, the number of animals at livestock operations, the amount of manure spread on crop fields, and the size of the field. The researchers noted that between 2005 and 2010 there were about 3,000 patients with MRSA and 50,000 with skin and soft tissue infections who were diagnosed and treated in the Geisinger Health System.

The cases came from more than 446,000 Pennsylvania residents between 2005 and 2010. The study identified 1,539 cases of community-associated MRSA and 1,335 cases of health-care-associated MRSA. The researchers found a significant association between community-associated MRSA and application of swine manure to crop fields. A similar but weaker association was found between swine operations and community-associated MRSA. No association was found between dairy farms and MRSA infections.

"This is the first study that has linked MRSA infection and skin and soft tissue infections in the community to high-density livestock production. The results require replication, but we believe we have provided additional strong evidence that these livestock practices have important public health consequences," said Joan A. Casey, MA, lead author of the study and doctoral candidate with Bloomberg School's Department of Environmental Health Sciences.

"We had a unique opportunity to evaluate these practices because of our work with the Geisinger Health System. The study shows the utility of electronic health records for demonstrating the unrecognized public health consequences of operations with environmental impacts," said Brian Schwartz, MD, MS, senior author and professor with Bloomberg School's Department of Environmental Health Sciences.

"High-density livestock operations, crop field application of manure, and the risk of community-associated methicillin-resistant Staphylococcus aureus infection in Pennsylvania" was written by Joan A. Casey, MA; Frank Curriero, PhD, MA; Sara E. Cosgrove, MD, MS; Keeve E. Nachman, PhD, MHS; and Brian S. Schwartz, MD, MS.

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The community effects of industrialized farming: Social science research and challenges to corporate farming laws

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Abstract. Social scientists have a long history of concern with the effects of industrialized farming on communities. Recently, the topic has taken on new importance as corporate farming laws in a number of states are challenged by agribusiness interests. Defense of these laws often requires evidence from social science research that industrialized farming poses risks to communities. A problem is that no recent journal articles or books systematically assess the extent to which research to date provides evidence of these risks. This article addresses the gap in the literature. We evaluate studies investigating the effects of industrialized farming on community well-being from the 1930s to the present. Using a pool of 51 studies, we document the research designs employed, evaluate results as to whether adverse consequences were found, and delineate the aspects of community life that may be affected by industrialized farming. Of these studies, 57% found largely detrimental impacts, 25% were mixed, finding some detrimental impacts, and 18% found no detrimental impacts. Adverse impacts were found across an array of indicators measuring socioeconomic conditions, community social fabric, and environmental conditions. Few positive effects of industrialized farming were found across studies. The results demonstrate that public concern about industrialized farms is warranted. Scholars often debate whether research should be oriented around disciplines' accumulated body of knowledge or, conversely, provide critical knowledge in the public interest. Social scientists' long-term engagement in building the body of research on industrialized farming allows for accomplishment of both objectives.

Key words: Agriculture, Corporate farming, Corporate farm laws, Community well-being, Industrialized farming, Communities

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Introduction

Social scientists have long been concerned with the effects of large-scale, industrialized farming on communities. An extensive body of research from the 1930s onward addresses the risks posed to community well-being (Lobao, 1990). This same concern is shared by states and localities particularly in the US farm belt. Nine states in the Midwest and Great Plains have statutes or constitutional provisions that restrict corporations from engaging in farming or from acquiring farm land. Although such laws cannot halt structural change in agriculture, they do control the organizational form of farm operations based on ownership arrangements

(McEowen and Harl, 2006). These laws also serve as a business climate signal, indicating that corporations may need to contend with a more stringent regulatory environment.

Recently, research on industrialized farming has assumed new importance because farm belt states are facing challenges to their corporate farming laws. Global agribusiness firms seeking to move to small, often remote rural communities along with farm organizations representing large, commercial clientele have sought to overturn existing laws. On the other side, state governments, often in alliance with family farm and environmental organizations have defended existing legislation. The clash has become one of "capital versus communities," whereby corporations use the Interstate Commerce Clause in an attempt to override state legislation aimed at protecting family farming and communities (Pittman, 2004). A main defense of corporate farming laws hinges on social science research: to what extent does the body of research find that industrialized farming poses risks to communities? Evidence for adverse effects beyond economic lines, particularly social impacts, and across historical periods is needed to support state claims that regulating industrialized farming is warranted in the public interest. A problem, however, is that no recent journal articles systematically assess whether extant research provides evidence of these effects.

Although numerous empirical studies on the community impacts of industrialized farming exist, little published work appraises the body of research as a whole, and no study draws together findings to date about detrimental impacts. This hampers development of a cumulative knowledge base and social scientists' ability to address a significant public issue.

Our purpose is to address the gap in the literature. We synthesize findings from eight decades of research. We document the types of studies conducted, evaluate results as to whether adverse consequences were found, and delineate aspects of community life that may be affected. The importance of these tasks is two-fold: our goal is to provide a systematic evaluation of research relevant to social scientists, and to provide states, localities, and nongovernmental organizations with a synthesis of findings useful in the public interest. First, we present an overview of the use of social science research in public debates about industrialized farming. Second, we take stock of research to date, focusing on conceptual and research design issues. Third, we evaluate findings from 51 empirical studies that address the question of detrimental impacts. The final section summarizes the results and considers future directions for research.

Although industrialized farming raises many public debates, we focus on the degree to which research provides evidence that industrialized farming jeopardizes communities. There are important reasons for this focus. First, concern with the risks of industrialized farming is widespread across scholarly, policy, and popular audiences, as seen in the serious questions raised about agribusiness concentration, consumer health, food safety, ecosystem sustainability, as well as community well-being (Schlosser, 2001; Lyson, 2004). The most immediate public risks of industrialized farms, however, occur in communities where they are located. Second, the body of research on the community impacts of industrialized farming is motivated foremost by the question of risks. Researchers are interesting in testing – and in turn, confirming or rejecting – the hypothesis that detrimental community impacts may arise, a hypothesis first formalized by Walter Goldschmidt in the 1940s (Lobao, 1990). We seek to summarize findings with regard to this hypothesis. Third, to contribute to current litigation, it is critical to document whether adverse consequences are present or absent. The presence of adverse impacts supports states' claims that the *intent* of corporate farm laws – to protect public well-being – is warranted in the public interest. The absence of these impacts supports the view that the state has no legitimate public interest in regulating corporate farming. Lastly, although our focus is the presence/absence of adverse outcomes, we also note studies finding positive outcomes.

Research on industrialized farming and the public interest

Researchers studying industrialized farming are concerned with a distinct structural shift, whereby farms have become larger-scale, declined in number, and integrated more directly into production and marketing relationships with processors through vertical or contractual integration (Drabenstott and Smith, 1996: 4). Small-scale farms (defined here as those with annual gross sales less than $50,000) made up nearly 79% of the nation's farms in 2002 but they produced only 6% of sales, while the top 3% of farms (those with sales of over a half million dollars annually) accounted for 62% percent of all sales (National Agricultural Statistics Service, 2006). Accompanying farm scale increases are organizational changes, such as increases in the proportion of hired to family labor and use of legal incorporation.[1] Another organizational shift is a more integrated industry, whose "hallmark" is "contract production and vertical integration that links farmers to other agribusiness (Barkema and Drabenstott, 1996: 64).

In classifying farms as "industrialized" as opposed to "family" operations, the difference between the construct and its empirical measurement must be recognized. The construct, "industrial farm," usually refers to a nonhousehold based production unit. As with nonfarm firms, industrialized farms have a division of labor: they "are

owned by one group of people, managed on a daily basis by another person or group, and worked by yet another group" (Browne et al., 1992: 30). Researchers studying industrialized farms invariably refer to both scale and organizational attributes.[2] Though distinct concepts, empirically scale tends to coincide with organizational attributes (Lobao, 1990; Wimberley, 1987). For the purpose of synthesizing research, we use the umbrella term "industrialized farming" when researchers refer to either scale or operating attributes of these units. We also distinguish between scale and operating attributes when useful and feasible to do so.

Social science research and public debates on industrialized farming: A brief history

Since the 1930s, social scientists have informed public debates regarding the community impacts of industrialized farming (Tetreau, 1938, 1940). However, the catalyst behind most studies is Walter Goldschmidt. Paralleling current controversies, Goldschmidt's research involved a state law restricting industrialized farming. In the early 1940s, Goldschmidt, then employed by the USDA, conducted a study using a matched-pair of California communities, Arvin where large, absentee-owned, non-family operated farms were more numerous, and Dinuba, where locally owned, family operated farms were more numerous. The purpose was to assess the effects of a California law placing acreage limits on farms. Goldschmidt (1978a: 458) notes: "Large landholders throughout the state and corporate interests generally opposed this provision while diverse church and other agrarian-oriented interests wanted this law... The comparative study of Arvin and Dinuba...was designed to determine the social consequences that might be anticipated for rural communities if the established law was applied or rescinded."

Goldschmidt (1978a) documented the adverse effects of large-scale farming on numerous community indicators. He found that relative to the family farming community, Arvin had a smaller middle class, more hired workers, lower family incomes, and higher poverty. There were poorer quality schools and public services and fewer churches, civic organizations, and retail establishments. Arvin's residents also had less control over public decisions and low civic participation. Goldschmidt's research report, though first suppressed by USDA and burned publicly in California, was later published as Congressional testimony (1968) and as a book (1978a). Although criticisms of his study exist (Hayes and Olmstead, 1984), its findings have proved quite resilient. Decades later, the Small Farm Viability Project (1977: 229–230) restudied Arvin and Dinuba, concluding: "The disparity in local economic activity, civic participation, and quality of life between Arvin and Dinuba...remains today. There can be little doubt about the relative effects of farm size and farm ownership on the communities of Arvin and Dinuba."

Social scientists neglected the study of industrialized farming and community well-being for decades, in part due to the controversy over Arvin-Duniba (Goldschmidt, 1978a). By the 1970s, changes in agriculture and social science shifts toward more critical perspectives opened the topic to new scrutiny. Congress conducted inquiries in which agricultural economists and rural sociologists testified about the risks to communities posed by industrialized farming (Boles and Rupnow, 1979: 468–469). The Office of Technology Assessment also commissioned a series of studies on the topic (Swanson, 1988).

Historically, concern with industrialized farming and community well-being proceeded irrespective of commodity (Lobao and Meyer, 2001). Since the 1990s, attention has turned to large integrated livestock producer/processor enterprises (DeLind, 1998; Guess-Murphy et al., 2001; Wright et al., 2001), the current source of controversy over corporate farming laws.

The current period: Corporate farming laws and the Commerce Clause

Nine farm belt states – South Dakota, North Dakota, Oklahoma, Iowa, Minnesota, Wisconsin, Nebraska, Missouri, and Kansas – have statutes or constitutional provisions that restrict corporations from engaging in farming or agriculture or from acquiring, purchasing or obtaining land for agricultural production (National Agricultural Law Center, 2006). Other specific regulations encoded in these laws vary by state.[3]

When these laws have been challenged on the basis that they violate the Equal Protection Clause, Due Process Clause, Privileges and Immunities Clause and Contract Clause of the US Constitution, courts have consistently upheld their constitutionality (Pittman, 2004). In 2003, however, in South Dakota Farm Bureau, Inc. v. Hazeltine, the Eighth Circuit Court held that a voter-approved amendment to the South Dakota constitution was unconstitutional because it violated the dormant Commerce Clause of the US Constitution. The dormant Commerce Clause is characterized as the negative implication of the Commerce Clause, the courts interpreting it as "States may not enact laws that discriminate against or unduly burden interstate commerce" (Pittman, 2004: 3). Closely following the South Dakota decision, the US District Court of the Southern District of Iowa held in Smithfield Foods, Inc. v. Miller that Iowa's corporate farming statute also violated the dormant Commerce Clause. The two cases marked the first time whereby corporate farming laws were challenged on the basis of the dormant Commerce Clause (Pittman, 2004). In both cases, the source of these challenges came from

integrated livestock producer/processors seeking to expand operations and encountering barriers due to existing legislation.

The dormant Commerce Clause creates a new use for research on the community impacts of industrialized farming: documenting the legitimate public purposes that the challenged corporate farming law serves. In deciding dormant Commerce Clause challenges to state laws, courts apply a two-tiered analysis. First, the court determines whether the challenged law discriminates against interstate commerce. Second, the court subjects the law to the "strictest scrutiny." Here, the courts will determine the law to be constitutional only if it can be demonstrated that the law is intended to accomplish a legitimate public interest and there were no other methods to accomplish that objective. Although the court may not find the law discriminatory, it still may find it unconstitutional under the second tier of the dormant Commerce Clause (Pittman, 2004: 4). When corporate farming laws are challenged, one of the legitimate public interests postulated by their defenders is that industrialized farming can harm communities – requiring evidence as to the presence or absence of adverse community effects. In recent cases (South Dakota Farm Bureau, Inc. v. Hazeltine and State of North Dakota v. Crosslands) efforts to document the legitimate public purposes that the corporate farming law serves has fallen upon social scientists as expert witnesses who draw upon extant research investigating the community effects of industrialized farming (Lobao, 2000; Stofferhan, 2006). Another recent case (Gale and Bruning v. Jones), an appeal filed in 2006 to uphold Nebraska's overturned corporate farm law, also draws directly from social science research on the topic.

Research on industrialized farming and community well-being

Numerous studies spanning different time periods and regions question the effects of industrialized farming. To provide a summary response, it is first important to explain the complex conceptual issues involved and research designs employed to answer the question.

Conceptual issues involved in determining the effects of industrialized farming

In assessing the effects of industrialized farming, a set of research issues must be considered. Although no one study can address all these issues, they should be considered cautionary parameters in documenting the risks posed to communities. In particular, studies may only assess direct, economic impacts of industrialized farming and overlook social impacts, providing an incomplete response to the question of community risks that establishes the legitimate public interest component of the dormant Commerce Clause.

Industrialized farming should be studied using indicators of farm organization and not only scale

Although scale and organizational attributes overlap, analysts often employ scale alone as a simple proxy measure. Scale is usually measured by sales or sometimes acreage. As a measure of industrialized farming, scale is limited because: (1) family owned and operated farms may be large scale owing to technology; and (2) scale alone does not fully capture organizational features of industrialized farming thought to put communities at risk. Organizational measures of industrialized farming include: vertical integration of corporations into farming; contract farming arrangements; absentee ownership; dependency on hired labor; operation by farm managers as opposed to family members; and legal status as a corporation. With regard to legal status, family and non-family-held corporations should be distinguished.[4]

To adequately assess risks to community well-being, an array of outcomes should be considered

Often research centers on economic performance such as employment growth and misses other aspects of community well-being that may be at risk. Research reviewed below points to three major types of outcomes from industrialized farming impacts on: socioeconomic well-being; community social fabric; and local environment conditions. *Socioeconomic well-being* refers to standard measures of economic performance (e.g., employment growth, income levels, and business activity) and to a broader range of indicators of material conditions (e.g., poverty rates and income inequality). *Community social fabric* refers to social organization, the features of a community that reflect its stability and quality of social life. Impacts on community social fabric are seen in indicators such as: population change; social disruption indicators (e.g., crime rates, births to teenagers, social-psychological stress, community conflict, and interference with enjoyment of property); educational attainments and school quality; changes in social class structure (e.g., decline of the local middle class, in-migration of low wage workers); health status indicators; civic participation (e.g., decline in voluntary organizations and voting); changes in governance, such as loss of local control over community decision-making; and resource/fiscal pressures on local government due to increased need for public services and diversion of public funds to subsidize agribusiness development. *Environmental outcomes* include quality of local water, soil, and air, energy use, and environmentally related health conditions.

Industrialized farming has direct and indirect consequences for community well-being and both consequences should be considered

Studies limited to immediate, direct effects miss the manner by which industrialized farming fully affects communities. Although analysts recognize the potential for indirect consequences, the pathways by which these occur are still not well articulated. Here we provide a synopsis of potential direct-indirect paths, drawing from several studies (Boles and Rupnow, 1979; Lobao, 1990; MacCannell, 1988; and NCRCRD, 1999).

Industrialized farms directly influence communities: through the quantity of jobs produced and the earnings' quality of those jobs; by the extent to which these farms purchase inputs and sell outputs locally; and by affecting local environmental conditions. Owners/managers of industrialized farms also may directly influence local government and community decision-making in economic development and other public-interest areas relevant to local quality of life.

First-order, indirect effects on local socioeconomic conditions occur because the quantity and quality of jobs generated and purchases and sales of local goods by industrial farms affect: total community employment, earnings, and income (e.g., economic multiplier effects); the local poverty rate; and the level of income inequality. First order, indirect effects on local social fabric occur because: the quantity of jobs generated by industrial farms affects population size; and both the quantity and quality of jobs generated affect social class composition, such as when an increase in hired farm workers reduces the proportion of the local middle class. Another first-order, indirect effect stems from greater influence of outside owners/managers: local control over decision-making can erode and community conflict can increase, since the interests of industrialized farmers are often detached from or contrary to the interests of local residents.

Second-order, indirect effects on local social fabric work through first-order effects listed above. Population size and social class composition are related to: indicators of community social disruption, such as crime, family instability, the high school dropout rate, and conflict resulting in civil suits; demand for schooling, public assistance, health, and other social services; and the property tax base (Boles and Rupnow, 1979; Murdock et al., 1988; Freudenburg and Jones, 1991; NCRCRD, 1999). Decline of local control over decision-making also creates problems associated with poor governance. These problems include the potential for diversion of public resources toward financial incentives for agribusiness developers and thereby the loss of public revenues to support local schools, services, and infrastructure.

Differences for social groups within the community should be considered

Changes in farming can affect social groups differently, based upon residents' age, class position, proximity to industrialized farms, and other attributes (Barlett et al., 1999). The elderly and poor may be affected by rising costs of housing and services whenever large corporations migrate to a rural community (Summers et al., 1976). In communities with large, confined animal feeding operations (CAFOs), residents who live closer to the operation often report inability to enjoy their properties and physical/psychological problems related to odor (Schiffman, 1998; Schiffman et al., 1998; Wing and Wolf, 1999; Reisner et al., 2004; Constance and Tunistra, 2005). Property closer to CAFOs has been found to fail to appreciate in value relative to places further away (Seipel et al., 1998). Income generated by industrialized farms (compared to family farms) appears less likely to trickle down to different social classes, with some studies finding that income inequality is greater in communities where industrialized farming is greater (Crowley and Roscigno, 2004; Lobao, 1990). Income inequality, proximity to industrialized farms, and other measures tapping the well-being of different social groups can shed light on more diverse community impacts.

Long-term as well as short-term consequences should be considered

Industrialized farming puts a community on a path of development whose consequences are not fully manifest in one or two years. For example, Lobao (1990) found some impacts were manifest a decade later. Counties with greater industrialized farming in 1970 had significantly lower income, higher poverty, and greater income inequality the next decade, net of other local conditions.

Research designs employed to assess the effects of industrialized farming

Social scientists employ primarily four different research designs to study the impacts of industrialized farms. Each design has inherent strengths and limitations in comprehensively addressing the conceptual issues delineated above.[5]

Case study designs provide in-depth analysis of the consequences of industrialized farming in a single or multi-community site. Usually, a comparative case study design is implemented whereby communities characterized by industrialized farming are contrasted with communities with a different farming pattern (usually moderate-size, family-owned and operated farms). A comparative case study design allows communities to be matched on similar site characteristics, such as economic base and location relative to metropolitan centers, which helps to control for extraneous factors that influence the

relationship between farming type and community well-being. Examples are the studies by Goldschmidt (1978a) and NCRCRD (1999). The strengths of case studies are the following. (1) They provide detailed information about how both scale and organizational aspects of industrialized farming impact community well-being. (2) They provide detailed information about outcomes for a great many indicators of socioeconomic well-being, social fabric, and the environment. (3) They trace the direct and indirect effects of industrialized farming. (4) They can address short-term as well as long-term outcomes. The inherent limitation of case studies is that detailed findings are produced about industrialized farms in specific site communities at the expense of producing less detailed findings over a greater number of research sites. Case studies also vary as to how well extraneous factors influencing the causal relationships of interest can be controlled.

Macro-social accounting designs involve statistical analysis of secondary data from federal and other sources to document relationships in local social structure (MacCannell, 1988). Areal units such as counties, towns, and states are the research focus. To assess the consequences of industrialized farming, analysts usually compare its effects relative to smaller or moderate-size family farm units. Multivariate statistical techniques are used in order to assess the effects of farm structure net of other community conditions. Examples are Gilles and Dalecki (1988), Lobao (1990), Crowley and Roscigno (2004), and Irwin et al. (1999). The strengths of these studies are the following. (1) They provide results that are generalizable across many communities, states, and the nation. (2) They provide results about industrialized farming using measures of scale and organization. Customary scale-based measures of industrialized farming include farm size in sales, such as the proportion of farms above some gross annual sales threshold, or acreage above a certain size. Customary organizational-based indicators include: the proportion of farms organized as corporations or non-family-held corporations; proportion of farms with full-time hired labor; annual costs of hired labor per farm; and proportion of non-resident farm operators. (3) Macro-social accounting designs provide results about a variety of socioeconomic well-being and social fabric indicators and some environmental indicators. (4) They address short-term and long-term relationships between industrialized farming and community well-being. The inherent limitation of these studies is that they usually depend on secondary data which constrains measures of industrialized farming, outcomes, and time periods of study. For example, some organizational measures of industrialized farming, such as vertical integration of farm units are not available over time across communities.

Regional economic impact models use linear programming methods to estimate impacts on employment and income for regions, states, counties, and cities. These studies focus on the integration of business enterprises in markets and use statistical packages, such as variants of input–output analysis, to model backward and forward linkages with enterprises in other industries and to estimate resulting local impacts. Costs and benefits of different firm-level practices can be estimated. Examples are Heady and Sonka (1974), Marousek (1979), and Deller (2003). The strengths of regional economic impact models are the following. (1) They provide detail about economic performance, such as the number of jobs and total income produced by firms or industries in a region or community. (2) They can provide projected estimates, so that impacts of not yet existing firms can be appraised. Limitations of regional economic impact, input-output models for the study of farm impacts are well known (Guess-Murphy et al., 2001). In brief, models involve assumptions about relationships not actually found in the community but depend on estimates from past years and different places. Indicators of industrialized farming and its impacts are also limited. Farm scale is analyzed, not the organization of production. These studies do not examine certain socioeconomic indicators, such as poverty and income inequality, and social fabric indicators, nor do they usually address long-term impacts.

Survey design studies use samples of populations from any number of communities. Researchers employ interviews or questionnaires to collect data on how industrialized farming affects residents or a particular social group exposed to industrialized farming as compared to those who are not exposed (such as residents in family farming communities). Multivariate statistical procedures are used to assess the effects of farm variables on individuals' well-being, controlling for other attributes. Examples of survey design studies are Heffernan and Lasley (1978), Poole (1981), Wing and Wolf (2000). The strengths of these studies are the following. (1) They provide detailed information about how both scale and organizational aspects of industrialized farming impact individuals and families. (2) They provide detailed, in-depth information about outcomes for many indicators of socioeconomic well-being and social fabric, tapping issues such as community participation, stress from local conflict, and health and environmental concerns. A major limitation is that cost considerations usually restrict surveys to specific states and communities and to one time point.

Findings from empirical studies

As shown above, any single study assessing the impacts of industrialized farming is inherently limited due to

research design and comprehensiveness. It is therefore useful to evaluate the body of work that spans different research designs, measures, regions of the country, and time points. To do so, we employ an integrative research review, an assessment across individual studies that provides a comparison and integration of empirical findings (Jackson, 1980; Cooper, 1989; Gough and Elbourne, 2002). Integrative research reviews are useful in drawing conclusions when a number of different empirical studies exist that examine the same research question.[6] We build on such a review by Lobao (1990) who evaluated the empirical studies on the community impacts of industrialized farming conducted from 1930 to 1988.

The strengths and limitations of integrative research reviews are discussed in a growing literature (Cooper, 1989; Gough and Elbourne, 2002; Young et al., 2002). An often noted methodological issue is selection of the pool of empirical studies. As in other types of research, sampling criteria for selecting observations (i.e., individual empirical studies) varies according to the researchers' objectives, while time and resources will limit the scope of work. Integrative research reviews thus are rarely exhaustive pools. In our analysis, the selection of empirical studies was based on two criteria important to establishing the legitimate public interest component of the dormant Commerce Clause: the need to provide consistent historical evidence on the impacts of industrialized farming; and the need to draw from leading scholarly sources. In litigation on corporate farm laws, the evidence that carries the most weight in court is peer-reviewed journal articles and books. To develop the pool of empirical studies, we surveyed the literature from 1988 to the present. We first examined journals relevant to the topic, followed by books, proceedings, and other major scholarly sources currently available electronically. We found 25 empirical studies since 1988 that addressed the topic. We combined these with the 26 studies in Lobao's (1990) analysis for a total of 51 empirical studies that form the basis of our analysis. These studies represent major research on the topic, but due to selection criteria and the inherent limitations of research reviews, they are not exhaustive of past work.[7]

We followed Lobao's (1990) methodology in classifying the studies along the following criteria: research design, as described above; regions of the country analyzed; use of scale and/or organizational indicators in measuring industrialized farming; types of community well-being impacts analyzed; and results. With regard to indicators of industrialized farming, most studies examine farm scale; organizational characteristics are examined less frequently. The studies examine a wide variety of impacts as shown below. While all center on the impacts of industrialized farming, most formally seek to test the hypothesis that where farms are larger scale or industrialized in terms of organizational characteristics, they have a negative impact on the indicator(s) of community well-being, relative to smaller and/or family-owned and operated farms. Appendix A presents each of the 51 studies classified along the criteria above.

Integrative research reviews are increasingly used to inform policy, particularly in health and education (Gough and Elbourne, 2002; Young et al., 2002). Recent litigation on corporate farm laws has ushered in the need for their extension to inform policy on agriculture and community well-being. Here, our analysis focuses on two sets of findings. We first document the types of adverse community impacts identified across studies. Then, we assess the extent to which studies in total find the presence/absence of detrimental impacts of industrialized farming.

Types of risks to communities reported across studies

Community impacts were grouped into three categories described earlier: socioeconomic well-being indicators (e.g., income levels, poverty, and unemployment); indicators of social fabric (e.g., population change, social class, civic involvement, quality and types of community services, population size and composition, and social disruption indicators such as stress and crime); and environmental impacts. The studies analyzed report that industrialized farms are related to relatively worse conditions for the following community impacts.

Socioeconomic well-being

1. Lower relative incomes for certain segments of the community: greater income inequality (income polarization between affluent and poor), or greater poverty (Tetreau, 1940; Heady and Sonka, 1974; Rodefeld, 1974; Flora et al., 1977; Goldschmidt, 1978a; Wheelock, 1979; Lobao, 1990; Durrenberger and Thu, 1996; Peters, 2002; Deller, 2003; Crowly and Roscigno, 2004: Lyson and Welsh, 2005).
2. Higher unemployment rates (Skees and Swanson, 1988; Lyson and Welsh, 2005).
3. Lower total community employment generated (Marousek, 1979).

Social fabric

1. Population: decline in population size where family farms are replaced by industrialized farms; smaller population sustained by industrialized farms relative to family farms (Heady and Sonka, 1974; Goldschmidt, 1978a; Rodefeld, 1974; Wheelock, 1979; Swanson, 1980).

2. Class composition: social class structure becomes poorer (increases in hired labor) (Goldschmidt, 1978a; Harris and Gilbert, 1982; Gilles and Dalecki, 1988).
3. Social disruption:
   - increases in crime rates and civil suits (NCRCRD, 1999);
   - increased general stress, social-psychological problems (Martinson et al., 1976; Schiffman et al., 1998);
   - swine CAFOs associated with areas having greater social vulnerability, high poverty and minority populations (Wilson et al., 2002);
   - greater childbearing among teenagers (Lobao, 1990);
   - deterioration of neighborly relations (McMillan and Schulman, 2003; Smithers et al., 2004; Constance and Tuinstra, 2005; Jackson-Smith and Gillespie, 2005).
4. Civic participation: deterioration in community organizations, less involvement in social life (Rodefeld 1974; Goldschmidt 1978a; Heffernan and Lasley 1978; Poole 1981; Lyson et al. 2001; Smithers et al. 2004).
5. Quality of local governance: less democratic political decision-making, public becomes less involved as outside agribusiness interests increase control over local decision-making (Tetreau, 1940; Rodefeld, 1974; Goldschmidt, 1978a; McMillan and Schulman, 2003).
6. Community services: fewer or poorer quality public services, fewer churches (Tetreau, 1940; Fujimoto, 1977; Goldschmidt, 1978a; Swanson, 1980).
7. Retail trade: decreased retail trade and fewer, less diverse retail firms (Goldschmidt, 1978a; Heady and Sonka, 1974; Rodefeld, 1974; Fujimoto, 1977; Marousek, 1979; Swanson, 1980; Skees and Swanson, 1988; Gomez and Zhang, 2000; Foltz et al., 2002; Smithers et al., 2004; Foltz and Zueli, 2005).
8. Reduced enjoyment of property: deterioration of landscape, odor in communities with hog CAFOs (Schiffman et al., 1998; Wing and Wolf, 1999; Wing and Wolf, 2000; Wright et al., 2001; McMillan and Schulman, 2003; Reisner et al., 2004; Constance and Tuinstra, 2005).
9. Health: neighbors of hog CAFOs report upper respiratory, digestive tract disorder, eye problems (Wing and Wolf, 1999; Wing and Wolf, 2000; Wright et al., 2001; Reisner et al., 2004; Constance and Tuinstra, 2005).
10. Real estate values: residences closest to hog CAFOs experience declining values relative to those more distant (Seipel et al., 1998; NCRCRD, 1999; Wright et al., 2001; Reisner et al., 2004; Constance and Tuinstra, 2005).

Environment

1. Eco-system strains: depletion of water, other energy resources (Tetreau, 1940; Buttel and Larson, 1979; NCRCRD, 1999).
2. Environmental consequences of CAFOs: increase in Safe Drinking Water Act violations, air quality problems, increased risks of nutrient overload in soils (NCRCRD, 1999).

Conclusions reported about impacts by study

The studies above indicate the types of community conditions associated with industrialized farming. To what extent do the studies overall provide evidence of the risks of industrialized farming? As noted, with regard to public interest defense of corporate farm laws, a count of studies where detrimental impacts were found is needed. If research shows that industrialized farming may jeopardize aspects of community life, this provides evidence to support the state's claim that laws restricting it are warranted; alternatively, few or no negative impacts undermines this claim. We classified studies according to whether the researchers report: largely detrimental impacts; mixed findings (i.e., authors report only some detrimental impacts were found); and no detrimental effects. Classifying the studies is somewhat complex because each may test a number of relationships about industrialized farming. We placed studies into detrimental/no detrimental outcome categories based on whether the findings for the majority of relationships tested consistently fell into either of these two categories. Remaining studies are those where researchers found some detrimental impacts but other relationships were mixed, as described further below. Appendix A presents these results individually for each study.

Out of the total 51 studies, authors report largely detrimental impacts in 29, some detrimental impacts in 13, and no evidence of detrimental impacts in nine. Thus, 82% (42 out of 51) of the studies report finding some negative impacts of industrialized farming. Table 1 presents the classification of findings by research design.

Of the 29 studies where social scientists found predominantly detrimental impacts, the following points should be noted. First, these studies use the four major types of research designs described earlier, comparative case study, macro-social accounting, regional economic impact models and surveys. Studies reporting detrimental impacts exist across all time periods and regions of the country. These studies report adverse outcomes for socioeconomic well-being, social fabric, and environmental conditions, using both scale and organizational measures of industrialized farming. In sum, the studies provide a great deal of evidence over many years by

Table 1. Summary of studies examining the effects of industrialized farming on community well-being.

	Findings with regard to detrimental effects		
	Detrimental	Mixed	No detrimental
Research design			
Case study	5[a]	2[f]	0
Macro-social accounting	12[b]	7[g]	8[j]
Regional economic impact	3[c]	2[h]	0
Survey	7[d]	2[i]	1[k]
Other design	2[e]	0	0[o]
Total (N = 51)	29 (57%)	13 (25%)	9 (18%)

[a]Goldschmidt (1968, 1978a), Small Farm Viability Project (1977), Constance and Tuinstra (2005), Whittington and Warner (2006), McMillan and Schulman (2003).[b]Fujimoto (1977), Goldschmidt (1978b), Buttel and Larson (1979), Swanson (1980), MacCannell (1988), Durrenberger and Thu (1996), Lyson et al. (2001), Peters (2002), Wilson et al. (2002), Crowley and Roscigno (2004), Smithers et al. (2004), Lyson and Welsh (2005).[c]Gomez and Zhang (2000), Foltz et al. (2002), Deller (2003).[d]Tetreau (1938, 1940), Heffernan (1972), Rodefeld (1974), Martinson et al. (1976), Poole (1981), Wing and Wolf (1999, 2000), Reisner et al. (2004).[e]Seipel et al. (1998), Schiffman et al. (1998).[f]NCRCRD (1999), Wright et al. (2001).[g]Flora et al. (1977), Wheelock (1979), Harris and Gilbert (1982), Skees and Swanson (1988), Flora and Flora (1988), Gilles and Dalecki (1988), Lobao (1990).[h]Heady and Sonka (1974), Marousek (1979).[i]Heffernan and Lasley (1978), Jackson-Smith and Gillespie (2005).[j]Heaton and Brown (1982), Swanson (1982), Green (1985), Buttel et al. (1988), van Es et al. (1988), Lobao and Schulman (1991), Barnes and Blevins (1992), Irwin et al. (1999).[k]Foltz and Zueli (2005).

researchers using different research designs, about the risks of industrialized farming.

Of the 13 studies where social scientists report some but not consistently negative impacts of industrialized farming, the following points should be noted. These studies provide mixed findings, in that while adverse effects on some community indicators were found, at least *one* of the following also occurred: (1) industrialized farming had no statistical relationship with other indicators (i.e., there was an absence of any relationship); (2) industrialized farming had a trade-off effect, with beneficial effects on certain indicators; (3) industrialized farming did not consistently produce negative impacts for all time periods or regions; or (4) industrialized farming produced effects beneficial for some groups but detrimental to other groups. Mixed findings are evident to a greater degree in regional economic impact and macro-social accounting studies (see Table 1). Regional impact studies tend to show costs-benefits for economic performance indicators, with larger farms injecting greater total income into the community, but also producing less employment relative to smaller farms (e.g., Heady and Sonka, 1974; Marousek, 1979). Macro-social accounting studies often test a number of relationships, adding to the greater potential of mixed findings. Lobao's (1990) study is an example. For counties in the contiguous states, industrialized farming had no relationship with poverty and median family income at either of two time points (1970 and 1980); however, industrialized farming was related to higher income inequality at both time points and also to lower family income, higher poverty, and higher income inequality across time (i.e., counties with greater industrialized farming experienced declines in well-being over the1970–1980 decade).

Other research designs also provide examples of mixed findings. An example of a case study showing mixed effects is Wright et al. (2001) conducted in six counties with CAFOs in Minnesota. This study found that CAFOs had: positive effects for farmers who expanded their operations; detrimental effects for neighbors to CAFOs whose ability to enjoy their property deteriorated; detrimental effects for younger and mid-sized producers unable to expand because expansion by others had restricted their access to markets; and no effects for those who were not neighbors or who were not expanding. A survey (Jackson-Smith and Gillespie, 2005) also found mixed effects for the impacts of large-scale, hired-labor dependent dairies on community social relations. Farm size was the strongest predictor of neighbors' complaints about dairy operations, but demographic attributes of dairy farm owners had a greater effect on their relationships with neighbors than did farm size or use of hired labor.

The nine studies that found no detrimental impacts of industrialized farming used mainly macro-social accounting designs and tended to analyze only indicators of socioeconomic well-being. Lobao's and Schulman's (1991) study is an example. They examined whether industrialized farming was related to higher family poverty across agricultural regions in the US for 1970–1980. They found no significant relationship in

any of the four regions analyzed. Finally, a recent survey design study (Foltz and Zueli, 2005) found no evidence that large farms are unlikely to purchase locally once the presence of local suppliers was taken into consideration. Instead, they demonstrated that purchasing patterns are commodity specific and determined by community attachment, and local supply considerations.

To what extent are there positive impacts of industrialized farming?

While our focus has been on the risks of industrialized farming, an alternative question is whether industrialized farming promotes community well-being. First, overall studies are more likely to report benign, that is, nonsignificant effects of industrialized farming, than they are any positive impacts. (Appendix A reports positive findings in the results column by study.) In the nine cases where no detrimental impacts are shown, six (Swanson, 1982; Buttel et al., 1988; Lobao and Schulman, 1991; Irwin et al., 1999; Flotz and Zueli, 2005; Jackson-Smith and Gillespie, 2005) find little relationship between industrialized farming and community well-being. Only three (Heaton and Brown, 1982; van Es et al., 1988; Barnes and Blevins, 1992) report largely positive effects. Second, in the 13 studies reporting mixed findings, eight (Heady and Sonka, 1974; Flora et al., 1977; Marousek, 1979; Wheelock, 1979; Harris and Gilbert, 1982; Giles and Dalecki, 1988; Skees and Swanson, 1988; NCRCRD, 1999) find some positive effects for different variables and/or for different types of model specifications. Positive impacts are almost entirely limited to socioeconomic conditions. In particular, where positive impacts are found, it is usually between farm scale (not organization) indicators and greater community income (Wheelock, 1979; Harris and Gilbert, 1982; Skees and Swanson, 1988; Barnes and Blevins, 1992). In sum, if the research question were recast to appraise the benefits of industrialized farming, 11 (22%) of the 51 studies would provide some evidence of positive impacts.

Summary and conclusions

Social scientists often debate whether empirical research should be oriented around disciplines' accumulated body of knowledge or, conversely, address the public interest and provide critical knowledge to build civil society (Burawoy, 2005). The stock of research produced on the community effects of industrialized farming contributes to both objectives. Recent challenges to state corporate farming laws usher in a new need to build this body of research.

This study addresses the longstanding question, does industrialized farming pose risks to the well-being of communities, through evaluating the findings of studies from the 1930s to the present. Based on a sample of 51 studies, we found that 82% provide evidence of adverse impacts (57% reporting largely detrimental effects and 25% some detrimental effects). These impacts were reported in studies using various research designs and across different time periods and regions. Beneficial effects of industrialized farming were few and confined largely to income-related socioeconomic conditions. Twenty-two percent of studies provide evidence of these effects but only 6% (three studies) report largely beneficial effects.

The types of community impacts reported by social scientists were detailed earlier and are seen in the following general relationships. First, for socioeconomic well-being, industrialized farming tends to be related to higher income inequality, indicating it is less likely to sustain middle-class communities. Places with higher income inequality are also prone to other social problems because economic gaps are wider. With regard to other socioeconomic impacts, regional economic impact models are likely to report greater total income generated by industrialized farming relative to family farming. However, findings for income inequality suggest that income growth is impeded from trickling down to all community members. Second, studies assessing consequences for the social fabric of communities often find detrimental impacts. Industrialized farming affects the social fabric of communities through altering population size and social composition which in turn affects social conflict, family stability, local class structure, community participation, and purchasing patterns. Case studies report the loss of local autonomy and greater influence of outside agribusiness. Third, studies on large animal confinement operations report environment problems affecting air and water quality and human health.

Although this study provides a comprehensive summary to date regarding the impacts of industrialized farming, it has limitations. The purpose was to document the findings regarding the presence/absence of risks posed by industrialized farming to communities, to contribute to public debates and litigation regarding the public interest *intent* of corporate farm laws, and to provide an integrative research review for social scientists. Thus the study is limited in scope largely to understanding the risks posed by industrialized farming, although we do note studies finding positive effects. Integrative research reviews are inherently limited by the selection criteria of the pool of studies for analysis. As explained earlier, selection of studies was based on the need to provide historical coverage and focus on major scholarly works, particularly journal articles and books. While these selection criteria are important to

establishing the robustness of evidence in court cases on corporate farm laws, other empirical work is inherently excluded. Also, research on the topic continues to grow, limiting any global assessment. Though we have captured much of the major research, we cannot claim to have an exhaustive pool of studies.

Based on the empirical studies reviewed here, some generalizations can be drawn for researchers and government and nongovernmental organizations concerned with the future impacts of industrialized farming. First, where industrialized farming expands we can expect distinct effects on communities' socioeconomic, social fabric, and environmental well-being. Communities that receive industrialized farming are likely to increase population relative to other communities (that is, if local family farmers are not displaced). They are also likely to experience greater income inequality; government services for the poor and other disadvantaged groups are likely to be needed. These communities will encounter stresses in the social fabric, particularly increased community conflict. In the case of large livestock confinement operations, communities will be at risk for environmental and health problems, entailing the need for government intervention. Finally, communities that lose moderate-size family farms, in part because of transaction cost advantages (e.g., volume buying-selling) and public incentives given to industrialized farms, will lose a base of middle-class producers and experience population decline and rifts in social fabric. These communities are likely to have declines in other local businesses and the property tax base and may require state aid for social and public services.

This study also suggests a number of directions for future research. First, our study as well as past work (Lobao, 1990; Wimberley, 1987) has argued for the need to improve the conceptualization and measurement of industrialized farming through attending to both indicators of farm organization and scale. While scale and organizational measures are often used interchangeably, researchers should explore their relationship in more depth and detail, both in terms of comparing their relative performance, and in determining the degree to which scale and organizational measures can be combined to create multi-dimensional indicators that more fully tap the complexities of today's industrialized farming.

Second, the paths by which industrialized farming affects communities are still not well-understood despite decades of research. Studies giving greater attention to conceptualizing and empirically assessing the direct and indirect paths of community influence are needed.

Third, future work should strive for a more comprehensive understanding of the types of impacts generated by industrialized farming. Most research, particularly quantitative studies, centers on socioeconomic impacts, when our analysis shows an array of potential impacts. Community conflict and decline in civic engagement are probably the most endemic problems to be expected from industrialized farming, but their documentation is confined largely to case studies. Long-term as well as short-term consequences should be examined. Studies often assume that impacts are homogeneous across communities. By contrast, the manner by which industrialized farming affects different social groups remains an important question.

New directions for methodology should be considered. Because research designs have different strengths and limitations, multi-method studies that combine both qualitative and quantitative approaches to the research question are particularly useful. In a similar vein, future research should pursue the use of integrative research reviews. These could be used to explore the topic in a more in-depth fashion than we have here, for example, by focusing only on studies that address a few select impacts but in much greater detail; or alternatively, by casting a wider net across the scope of existing studies.

Finally, researchers should give greater attention to the community factors that mediate the effects of industrialized farming. For example, a strong civil society (Lyson et al. 2001), high quality, non-farm local employment (Lobao, 1990), a state and local context supportive of labor unions and a strong social safety net (Lobao and Meyer, 2001) have been argued to buffer the potential negative effects of industrialized farming. In a similar vein, researchers might seek to study positive exemplars: are there community contexts where industrialized farming has been harnessed to improve local socioeconomic, social fabric, and environmental conditions?

The role that corporate farming laws play in protecting rural communities has been alluded to in past research (NCRCRD, 1999) but only recently addressed in a study by Lyson and Welsh (2005). They found that counties in states with anti-corporate farming laws fared better (relative to those in states without such laws) on socioeconomic indicators, such as having proportionately few families in poverty and lower unemployment. In comparing states with less restrictive and states with more restrictive laws, they generally found the same results, better conditions in states with more restrictive laws. Additional research is needed to explain these findings, such as whether corporate farming laws per se or broader aspects of the institutional regulatory environment are protecting the fortunes of local communities. It is clear, however, that within states, remote communities distant from metropolitan centers particularly need state-level protection. Remote rural communities are often targeted as operating sites by large animal confinement operations, but their governments have the least resources to cope with industrialized farming. They are in weak

positions to bargain successfully with external corporations, to regulate their operations once they are in place, and to protect community social life and environment overall. State protection from industrialized farming is most critical in remote communities due, in part, to the fragility of local government (Lobao and Kraybill, 2005).

In summary, social science research provides substantial evidence to support the position that public concern about industrialized farming is warranted and, in turn, that states have a legitimate public interest in regulating these farms. This conclusion rests on the consistency of eight decades of research which has found detrimental effects of industrialized farming on many indicators of community quality of life, particularly those involving the social fabric of communities.

Notes

1. In 2002, more than 95.8% of the nation's 2.1 million farms were classified as family operations. Almost 90% were sole proprietorships and 6% were partnerships. Only 3.5% of all farms were incorporated, and of these, 88% were considered family-held corporations by USDA as they had 10 or fewer stockholders (National Agricultural Statistics Service, 2006).
2. Social scientists measure industrialized farming by both scale and organizational variables. Scale is usually measured by sales and sometimes by acreage and real estate and for livestock operations, animal inventory. The actual dollar value for scale indicators used by analysts to indicate a "large-scale" farm will obviously vary by the time period of study. In addition, what is considered a "large-scale farm" also varies by regional context and commodity. Organizational measures of industrialized farming include: vertical integration of corporations into farming; production contract farming arrangements; absentee ownership of production factors; dependency on hired labor; operation by farm managers; and legal status as a corporation (family or non-family) or syndicate.
3. Some of these laws date back to the 1930s while others are of more recent origin. In addition to general provisions about corporations, some states limit absentee owned farms and contract farming, and some provide exemptions for certain types of farms and for some locales. For the regulations under each state's laws, see the Community Legal Environmental Defense Fund (2007). For a study rating the restrictiveness of each state's law, see Lyson and Welsh (2005). In addition to state laws, counties also may restrict the operation of large farms through zoning and other regulations. For a discussion of regulatory mechanisms used by counties, see the National Association of Counties (1999).
4. Farms may be incorporated because of family farmers' interests in estate planning, greater assurance of business continuity, limited liability, and income tax advantages.
5. We outline the strengths and limitations that are intrinsic to each research design. Any individual study will vary as to how the analysts have exploited the strengths or overcome the limitations of the design.
6. Integrative research reviews are systematic literature reviews, a family of methodologies that include meta-analyses. In integrative research reviews, studies center on the same research question but vary in other attributes such as those related to methodology (Cooper, 1989). The degree of similarity needed for comparison across studies varies according to the research question. In our case, we are concerned with a general question about the presence/absence of adverse impacts reported in studies using the range of methodologies common to this body of work, across regions, and across time.
7. To provide historical evidence, a sampling pool across time is needed. Hence, we used the 26 studies from Lobao's (1990) analysis, which covered the 1930–1988 period, then added studies from 1988 to the present. To compile the studies from 1988–present, we surveyed the following journals: *Agriculture and Human Values*, *Rural Sociology*, *Culture and Agriculture*, *Sociologia Ruralis*, *Southern Rural Sociology*, *American Journal of Alternative Agriculture* (now *Renewable Agriculture and Food Systems*), *Journal of Rural Studies*, *American Journal of Agricultural Economics*, and the *International Journal of the Sociology of Agriculture and Food*. Two scholarly search engines, Google Scholar and Agricola, were also used. Here we focused on the types of empirical studies given the most weight in litigation over anti-corporate farm laws: peer-reviewed journal articles, books, and other scholarly work from major national outlets. A number of reports produced for state and nongovernmental organizations exist. Some are literature reviews, not independent empirical studies, and hence are not included. Empirical studies from experiment station and extension reports were not specifically included unless the results were published as journal articles or given at professional meetings and currently available on a central website. Studies from dissertations and theses were also not included unless they too met the same criteria as above, such as Crowley and Roscigno (2004). Unpublished theses and dissertations are given less weight overall in court cases and until recently have not been widely accessible on-line so that attorneys and others can easily review findings. Theses and dissertations also raise issues with regard to quality equivalence relative to journal articles and work by senior scholars. As in any integrative research review, a limitation of the criteria used to select the pool of studies is that excellent empirical work likely exists which falls outside the scope of the analysis.

Appendix A. Summary of 51 individual studies examining the effects of industrialized farming on community well-being

Study	Methodology	Region	Measures of industrialized farming	Community well-being indicators	Results
Goldschmidt (1968, 1978a)	Comparative case study: two communities	California	Scale/organization	Socioeconomic and social fabric (class structure, local services and organizations, politics, retail trade)	Detrimental: variety of community indicators
Tetreau (1938, 1940)	Survey design study: 2700 households	Arizona	Scale/organization	Socioeconomic and social fabric (class structure)	Detrimental: increased class inequality, rise in number of poor farm workers
Heffernan (1972)	Survey design study: 138 broiler producers, contract farming	Louisiana	Organization	Social fabric (social psychological indicators, community involvement)	Detrimental: poorer social psychological well-being, less community involvement
Heady and Sonka (1974)	Regional economic impact: 150 producing areas	Continental US	Scale	Socioeconomic	Mixed: large farms generate less total community income but also lower food costs
Rodefeld (1974)	Survey design study: 180 producers from 100 farms	Wisconsin	Scale/organization	Socioeconomic and social fabric (class structure, services, population size)	Detrimental: variety of community indicators
Martinson et al. (1976)	Survey design study: 180 producers	Wisconsin	Organization	Social fabric (social psychological indicators)	Detrimental: community isolation of farm workers
Fujimoto (1977)	Macro-social accounting: 130 towns	California	Scale	Social fabric (community services)	Detrimental: fewer and poorer quality services
Flora et al. (1977)	Macro-social accounting: 105 counties	Kansas	Scale/organization	Socioeconomic and social fabric (class structure, retail sales, crime)	Mixed: industrialized farming related to income inequality and crime but also to higher income; other relationships less consistent
Small Farm Viability Project (1977)	Comparative case study: reanalysis of Arvin and Dinuba	California	Scale/organization	Socioeconomic and social fabric (class structure, services)	Detrimental: variety of community indicators
Goldschmidt (1978b)	Macro-social accounting: states	Entire US except Alaska	Scale	Social fabric (agrarian class structure)	Detrimental: poorer class structure

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Appendix A. continued

Study	Methodology	Region	Measures of industrialized farming	Community well-being indicators	Results
Heffernan and Lasley (1978)	Survey design study: 36 grape producers	Missouri	Organization	Social fabric (community social and economic involvement)	Mixed: industrialized farmers less involved in community socially but not more involved in economic control
Wheelock (1979)	Macro-social accounting: 61 counties	Alabama	Scale	Socioeconomic and social fabric (class structure, population size)	Mixed: rapid increases in farm scale related to decline in income, population, and white collar workers, but scale also positively related to income in a cross-time model
Marousek (1979)	Regional economic impact: one community	Idaho	Scale	Socioeconomic	Mixed: large farms generate less community employment but also greater income
Buttel and Larson (1979)	Macro-social accounting: state-level data	Entire US	Scale/organization	Environment (energy usage)	Detrimental: industrialized farming conserves less energy
Heaton and Brown (1982)	Macro-social accounting: county-level data	Continental US	Scale/organization	Environment (energy usage)	No detrimental: industrialized farming conserves more energy
Swanson (1980)	Macro-social accounting: 27 counties	Nebraska	Scale	Socioeconomic and social fabric (population size)	Detrimental: variety of community indicators
Poole (1981)	Survey design study: 78 producers	Maryland	Scale	Social fabric (involvement in community organizations)	Detrimental: large farms related to less community involvement
Harris and Gilbert (1982)	Macro-social accounting: state-level data	Continental US	Scale/organization	Socioeconomic and social fabric (class structure)	Mixed: industrialized farming produces poorer community class structure but also greater local income
Swanson (1982)	Macro-social accounting: 520 communities	Pennsylvania	Scale	Social fabric (population size)	No detrimental: farm size has little effect on change in population size
Green (1985)	Macro-social accounting: 109 counties	Missouri	Scale/organization	Socioeconomic and social fabric (services, population size)	No detrimental: farm size/ organization have little effect on community indicators

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Appendix A. continued

Study	Methodology	Region	Measures of industrialized farming	Community well-being indicators	Results
Skees and Swanson (1988)	Macro-social accounting: 706 counties	Southern US, excluding Florida, Texas	Scale/organization	Socioeconomic	Mixed: large farms related to higher unemployment and also to poorer conditions over time, but cross-sectional models show some positive effects on income
MacCannell (1988)	Macro-social accounting: 98 counties	Arizona, California, Florida, Texas	Scale/organization/ capital intensity	Socioeconomic and social fabric (population size, local trade, local government)	Detrimental: variety of community indicators
Flora and Flora (1988)	Macro-social accounting: 234 counties	Great Plains and West	Scale	Socioeconomic and social fabric (local retail trade, population size)	Mixed: large farms related to lower retail sales and population decline but not related to poverty or income
Buttel et al. (1988)	Macro-social accounting: 105 counties	Northeast	Organization	Socioeconomic and social fabric (housing, retail trade, property taxes)	No detrimental: farm organization has little effect on community indicators
van Es et al. (1988)	Macro-social accounting: 331 counties	Corn belt	Scale/organization	Socioeconomic and social fabric (population size)	No detrimental: farm scale/ organization have little effect; in a few areas, large farms related to higher income
Gilles and Dalecki (1988)	Macro-social accounting: 346 counties	Corn belt and central Plains	Scale/organization	Socioeconomic	Mixed: farm organization (hired labor) related to poorer conditions but larger scale related to better conditions
Lobao (1990)	Macro-social accounting: 3037 counties	Continental US	Scale/organization	Socioeconomic and social fabric (teenage fertility, infant mortality)	Mixed: industrialized farming related to higher income inequality and births to teen agers, and over time to higher poverty and lower income, but other relationships not significant
Lobao and Schulman (1991)	Macro-social accounting: 2,349 rural counties	US and four regions	Scale/organization	Socioeconomic	No detrimental: industrial farming has little relationship to poverty

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Study	Methodology	Region	Measures of industrialized farming	Community well-being indicators	Results
Barnes and Blevins (1992)	Macro-social accounting: 2,000 rural counties	US	Scale	Socioeconomic	No detrimental: larger farms related to higher income and lower poverty, but controls for hired labor show detrimental impacts
Durrenberger and Thu (1996)	Macro-social accounting, 99 counties	Iowa	Scale, hog farms	Social fabric (food stamp need)	Detrimental: large farms related to greater need for food stamps
Seipel et al. (1998)	Hedonic price analysis: one county	Missouri	CAFOs (concentrated animal feeding operations)	Sales prices of farmland parcels with and without homes	Detrimental: reduction in property prices of $144 per hectare within 3.2 km of a hog CAFO
Schiffman et al. (1998)	Quasi-experimental design: 88 matched individuals who vary by residence near CAFOs	North Carolina	CAFOs	Social fabric (social-psychological distress)	Detrimental: residents living near hog CAFOs are more depressed due to psychological and physical effects of odors
Wing and Wolf (2000)	Survey design study: 155 residents, three communities	North Carolina	CAFOs	Social fabric (health status, quality of life)	Detrimental: residents of hog CAFO community report greater respiratory and gastrointestinal problems and eye irritations, poorer quality of life
NCRCRD (1999)	Comparative case study: 14 farm dependent counties, one which recruited a hog CAFO	Oklahoma	CAFOs	Socioeconomic, social fabric (population size, retail sales, school drop-out rates, crime, social conflict, property values, and other well-being indicators), and environment	Mixed: detrimental on most social fabric and environment indicators; no appreciable gains in per capita income and jobs; beneficial effects for a few indicators (increases in population size, retail sales, and property values)
Irwin et al. (1999)	Macro-social accounting: 3024 counties	Continental US	Organization	Social fabric (residential stability)	No detrimental: industrialized farming has little relationship to non-migration
Gomez and Zhang (2000)	Regional economic impact models: (1,106 towns and cities)	Illinois	Scale, focus on hog farms	Social fabric (retail spending)	Detrimental: larger farms related to less retail spending, weaker economic growth

Appendix A. continued

Study	Methodology	Region	Measures of industrialized farming	Community well-being indicators	Results
Lyson et al. (2001)	Macro-social accounting: 433 counties	US all agriculturally dependent counties	Scale/organization	Socioeconomic and social fabric (civically engaged middle class, crime, low birth weight babies)	Detrimental: industrialized farming related to a less civically engaged middle class, low birth weight babies, and greater crime; the civically engaged middle class also mediates other effects of industrialized farming
Wright et al. (2001)	Case study: six counties with CAFOs	Minnesota	CAFOs/scale	Social fabric: (quality of life, community interaction, social capital)	Mixed: for quality of life, negative effects for neighbors, younger and mid-sized producers; positive effects for those who expanded operations; no effects for those who are not neighbors or not expanding. Community social capital and interaction quality declines
Foltz et al. (2002)	Regional economic impact models: 100 dairy farms in three communities	Wisconsin	Scale	Social fabric (farm input purchases made locally)	Detrimental: larger farms related to less input purchases made locally
Peters (2002)	Macro-social accounting: all agriculturally dependent counties	Iowa, Kansas & Missouri	Organization	Social fabric (children-at-risk, composite index of health, education, and general welfare)	Detrimental: industrialized farming related to higher children-at-risk scores
Wilson et al. (2002)	Macro-social accounting: census blocks in rural counties with swine CAFOs	Mississippi	CAFOs	Social fabric (environmental injustice)	Detrimental: CAFOs more likely to be located census block with poor African Americans
Deller (2003)	Regional economic impact: 2249 nonmetro counties	Nonmetro US counties	Scale	Socioeconomic	Detrimental: large farms related to slower growth in per capita income

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Appendix A. continued

Study	Methodology	Region	Measures of industrialized farming	Community well-being indicators	Results
Reisner et al. (2004)	Survey design study: 109 stakeholders in 52 counties with swine CAFOs	Illinois	CAFOs	Social fabric (perceptions of community problems caused by CAFOs)	Detrimental: residents reported greater dissatisfaction with CAFOs, odors, loss of values of homes, and water quality problems
Crowley and Roscigno (2004)	Macro-social accounting: 1054 counties	North Central States	Scale/ organization	Socioeconomic	Detrimental: industrialized farming related to higher poverty and income inequality
Smithers et al. (2004)	Survey design study: 120 farmers in two townships	North Huron County, Ontario	Scale	Social fabric (community involvement, purchasing behavior, perceptions of community)	Detrimental: farmers expanding in scale participated less in community activities and organizations and were less committed to sourcing locally
Lyson and Welsh (2005)	Macro-social accounting: 433 agriculturally dependent counties	US all agriculturally dependent counties	Scale/ organization	Socioeconomic	Detrimental: industrialized farming related to greater poverty and unemployment, with corporate farming laws mediating these effects. Counties in states with weak or no anti-corporate farming laws have poorer conditions
Constance and Tuinstra (2005)	Case study design: three clusters of rural communities with poultry CAFOs	East Texas	CAFOs	Social fabric (general quality of life, stress, odor, water quality, health, property values)	Detrimental: deterioration of quality of life along a variety of indicators experienced by those living closer to CAFOs
Whittington and Warner (2006)	Case study design: two communities with large-scale dairies	Ohio	Scale	Social fabric: (perceptions of local capacity to manage risks of large-scale dairies)	Detrimental: residents report weak capacity of local institutions, feelings of hopeless to address problems
Jackson-Smith and Gillespie (2005)	Survey design study: 836 residents from nine dairy-dependent rural areas in seven states	New York, New Mexico, Texas, Minnesota, Utah Wisconsin, and Idaho	Scale	Social fabric (farmers' and neighbors' relationships, community involvement, neighbors' complaints about odor, flies, and noise)	Mixed: dairy farm size has little relationship to most variables, but it is the strongest predictor of neigh bors' complaints

Appendix A. continued

Study	Methodology	Region	Measures of industrialized farming	Community well-being indicators	Results
Foltz and Zueli (2005)	Survey design study: 141 dairy farmers in three dairy dependent Wisconsin towns	Wisconsin dairy dependent towns	Scale	Social fabric (farm input purchases made locally)	No detrimental: little evidence that large farms are less likely to buy locally. Purchasing patterns are commodity specific and not determined by farm size
McMillan and Schulman (2003)	Case study: two CAFO counties, four focus groups	North Carolina	CAFOs	Social fabric (relations with neighbors, health and environmental concerns, enjoyment of property, local democratic participation, community cohesiveness)	Detrimental: variety of community indicators

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AMERICAN PUBLIC HEALTH ASSOCIATION
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Precautionary Moratorium on New Concentrated Animal Feed Operations

An estimated 54 percent of U.S. livestock are now concentrated on 5 percent of livestock farms,[1] with the largest of such farms getting larger;[2] and these industrial-scale, concentrated animal feeding operations (CAFOs) which are, according to Environmental Protection Agency (EPA) criteria, facilities with more than 1,000 beef cattle, 2,500 hogs or 100,000 broiler hens now dominate U.S. livestock and poultry production; and

Increased numbers of CAFOs in an area often are associated with declines in local economic and social indicators (e.g., business purchases, infrastructure, property values, population, social cohesion), which undermine the socioeconomic and social foundations of community health,[3] particularly in poor and African American rural communities;[4,5] and

CAFOs generate an estimated 575 billion pounds of animal manure yearly.6 CAFO generated manure has constituents and byproducts of health concern including heavy metals, antibiotics, pathogen bacteria, nitrogen and phosphorus, as well as dust, mold, bacterial endotoxins and volatile gases; CAFO-generated manure being uneconomical to transport for any distance,[7] it is typically stored in open or covered pits or lagoons and later spread or sprayed untreated on nearby cropland, posing additional risks to public health; and

Manure pathogens capable of causing severe gastrointestinal disease, complications, and sometimes death in humans include Campylobacter and Salmonella species, as well as Listeria monocytogenes, Helicobacter pylori, and E coli O157:H7, and the protozoa Cryptosporidium parvum.[8] Runoff from manure-applied fields can carry human pathogens into surface waters, which often serve as drinking water sources. Epidemiology studies have, in fact, linked several outbreaks involving these pathogens to livestock waste;[9] and

Manure land application in excess of the land's absorptive capacity also can lead to excess nitrogen and phosphorus in soil,10 eutrophication of surface waters and algae overgrowth——including some algaes producing human toxins;[11-13] and

The emerging scientific consensus is that antibiotics given to food animals contribute to antibiotic resistance transmitted to humans.[14,15] Antibiotics, as well as arsenic and other metal compounds,[16-18] are routinely added to the feeds of concentrated animals absent any diagnosed illness——to promote growth and to compensate for the stress of raising animals under confinement——increasing the risks from antibiotic resistance.[19,20] These routine, non-therapeutic animal uses account for an estimated 13 million pounds of antibiotics annually, most being identical or very similar to human medicines, as compared to 3 million pounds of antibiotics prescribed for humans.[21] Current APHA Policy (Nos. 9908 and 00-LB-5) registers appropriate concern about agricultural use of these medically-important antibiotics;[22,23] and

An estimated 25–75 percent of feed antibiotics pass unchanged into manure waste, posing additional risks to soil, water and air quality and public health following land application.[24] Pig house dust, in a recent study, was found to contain total antibiotics at a concentration of up to 12.5 mg/kg dust with up to five separate compounds, including tylosin, tetracyclines, sulfamethazine, and chloramphenicol;[25] and

In several states, storage pits or lagoons legally can leak millions of gallons of liquid manure,[26-28] and often spill or burst.[29,30] They are frequently sited on floodplains, below the water table or over alluvial aquifers (formations favored as drinking water sources but more easily subject to microbial contamination);[31] and

CAFO manure wastes also include organic dust, molds, bacterial endotoxins and manure-generated gases of up to 400 separate volatile compounds, such as ammonia and hydrogen sulfide, many of which are known airway irritants, allergens or respiratory hazards;[32-34] and

Numerous studies document serious respiratory problems among CAFO workers, including chronic bronchitis and non-allergic asthma in about 25 percent of confinement swine workers.[35,36] Workers exposed to the potent neurotoxin hydrogen sulfide at levels only slightly higher than those at which its odor becomes detectable (5.0 ppm vs .025 ppm), have been found to have accelerated deterioration of neurobehavioral function;[37] and

Scientists convened first by the Centers for Disease Control and Prevention (CDC), and more recently by the University of Iowa and Iowa State University, agree CAFO air emissions may constitute a hazard to public health, in addition to workers' health.[3] The latter report recommends that "precautions should be taken to minimize both specific chemical exposures (hydrogen sulfide and ammonia) and mixed exposures (including odor) arising from CAFOs. The Environmental Protection Agency and the Agency for Toxic Substances and Disease Registry (ATSDR) have both recommended that ambient exposure limits be set for ammonia and hydrogen sulfide

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emissions from CAFOs. These recommendations are based on several experimental and epidemiologic studies of non-CAFO populations documenting respiratory symptoms associated with low level exposure to individual chemical components of CAFO air emissions, particularly including ammonia and hydrogen sulfide. Two published, controlled studies of people residing near CAFOs report eye and respiratory symptoms associated with CAFO air emissions exposures "similar to more prevalent and severe symptoms experienced by CAFO workers who are exposed at much higher concentrations of mixed emissions,"[38] although it should be acknowledged these studies cannot be construed as certain "proof" that a specific disease(s) among community residents has arisen from a specific chemical, bacteria or aromatic compound in CAFO emissions.

Noting that moratoria on new CAFO construction have been called for by the Michigan State Medical Society, the Canadian Medical Association as well as local boards of health, moratoria generally citing existing scientific evidence for threats to worker health and public health, combined with insufficient data to determine whether in the face of those risks public health is being adequately protected;[39-41] and

Considering APHA's recently passed policy (#200011) encouraging as a precautionary principle—"that public health decisions must often be made in the absence of scientific certainty, or in the absence of perfect information"—action to prevent potential harm to reproductive health, infants and children, even if some cause and effect relationships have not been established with scientific certainty;[42] while noting that children suffer disproportionately from asthma; while fetuses, infants and children are more vulnerable to adverse impacts from bacterial and antimicrobial-resistant infections,[43-45] as well as from exposure to neurotoxins,[46] all health impacts to which existing science suggests that emissions from CAFOs may contribute; and

Considering the health and economic impacts on CAFO workers, as well as evidence, albeit less certain, indicating impacts on children and CFO neighbors from exposure to large concentrations of manure and their subsequent emissions of dust, toxins, microbes, antibiotics and pollutants into air and water.
Therefore, the American Public Health Association hereby:

1. Resolves that APHA urge federal, state and local governments and public health agencies to impose a moratorium on new Concentrated Animal Feed Operations until additional scientific data on the attendant risks to public health have been collected and uncertainties resolved.

2. Resolves that APHA urge federal and state governments to initiate and support research to quantify more precisely the exposures to pollutants in air, water and soil emissions of CAFOs experienced by communities surrounding CAFOs, as well as to investigate the greater vulnerability of infants and children to harm from such pollutants, deriving from either greater exposure or increased toxicity.

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Executive Summary

Over the last two decades, small- and medium-scale farms raising livestock have given way to factory farms that confine thousands of cows, hogs and chickens in tightly packed facilities. Farmers have adopted factory farming practices largely at the behest of the largest meatpackers, pork processors, poultry companies and dairy processors. The largest of these agribusinesses are practically monopolies, controlling what consumers get to eat, what they pay for groceries and what prices farmers receive for their livestock.

This unchecked agribusiness power, along with misguided farm policies, have pressed livestock producers to become significantly larger and to adopt more-intensive practices. Despite ballooning in size, many livestock producers are just squeezing by financially, because the real price of beef cattle, hogs and milk has been falling for decades.

These intensive methods come with a host of environmental and public health impacts that are borne by consumers and communities. Factory farms produce millions of gallons of manure that can spill into waterways from leaking storage lagoons or fields where manure is over-applied to soil. Manure generates hazardous air pollutants and contains contaminants that can endanger human health. Neighbors of these animal factories, as well as the workers in them, often suffer intensely from overwhelming odors and related headaches, nausea and other long-term health effects.

What Is a Factory Farm?

Beef cattle: 500 head on feed (feedlot)
Dairy: 500 cows
Hogs: 1,000 head
Broiler chickens: 500,000 sold annually
Egg-laying chickens: 100,000

Even people thousands of miles away from these facilities are not immune to their impacts. Thousands of animals crowded into facilities are vulnerable to disease. Consumers eating the dairy, egg and meat products from factory farms can be exposed inadvertently to foodborne bacteria such as *E. coli* and *Salmonella*, as well as to the public health consequences of unchecked antibiotics use. And yet, despite all of the well-documented problems and health risks related to this type of industrialized production, the number and concentration of factory farms in the United States continues to increase.

Key Findings

Between 1997 and 2012, there was an economic and geographic shift in how and where food animals are raised in the United States. Even just a few decades ago, small- and medium-sized dairy, cattle and hog farms were dispersed across the country. Today, these operations are disappearing. The remaining operations are primarily large-scale factory farms that are concentrated in specific regions, states and even counties, where thousands of animals on each farm can produce more sewage than most large cities, overwhelming the capacity of rural communities to cope with the environmental and public health burdens.

Food & Water Watch analyzed U.S. Department of Agriculture (USDA) *Census of Agriculture* data from 1997, 2002, 2007 and 2012 for beef cattle, hogs, dairy cattle, broiler meat chickens and egg-laying operations.[1] In this report, and in our accompanying online map (www.factoryfarmmap.org), we define factory farms as operations with more than 500 beef cattle (feedlots only), 1,000 hogs, 500 dairy cows, 100,000 egg-laying chickens and 500,000 broiler chickens (sold annually), the largest size categories that the USDA recognizes in its survey. (See the methodology in the appendix for a more detailed description of Food & Water Watch's data analysis.)

Key findings from Food & Water Watch's analysis include:

- **The total number of livestock on the largest factory farms rose by 20 percent between 2002 and 2012.** The number of livestock units on factory farms increased from 23.7 million in 2002 to 28.5 million in 2012.[2] "Livestock units" is a way to measure different kinds of animals on the same scale based on their weight — one beef cattle is the equivalent of approximately two-thirds of a dairy cow, eight hogs or four hundred chickens.[3]

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- **These factory-farmed livestock produced 369 million tons of manure in 2012**, about 13 times as much as the sewage produced by the entire U.S. population. This 13.8 billion cubic feet of manure is enough to fill the Dallas Cowboys stadium 133 times.[4] Unlike sewage produced in cities, the manure on factory farms does not undergo any wastewater treatment.
- **The number of dairy cows on factory farms doubled, and the average-sized dairy factory farm increased by half, between 1997 and 2012.** The number of dairy cows on factory farms rose 120.9 percent from 2.5 million cows in 1997 to 5.6 million in 2012, the equivalent of adding 550 factory-farmed dairy cows every day for 15 years. The average size of dairy factory farms grew by half (49.1 percent), from 1,114 cows in 1997 to 1,661 in 2012. In nine states — Kansas, Oklahoma, New Mexico, Arizona, Idaho, Texas, Indiana, Missouri and Nevada — the average size was more than 2,000 cows in 2012.
- **The number of beef cattle on feedlots rose 5 percent from 2002 to 2012. Feedlot size grew even as the 2012 drought reduced total cattle numbers.** The number of beef cattle on operations with at least 500 head grew from 11.6 million in 2002 to 12.1 million in 2012 — adding about 157 beef cattle every day for 10 years.[5] Texas, Nebraska and Kansas all had more than 2 million beef cattle on feedlots in 2012. The 2012 drought reduced the total number of beef cattle on feedlots nationwide, but the average feedlot size increased by 13.7 percent over five years, from 3,800 in 2007 to more than 4,300 in 2012.
- **The number of hogs on factory farms increased by more than one-third, and the average farm size swelled nearly 70 percent from 1997 to 2012.** The number of hogs on factory farms grew by 37.1 percent — from 46.1 million in 1997 to 63.2 million in 2012 — the equivalent of adding 3,100 hogs to factory farms every day for the past 15 years. The average size of a hog factory farm increased 68.4 percent, from 3,600 hogs in 1997 to nearly 6,100 in 2012.
- **The number of broiler chickens on factory farms rose nearly 80 percent from 1997 to 2012, to more than 1 billion.** The number of broiler chickens raised on factory farms rose 79.9 percent from 583.3 million in 1997 to 1.05 billion in 2012 — about three birds for every person in the United States.[6] The growth in industrial broiler production added 85,000 chickens to factory farms every day over the past 15 years. The average size of U.S. broiler chicken operations rose by 5.9 percent, from 157,000 in 1997 to 166,000 birds in 2012. The average size in California and Nebraska exceeded 500,000 birds in 2012.
- **The number of egg-laying hens on factory farms increased by nearly one quarter from 1997 to 2012, to 269 million.** The number of egg-producing layer hens increased 24.8 percent, from 215.7 million in 1997 to 269.3 million in 2012. Nearly half (49.3 percent) of the egg-laying hens in 2012 were in the top-five egg-producing states: Iowa, Ohio, Indiana, California and Texas. The average size of egg operations has grown by 74.2 percent over 15 years, rising from 399,000 in 1997 to more than 695,000 in 2012.

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The incredible growth of factory farming is due to three key factors. First, unchecked mergers and acquisitions between the largest meatpacking, poultry processing and dairy companies created an intensely consolidated landscape where a few giant agribusinesses exert tremendous pressure on livestock producers to become larger and more intensive. Second, lax environmental rules and lackluster enforcement allowed factory farms to grow to extraordinary sizes without having to properly manage the overwhelming amount of manure they create. And finally, for much of the past 15 years, misguided farm policy encouraged over-production of commodity crops such as corn and soybeans, which artificially depressed the price of livestock feed and created an indirect subsidy to factory farm operations. Although crop prices rose in recent years, in 2014 the USDA projected that prices would decline for several years, and the pace of factory farm construction has increased to take advantage of expected cheaper feed prices in coming years.

The combination of these trends has eroded rural economies, driven independent producers out of business and allowed the largest livestock operations to dominate animal agriculture in the United States. The manure from these factory farm operations pollutes the environment and endangers public health. Crowded conditions leave animals susceptible to disease, drive the overuse of antibiotics and can mean that food safety problems on even a few factory farms can end up in everyone's refrigerator.

The stakes are high for the future of livestock production. Because government at all levels has made decisions that contributed to the rise of factory farms, all levels of government must be involved in changing policies and enforcing existing laws to rein in this industry.

Food & Water Watch recommends:

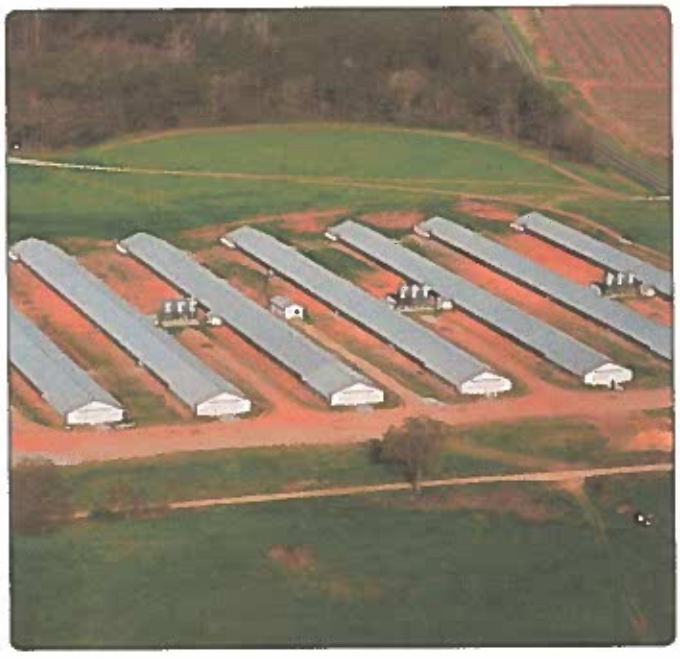
- The U.S. Environmental Protection Agency (EPA) and states should establish a moratorium on the construction of new factory farms and on the expansion of existing facilities.
- The EPA must implement and enforce appropriate environmental rules to prevent factory farm pollution.
- The Department of Justice must prevent the continued consolidation of the meatpacking and poultry, egg and dairy processing industries and revisit the mergers that it already has approved to ensure that farmers get fair prices for their livestock.
- Congress must restore sensible commodity programs that do not prioritize the production of artificially cheap livestock feed over fair prices to crop farmers.
- The Food and Drug Administration (FDA) must prohibit non-therapeutic use of antibiotics and other livestock treatments that facilitate factory farming at the expense of public health.
- The USDA must enforce and strengthen livestock marketing and contract regulations to allow independent livestock producers access to fair markets.
- State environmental authorities must step up their permitting and enforcement of water and air pollution regulations on factory farms.

Introduction

The significant growth in industrial-scale, factory-farmed livestock has contributed to a host of environmental, public health, economic, food safety and animal welfare problems. Thousands of animals in one location can generate millions of tons of manure annually, which pollutes water and air and can have health repercussions for neighbors and nearby communities. Consumers in distant markets also feel the impacts, through either foodborne illness outbreaks, other public health risks or the loss of regional food systems. Even most producers are not benefiting from this system of production because they are not getting paid much for the livestock that they raise.

The rise of factory farming was no accident. It resulted from public policy choices driven by big agribusinesses, especially meatpackers and processors that dominate the critical steps in the food chain between livestock producers and consumers. The silos and gentle meadows pictured on the labels of the food that most Americans buy have little relation to how that food is actually produced. Most of the pork, beef, poultry, dairy and eggs produced in the United States come from large-scale, confined livestock operations.

These animals produce tremendous amounts of manure. Food & Water Watch estimates that the livestock and poultry on the largest factory farms in 2012 produced 369 million tons of manure — almost 13 times more than the 312 million people in the United States.[7] This 13.8 billion cubic feet of manure is enough to fill the Dallas Cowboys stadium 133 times.[8] Unlike the household waste produced in an overwhelming majority of U.S. communities, which have municipal sewer systems, the manure and waste from livestock operations is untreated. Instead, factory farm waste is stored in manure pits or lagoons, and ultimately it is applied to farm fields as fertilizer. As the *Wisconsin State Journal* noted, "[u]nlike cities, which treat their waste, most of the large farms dispose of manure the same way farmers disposed of it in the Middle Ages — by spreading it on fields as fertilizer."[9]



Small, diversified farms that raise animals as well as other crops have always used manure as fertilizer without polluting water. The difference with factory farms is scale. They produce so much waste in one place that it must be applied to land in quantities that exceed the soil's ability to incorporate it. The vast quantities of manure can — and do — make their way into the local environment, where they pollute air and water. Manure contains nitrogen, phosphorus and often bacteria that can impact the environment and human health. Manure lagoons leak, and farmers over-apply manure to their fields, which allows the waste to seep into local streams and groundwater. Residential drinking wells can be contaminated with dangerous bacteria that can sicken neighbors, and the runoff can damage the ecological balance of streams and rivers. In some cases, manure spills that reach waterways can kill aquatic life.

Large quantities of decomposing manure don't just stink, they can be a health hazard as well. Noxious gas emissions from manure holding tanks and lagoons — including hydrogen sulfide, ammonia and methane — can cause skin rashes, breathing problems, and headaches, and long-term exposure can lead to neurological problems. For children, senior citizens and adults with other health problems, exposure to these fumes can cause even more problems.

Industrial livestock operations also can create public health hazards in other ways. The facilities are overcrowded and stressful to animals, making it easy for disease to spread. When thousands of beef cattle are packed into feedlots full of manure, bacteria can get on their hides and then into slaughterhouses. Contamination on even one steer can contaminate thousands of pounds of meat inside a slaughterhouse. In 2010, the crowded, unsanitary conditions at two Iowa egg companies caused a recall of more than half a billion potentially *Salmonella*-tainted eggs and was linked to illness in nearly 1,500 people.[10]

Factory farms can create public health concerns beyond foodborne illness. Because over-crowded animals are susceptible to infection and disease, most industrial livestock facilities treat the animals with low levels of antibiotics to try to prevent illness and compensate for stressful conditions. By creating an ideal breeding ground for antibiotic-resistant bacteria, the overuse of antibiotics on factory farms can reduce the effectiveness of antibiotics for human patients. The feed used for livestock can also introduce public health threats. For decades, broiler chickens received arsenic-based feed additives to promote pinker flesh and faster growth, and beef cattle continue to be fed with animal byproducts, which increases the risk of mad cow disease.

These unhealthy conditions and additives not only pose threats to the environment and public health, they also are detrimental to the animals themselves. Most factory-farmed hogs and chickens have no access to the outdoors and never see daylight. Beef cattle and dairy cows spend time outside, but they are crammed onto feedlots with no access to pasture or grass. The lack of outdoor access, inability to express natural behaviors or graze, health problems and stress caused by production practices, and breeding designed to maximize weight gain or egg and milk production take a toll on animal welfare.

Nor have most farmers benefited from the shift to factory farming. The number of dairy, hog and beef cattle producers in America has declined sharply over the last 20 years as the meatpacking, processing and dairy industries have driven farmers to increase in scale. Most farmers barely break even. In 2012, more than half of farmers lost money on their farming operations.[11] The tiny handful of companies that dominates each livestock sector exerts tremendous control over the prices that farmers receive, and these companies micromanage the day-to-day operations of many farms. The real price that farmers receive for livestock has trended steadily downward for the last two decades.

The rapid transformation of livestock production from hundreds of thousands of independent farmers with reasonably sized operations to a few thousand mega-farms did not happen naturally. Factory farming was facilitated by three policy changes pushed by the largest agribusinesses: 1) Farm Bills from the mid-1990s through mid-2000s artificially lowered the cost of crops destined for livestock feed, 2) the EPA ignored factory farm pollution and 3) the Department of Justice allowed the largest meatpackers to merge into a virtual monopoly.

Since the 1980s, U.S. farm policy has encouraged the overproduction of corn, soybeans and other crops used for livestock feed. For most of the past quarter century, this overproduction made the cost of feed artificially low — below the cost it took to raise the crops. Permitting crop prices to fall below their cost of production and then paying farmers some of the difference with taxpayer dollars indirectly subsidizes factory farms, meatpackers and food processors. Artificially low commodity prices encouraged livestock producers to buy feed rather than pasture their livestock or grow their own feed crops. Since producers no longer needed land for pasture or feed crops, and feed costs were low, it became economically feasible to confine large numbers of animals together in factory farm facilities without an enormous amount of land.

Crop prices rose in 2008 when bad weather coincided with increased demand from overseas consumers and biofuel plants that absorbed more of U.S. crop production.[12] Wall Street investment banks accelerated the price increases and volatility as speculators increasingly viewed farm production as an asset class.[13] Prices generally remained high, but volatile, between 2008 and 2012.[14] By 2014, crop prices began to fall again and were projected to remain lower for the foreseeable future.[15] The forecast of a long-term, low-priced feed environment has encouraged a resurgence of factory farm construction for hogs and broiler chickens.[16]

The environmental oversight of factory farms is disjointed, toothless and almost non-existent. Weak oversight of waste disposal, a major expense in livestock operations,

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reduces the costs of factory farming and encourages the development of larger operations. Although the EPA is tasked with regulating factory farms, it has done little to nothing to control the environmental damage caused by factory farms. Attempts to require adequate oversight have been blocked repeatedly by the livestock industry, which has opposed any safeguards or oversight of factory farm pollutants.

While these two policies reduced the major operating costs of factory farming — feed and manure disposal — the growing trend toward consolidation within the meat-packing, poultry and dairy industries cemented factory farming as the dominant model of livestock production. Over the past two decades, a wave of mergers and acquisitions has concentrated the livestock sectors into the hands of just a few dominant companies. These powerhouses employ heavy-handed tactics, abusive contract terms and manipulative practices that minimize the prices they pay for livestock. In many cases, the companies encourage or require farmers to increase the scale of their operations, or the companies will not buy their livestock at all.

The result of these trends converging is clear: most animals raised for food in the United States are raised on factory farms, and, over the past decade, factory farms have become bigger and more concentrated in certain regions of the country.

Dairy

In recent years, small and mid-sized dairy farms have been disappearing and are being replaced by dairy factory farms that now dominate milk production. Between 1997 and 2012, the United States lost nearly half its dairy farms (52,750 farms, or about 3,500 farms per year on average), but because the remaining farms added more cows, total milk production has actually increased by nearly a third.[17]

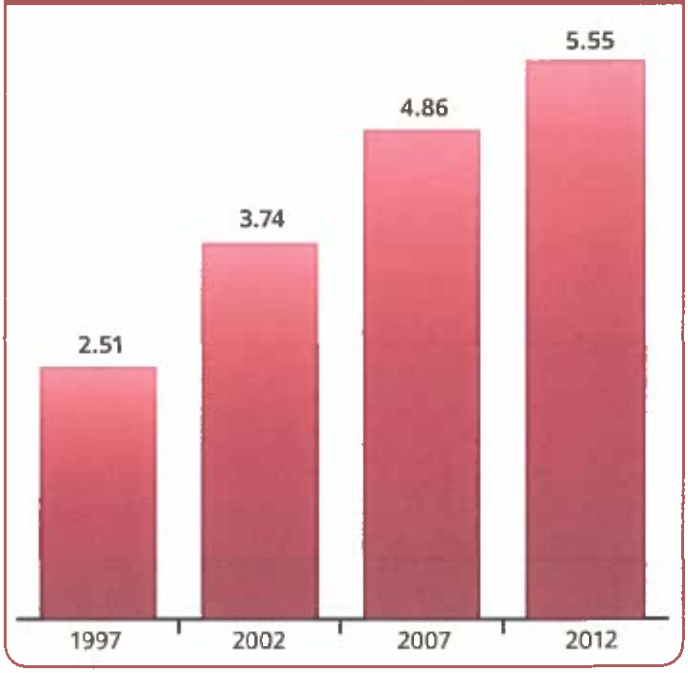
Consolidation in the dairy processing industry has driven both the loss of farms and the rise of dairy factory farms. Up until the 1990s, medium-sized fluid milk processors were local businesses that bought milk from local dairy farms and supplied local consumers and retailers.[18] Now, a handful of companies buys the majority of milk, increasingly from industrial mega-dairy farms, and processes it into dairy products and processed food ingredients. The largest milk processing company, Dean Foods, controls over a third (36 percent) of the nation's fluid milk supply.[19] While Dean Foods is the most common source of milk in the dairy case, consumers might not see a Dean label because the milk is marketed under more than 55 regional brands, including Garelick, Alta Dena and Fieldcrest.[20] Consumers at the dairy case see familiar labels that they have long associated with local or regional companies, but the company behind many of the labels is Dean.

Increasing Size

Food & Water Watch's analysis of the USDA *Census of Agriculture* data found that the number of cows on factory farms with over 500 head more than doubled from 2.5 million in 1997 to 5.5 million in 2012.[21] (See Figure 1.) About 3.0 million dairy cows were added to factory farm operations over 15 years — about 555 additional cows every day.

The rise of the factory farm dairy industry has been more pronounced in western states and has transformed the national dairy landscape over the past decade. Food & Water Watch found that although traditional dairy states like Wisconsin and New York added more than 550,000 dairy cows to their largest operations over 15 years, these states were outpaced by the size and growth of dairy factory farms in western states. In 2012, there were more than 2.9 million cows on dairy factory farms in California, Idaho, Texas and New Mexico. The emergence of western dairy factory farms has contributed to the decline of local dairy farms in the Southeast, Northeast, Upper Midwest and parts of the Midwest.

Figure 1 • Number of Dairy Cows on Factory Farms *(in millions)*



SOURCE: FOOD & WATER WATCH ANALYSIS OF USDA DATA.

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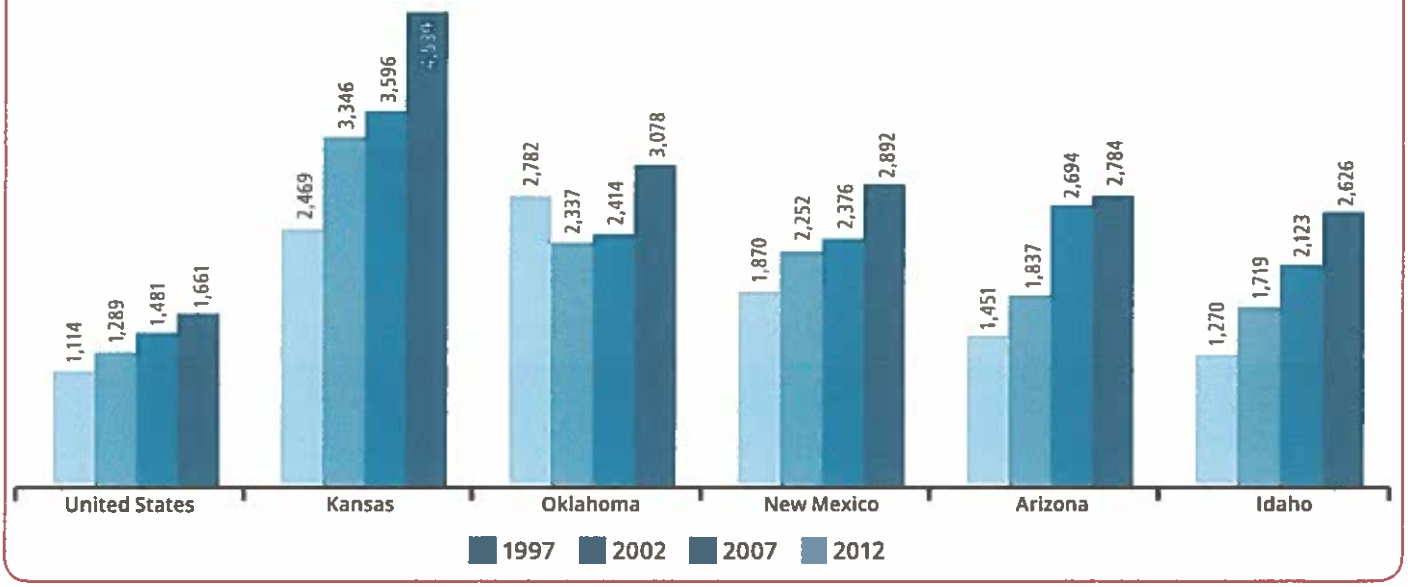
Figure 2 • Average Size of Dairy Factory Farms



SOURCE: FOOD & WATER WATCH ANALYSIS OF USDA DATA.

Food & Water Watch found that the average size of dairy factory farms increased by half over the decade, rising from 1,114 head in 1997 to 1,661 head in 2012. Many states have higher average-sized dairy factory farms. The average-sized dairy factory farms in Kansas, Oklahoma, New Mexico, Arizona and Idaho contained more than 2,500 cows. (See Figure 2.)

Manure Overload

Small dairy farms generate less manure than factory farms; they usually apply that manure to cropland, or it is incorporated into pasture as cows graze. Because big dairies generate far more manure than they can use as fertilizer, they must either store it in giant lagoons or apply it to cropland at excessive rates, where it can leach into groundwater and run off into nearby rivers and streams.

The largest dairy factory farm counties produce as much untreated dairy waste as the sewage produced in major American metropolitan areas (which goes to wastewater treatment plants). (See Table 1.) The more than 485,000 dairy cows on dairy factory farms in Tulare County, Cali-

TABLE 1 • Top Dairy Factory Farm Counties and Human Sewage Equivalent

Top Dairy Factory Farm Counties	Dairy Cows on Factory Farms	Human Population Sewage Equivalent (millions)	Comparable Metropolitan Area
California/Tulare	485,938	107.6	5 x New York City
California/Merced	268,656	59.5	10 x Philadelphia
Idaho/Gooding	173,870	38.5	10 x Seattle
California/Stanislaus	165,740	36.7	Chicago + Dallas + Washington, DC + Miami + Atlanta + Minneapolis-St. Paul
California/Kings	165,623	36.7	New York City + Los Angeles + San Diego
California/Kern	128,302	28.4	10 x Tampa-St. Petersburg
California/Fresno	109,195	24.2	10 x Pittsburgh
Arizona/Maricopa	107,537	23.8	10 x Charlotte, NC
California/San Joaquin	104,298	23.1	New York City + San Diego
Washington/Yakima	97,718	21.6	6 x Seattle
California/San Bernardino	82,031	18.2	3 x Philadelphia
New Mexico/Chaves	75,941	16.8	Los Angeles + San Diego

NOTE: comparison is to the population of the entire greater metropolitan area, not only the city population.

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fornia produce five times as much waste as the population in the greater New York City metropolitan area.[22] The nearly 268,000 dairy cows in Merced County, California produce about 10 times as much waste as the population of the entire metropolitan area of Philadelphia.

Beef

Over the past decade, large-scale industrial feedlots that fatten beef cattle prior to slaughter came to dominate the entire cattle industry. These feedlots buy from small or mid-sized ranches that raise young cattle and then "finish" cattle to market weight. Even in 2012, nearly half (46 percent) of all beef cattle were raised on 665,000 farms and ranches with fewer than 100 head of cows.[23] But most of these cattle ultimately end up on feedlots before they go to the slaughterhouse.

These feedlots have gotten much larger and often partner with or are owned by meatpackers. Until the mid-1960s, most feedlots were small, family-owned operations that handled fewer than 1,000 head. They marketed most of the nation's beef cattle.[24] Now, the largest beef feedlots finish the vast majority of beef cattle. In 2012, the largest 607 feedlots (1.8 percent) each finished more than 32,000 cattle and marketed more than three quarters (76.5 percent) of beef cattle.[25]

Increasing Size

Food & Water Watch found that the number of beef cattle on feedlots larger than 500 head grew by 5.0 percent — from more than 11.5 million in 2002 to 12.1 million in 2012 — adding about 157 beef cattle every day for 10 years.[26] (See Table 2.) Cattle on the largest feedlots declined from 2007 to 2012 because persistent drought and high feed prices reduced the number of cattle and forced some feedlots to close.[27] Nonetheless, five states with the largest inventories of beef cattle on the biggest feedlots all had more than 950,000 factory-farmed beef cattle. Combined, these five states (Texas, Nebraska, Kansas, Colorado and Iowa) held 9.3 million head of beef cattle on feedlots in 2012 — more than three fourths (77.0 percent) of all factory-farmed beef cattle in the country.

TABLE 2 • Top Factory Farm Feedlot Inventory

State	2002	2007	2012
	Head of Cattle		
Texas	2,644,450	2,993,215	2,738,120
Nebraska	2,173,979	2,512,659	2,481,426
Kansas	2,223,850	2,566,734	2,180,082
Colorado	1,062,357	1,102,792	992,007
Iowa	606,648	1,178,958	953,728
United States	**11,555,300**	**13,528,205**	**12,130,113**

The national average for beef feedlot size was over 4,300 head in 2012, 13.7 percent higher than 2007 despite the drought and high feed prices. In many states, the average feedlot size increased significantly, and in five states (Arizona, California, Texas, Washington and Oklahoma), the average feedlot size was larger than 18,000 head, triple the national average.

Most cattle feedlots are located in rural counties, but the large number of cattle in these areas produces the same amount of waste as some of America's largest cities. The manure from cattle feedlots is stored on site until it is

TABLE 3 • Top Factory Farmed Beef Feedlot Counties and Human Sewage Equivalent

Top Factory Farm Beef Feedlot Counties	Beef Cattle on Feedlots	Human Population Sewage Equivalent (millions)	Comparable Metropolitan Area
California/Imperial	340,548	34.3	2 x Los Angeles + San Francisco-Oakland + Sacramento
Kansas/Haskell	330,882	33.3	10 x St. Louis + 2 x Kansas City
Texas/Deaf Smith	328,196	33.0	3 x Dallas + 2 x Houston
Texas/Castro	292,440	29.4	2 x Dallas + 2 x Houston + San Antonio
Nebraska/Cuming	248,710	25.0	28 x Omaha
Colorado/Weld	243,345	24.5	9 x Denver
Iowa/Sioux	240,469	24.2	40 x Des Moines
Texas/Parmer	219,040	22.1	3 x Houston + 2 x Austin
Texas/Hartley	216,215	21.8	4 x San Antonio + Dallas + Houston
Texas/Hansford	209,947	21.1	3 x Houston + San Antonio

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spread on to nearby farm fields. But feedlots can flood or generate polluted runoff, and over-applied manure on farm fields can leach into groundwater or run off into nearby waterways. The more than 340,500 beef cattle on feedlots in Imperial County, California produce as much manure as the human sewage output of twice the greater metropolitan Los Angeles area plus San Francisco-Oakland and Sacramento.[28] The nearly 331,000 beef cattle on feedlots in Haskell County, Kansas produce twice as much waste as 10 St. Louis metropolitan areas and two Kansas City metro areas combined.

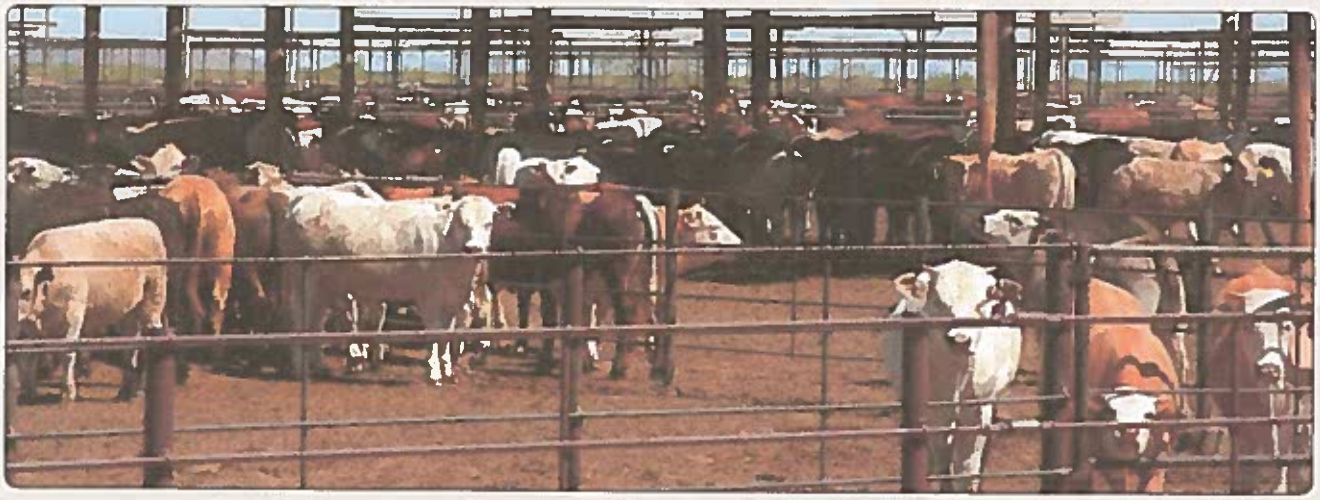
Packers v. Cowboys: How Meatpackers Manipulate Cattle Markets

The beef packing industry is more powerful and consolidated now than it was a century ago when Congress enacted the Packers and Stockyards Act to break up the beef monopolies.[29] Beef packing is the most concentrated industry in the livestock sector. Feedlots are getting larger in order to sell into an increasingly consolidated meatpacking industry, with just four firms slaughtering more than four out of five beef cattle.[30] This concentration gives large packers tremendous leverage over independent cattle producers. The pressure to sell to larger meatpackers has encouraged independently owned feedlots to get bigger, in part to compete with large meatpacker-owned feedlots.

The large beef packers now own their own cattle and operate feedlots, thus controlling supply through multiple stages of production and reducing their need to buy cattle from independent and small operators. More than 1 out of 20 cattle (5.6 percent) slaughtered in 2012 were packer-owned.[31] Packer-owned feedlots enable the meatpackers to drive down cattle prices, keep consumer beef prices high and push down the prices paid to producers. Because meatpackers who own cattle can be sellers, buyers or on both sides of a sale, they can distort or manipulate prices. They can slaughter their own cattle when the cash price is high or buy at auction when prices are low, which can drive down prices for other independent cattle producers.[32] It also effectively reduces the options for independent producers to market their cattle because 1 out of 20 cattle never go to auction.

Company-owned feedlots can be immense. The world's largest beef processor, JBS, owns the Five Rivers Cattle Feeding company, which in 2012 had a capacity of 930,000 head on 12 feedlots in Arizona, Colorado, Idaho, Kansas, Oklahoma, Texas and Alberta, Canada.[33] The average Five River feedlot has about 77,500-head capacity, but the largest in Wellton, Arizona had a capacity of 120,000.[34] In 2012, Cargill's cattle feedlot business was the third largest in the United States, feeding more than 350,000 head of cattle.[35] In 2015, Cargill operated two feedlots in Texas, one in Kansas and one in Colorado.[36]

These corporate-owned feedlots are generally bigger than independently owned feedlots, and they lack roots in their local communities. Cargill is headquartered in Minnesota, but its feedlots are located in Texas, Colorado and Kansas. JBS is a Brazilian company. While farmers and ranchers drink the same water and breathe the same air as their neighbors, the corporate owners of these largest feedlots are located thousands of miles from any environmental problems they may create.



Pork

Hog farms have grown dramatically, with thousands of hogs packed into confinement barns. In many regions, there are only one or two pork packers, so hog producers have few potential buyers for their hogs. This economic pressure has led many hog producers to follow the meat industry's mantra to "get big or get out."[37] In less than two decades, the number of hog farms declined by 70 percent, from more than 240,000 in 1992 to fewer than 70,000 in 2007.[38] The number of farms continued to drop to under 56,000 farms in 2012.[39]

Despite the collapse in the number of farms, the number of hogs grew as the scale of the remaining operations exploded. (See Figure 3.) What makes the rise of factory farms in the hog industry so noteworthy is that it happened recently and quickly. In 1992, less than a third of hogs were raised on farms with more than 2,000 animals.[40] By 2012, 97.4 percent of hogs were raised on operations with more than 2,000 hogs.[41] (See Figure 4.)

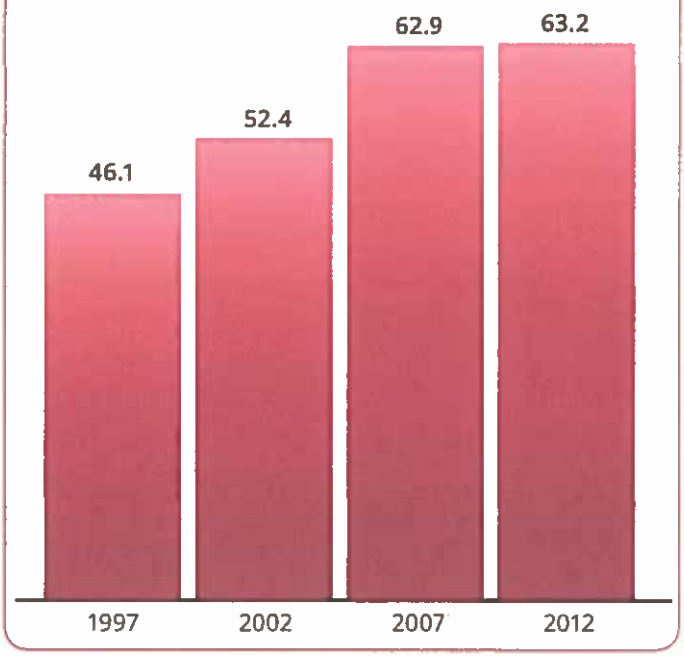
The decline in the number of farms and the explosion in the size of hog operations was driven by consolidation in the pork packing and processing industry. Since the 1990s, a wave of mergers has significantly increased consolidation in the pork packing industry. In 1995, the top four pork packers slaughtered less than half of the hogs (46 percent), but by 2012 the top four firms slaughtered nearly two thirds of the hogs.[42] These companies pressed farmers to enter into contracts to raise hogs owned by the packers or to commit to selling to a specific packer long before the hogs are ready to be slaughtered.

In 1993, almost all hogs (87 percent) were sold at auction to pork packers or processors. By 2013, nearly all (93 percent) hogs were controlled well before the time of slaughter by the pork packers, either because they owned the hogs (29 percent) or because they already had contracted to buy the hogs (64 percent).[43] The use of these contract arrangements depresses the price of hogs. Average hog prices were $81 per hundredweight between 1989 and 1993 (in 2014 dollars), when most hogs were not under contract. During the 2010 to 2014 period, average hog prices were $68 per hundredweight, nearly 20 percent less.[44]

Increasing Size

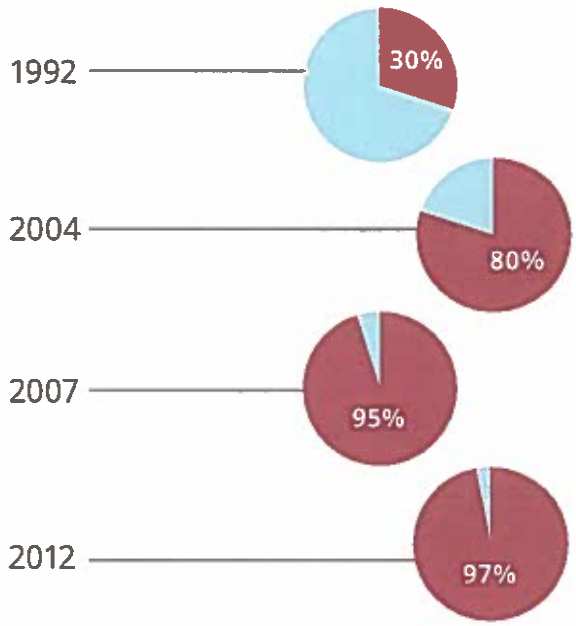
Food & Water Watch found that the number of hogs on factory farms with more than 1,000 head grew by more than a third (37.1 percent), from 46.1 million in 1997 to 63.2 million in 2012, although the growth slowed as feed prices increased after 2008. (See Figure 3.) The addition of 17.1 million hogs over 15 years put 3,100 more hogs onto factory farms *every day*. The decline in feed prices after 2012 has encouraged a resurgence in hog factory farm construction. During 2013 and 2014, Iowa farmers have applied to build 700 new hog facilities, six times the level

Figure 3 • Number of Hogs on U.S. Factory Farms *(in millions)*



SOURCE: FOOD & WATER WATCH ANALYSIS OF USDA DATA.

Figure 4 • Share of Hogs on Operations Larger Than 2,000 Head



SOURCE: USDA

Figure 5 • Top Factory Farm Hog States

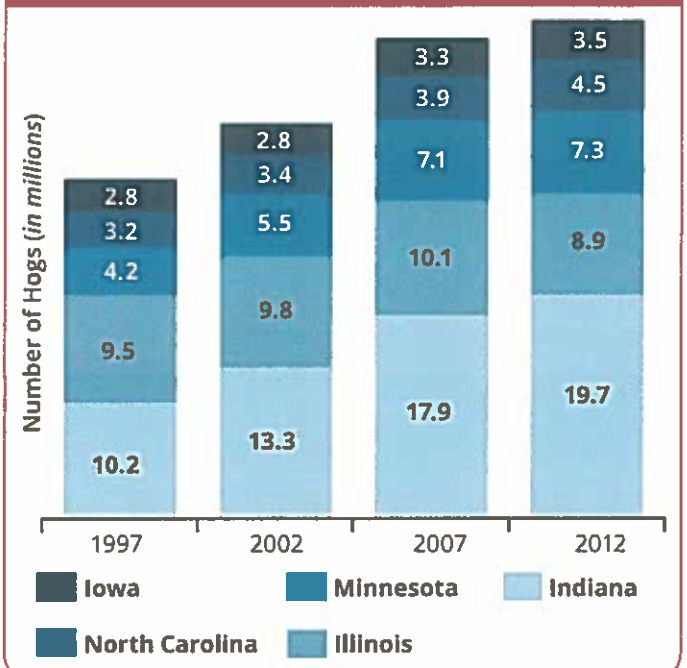
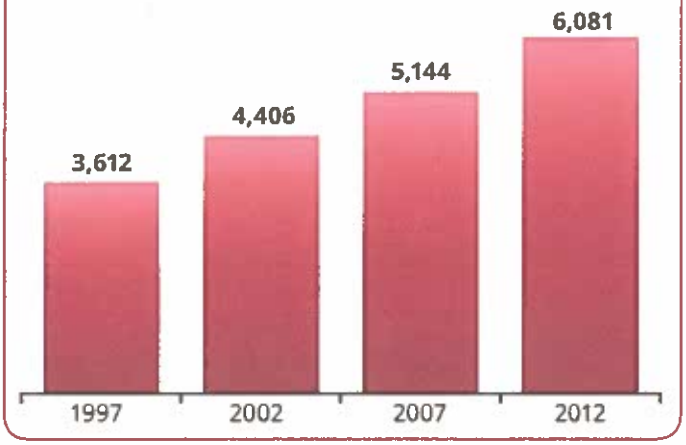


Figure 6 • Average Size of U.S. Factory Hog Farms



SOURCE – FIGURES 5 AND 6: FOOD & WATER WATCH ANALYSIS OF USDA DATA.

five years earlier when feed was more expensive, and other Midwestern states have seen similar hog factory farm building booms.[45]

The five largest states for factory-farmed hogs (Iowa, North Carolina, Minnesota, Illinois and Indiana) represent about 70 percent of all factory-farmed hogs. (See Figure 5.) They have held this ranking since 1997, but the most rapid growth has been in the Midwest. The number of hogs on factory farms in Iowa nearly doubled (a 93 percent increase) between 1997 and 2012, and in Minnesota, the number surged 76 percent. In contrast, although North Carolina has maintained the second-place ranking for the number of factory-farmed hogs, this number has fallen from its peak of 10 million in 2007, and now there are fewer factory farmed hogs in the state than in 1997, in part due to state laws limiting the construction of new manure systems.[46]

Food & Water Watch found that the average hog factory farm size increased by 68.4 percent over a decade, rising from 3,612 hogs per farm in 1997 to 6,081 in 2012. (See Figure 6.) The largest hog factory farms were not in the states with the largest number of hogs, but in states where hog production was limited largely to a few counties with enormous operations. Eight states averaged more than 10,000 hogs per factory farm, and Utah factory hog farms had more than 65,000 hogs — 10 times the national average.

Manure Overload

Much of U.S. hog production is concentrated in the grain- and soybean-producing Midwest. The tremendous amount of manure produced on hog factory farms is stored in lagoons and applied — often over-applied — to cropland. In the upper Midwest, where farmland freezes solid during the winter, manure applied to frozen fields

TABLE 4 • Top Factory Farm Hog Counties and Human Sewage Equivalent

Top Factory Farm Hog Counties	Hog Inventory	Human Population Sewage Equivalent (millions)	Comparable Metropolitan Area
North Carolina/Sampson	1,854,471	32.3	14 x Charlotte
North Carolina/Duplin	1,725,305	30.1	25 x Raleigh
Oklahoma/Texas	1,204,135	21.0	3 x Dallas
Iowa/Sioux	1,134,262	19.8	33 x Des Moines
Iowa/Washington	972,291	17.0	65 x Cedar Rapids
Minnesota/Martin	797,305	13.9	4 x Minneapolis-St. Paul
Iowa/Plymouth	722,227	12.6	21 x Des Moines
Iowa/Hardin	714,373	12.5	Chicago + St. Louis
Iowa/Lyon	698,205	12.2	14 x Omaha
North Carolina/Bladen	650,537	11.3	5 x Charlotte

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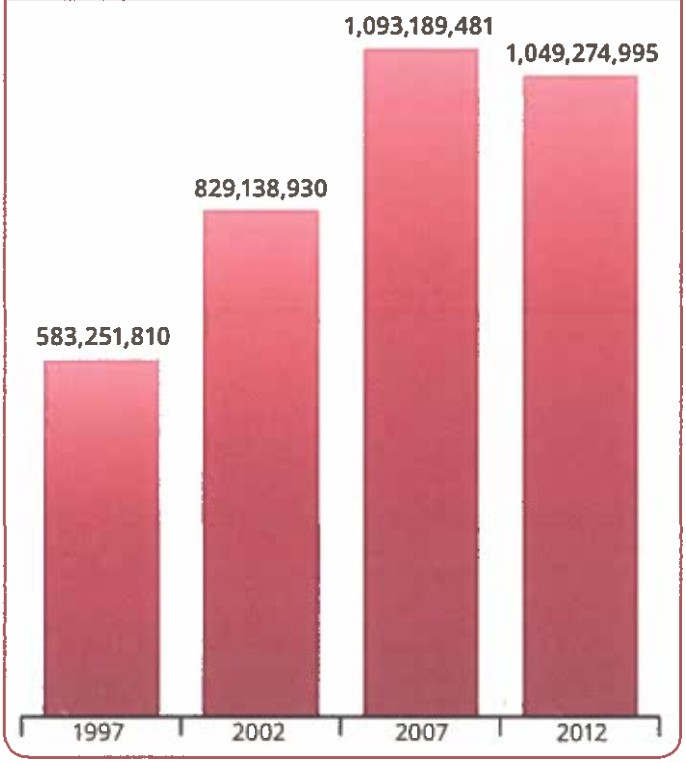
cannot be absorbed, so it runs off into local waters. When manure storage lagoons spill or leak, or if manure is over-applied on farmland, it easily can end up in local waterways.

In 2012, eighteen U.S. counties held more than half a million hogs on factory farms. These counties effectively generated the same amount of untreated manure as the volume of sewage that enters the wastewater treatment plants of some of America's largest cities. The more than 1.8 million hogs in Sampson County, North Carolina generated 14 times as much waste as the entire Charlotte metropolitan area, and the million-plus hogs in Sioux County, Iowa produced 33 times as much waste as Des Moines.[47]

Chicken

Chicken meat comes from billions of chickens raised on thousands of broiler chicken operations, where farmers raise birds on contract for the few poultry processing companies that dominate the industry. This means that the companies own the chickens and pay farmers to raise them. Under these contracts, the companies make management decisions such as feed and chick delivery scheduling, and they lock farmers into contracts that prohibit the farmers from selling chickens to anyone else. The scale of chicken farms has grown rapidly, as growers try to eke out a living by increasing the volume of birds they produce on contract. The median-sized chicken operation increased by 21 percent in a decade, rising from 520,000 birds annually in 2002 to 628,000 birds in 2011.[48]

Figure 7 • Broiler Chickens on Factory Farms



SOURCE: FOOD & WATER WATCH ANALYSIS OF USDA DATA.

Increasing Size

Food & Water Watch found that in 2012, there were over 1 billion broiler chickens on large farms in the United States at any one time — more than three birds for each person in the country.[49] The number of broiler chickens increased by 79.9 percent over 15 years, rising from 583.3 million in 1997 to 1.05 billion in 2012, adding about 3,500 chickens every hour. (See Figure 7.) The number of broiler chickens declined slightly (by 4.0 percent) from 2007 to 2012 as a result of higher feed prices.[50] As feed prices subsequently moderated and began to fall, more new chicken houses were being built in poultry regions like the Eastern Shore of the Chesapeake Bay.[51]

Broiler production is concentrated largely in Southeastern states and is even more concentrated within states into localized clusters.[52] In 2012, more than half of broilers were raised in Georgia, Arkansas, Alabama, Mississippi and Texas. (See Table 5.) In Arkansas, Mississippi and Texas, the number of broilers nearly doubled between 1997 and 2012. The concentration of broiler operations means that 21 states have no large-scale broiler production at all.

The average size of U.S. broiler operations rose from about 156,000 chickens in 1997 and 2002 to about 166,000 chickens in 2007 and 2012. These figures represent the average number of birds housed in facilities at any one time. Over the course of a year, 911,000 broilers would have passed through the average operation in 2012, in five-and-a-half flocks that each stayed on the farm for roughly seven weeks. In the states with the largest opera-

TABLE 5 • Top Broiler Factory Farm States

State	1997	2002	2007	2012
	Inventory in Millions of Chickens			
Georgia	111.5	148.8	204.9	170.9
Arkansas	58.8	84.2	133.8	116.3
Alabama	68.3	99.5	107.6	110.1
Mississippi	51.8	75.4	110.3	102.4
Texas	46.7	77.9	90.4	92.8
United States	**583.3**	**829.1**	**1,093.2**	**1,048.9**

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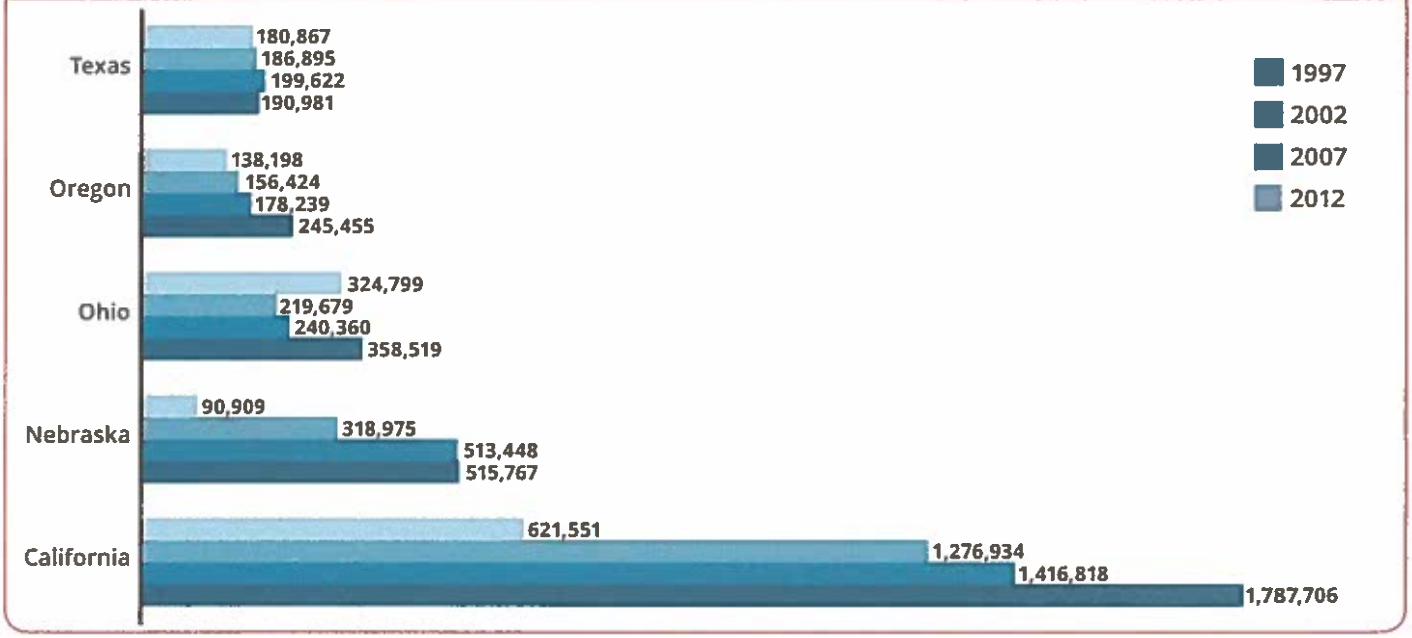
tions, these operations are considerably larger than the national average — four states averaged broiler flocks in excess of 200,000 birds at any one time.[53] (See Figure 8.) In 2012, the average broiler operation inventory in California exceeded 1.7 million birds.

Litter Overload

Although the poultry companies own the chickens and the feed that goes into them, the contract farmers are responsible for the management of the manure. Poultry litter — chicken manure and manure-laden bedding (usually rice hulls or straw) — is stored on farms, where it is applied to farmland as fertilizer. In many dense poultry-production areas, the volume of poultry litter greatly exceeds the fertilizer need and capacity of nearby farmland. With so many birds and so much manure, the accumulated litter can pose a significant environmental risk.

Even though chickens are small and produce less manure than cattle or hogs, the sheer number of broilers in many rural counties produces as much untreated manure as the sewage output of some major and mid-sized metropolitan areas. (See Table 6.) The more than 18 million broiler chickens on factory farms in Shelby County, Texas produce about as much waste as the population of the entire Dallas-Fort Worth metropolitan area. The 17.8 million broilers in Fresno County, California produce six times as much waste as the population of the Fresno metro area.

Figure 8 • Average Broiler Factory Farm Size in States with Largest Operations



SOURCE: FOOD & WATER WATCH ANALYSIS OF USDA DATA.

TABLE 6 • Top Factory Farm Broiler Counties and Human Sewage Equivalent

Top Factory Farm Broiler Counties	Number of Chickens	Human Population Sewage Equivalent (millions)	Comparable Metropolitan Area
Texas/Shelby	18,907,120	6.4	Dallas
California/Fresno	17,877,062	6.0	6 x Fresno
Arkansas/Benton	16,958,946	5.7	8 x Little Rock
Texas/Nacogdoches	14,323,576	4.8	2 x San Antonio
Georgia/Franklin	13,436,316	4.5	2 x Charlotte
Missouri/Barry	12,164,827	4.1	2 x Kansas City
Delaware/Sussex	11,744,313	3.9	Baltimore + Wilmington
Virginia/Rockingham	11,553,334	3.9	3 x Richmond
Arkansas/Washington	11,258,460	3.8	5 x Little Rock
Mississippi/Smith	10,729,243	3.6	6 x Jackson, MS

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Contract Abuse

The broiler industry is the most "vertically integrated" segment in agriculture — a system where companies own and control every step of the supply chain. Over the past 20 years, as larger companies acquired smaller, regional processors and cooperatives, it has become increasingly concentrated. Over the past 30 years, the market share of the top four poultry integrators has doubled. In 1987, the four largest firms slaughtered less than a third (29 percent) of broilers, but by 2012 the four largest firms slaughtered nearly three out of five (57 percent) of broilers.[54]

These companies control the entire chicken meat production chain: operating hatcheries and specialized feed mills, contracting with growers to raise the chickens for them and running processing plants.[55] Production contracts exist for almost all types of livestock, but the broiler industry is unique in the near-universal use of production contracts.[56] Under these contracts, the companies deliver chicks and feed to the farmers (referred to in the industry as "contract growers"), tell them how to raise the chickens and collect the birds when they have reached their full weight.[57] The farmers don't own the chickens. These production contracts pay the growers for raising the birds, not for the actual chickens.[58]

The transformation of chicken farmers from independent producers to subcontractors of the poultry companies began more than 50 years ago.[59] Over the past five or six decades, the poultry industry has strengthened its grip on contract poultry growers through unfair and often abusive "take-it-or-leave-it" contracts.[60] About half of growers have only one or two processors located near enough to get contracts, so they have little choice but to accept whatever terms the companies offer.[61] Many contracts only cover growing a single flock of birds, which takes about seven weeks. Even when flock-to-flock contracts are automatically renewed, growers are dependent on the companies to maintain new deliveries of birds, and thus income.[62]

The short-term contracts must generate enough income to support the farmers and repay significant long-term loans on their broiler houses.[63] Many processors demand that poultry growers invest in significant upgrades to broiler houses and other equipment to secure contracts.[64] New broiler houses are extraordinarily expensive, often costing upward of $1 million for the four houses that most growers use.[65] Although processors require these new investments, their contracts do not pay more to the farmers, who must repay the loans required to make the upgrades.[66] Nor do growers who make upgrades receive guaranteed long-term contracts that ensure that they can pay off these debts.[67] Even after growers made the required investments, some integrators have cancelled contracts.[68]

Many contract poultry growers barely break even, as the prices that growers receive for broilers have been falling steadily, while the mandated upgrade investments can mire growers in debt. In 2011, the average farm business income was $12,700 for poultry operations with one or two houses and $35,500 for farms with three or four houses.[69] These meager earnings can barely make a dent in the debt from poultry house upgrades. For example, Alabama poultry growers lost money during 10 of the 15 years from 1995 to 2009, the most recent year for which data are available.[70]

Eggs

Eggs also are produced in large-scale operations, with hundreds of thousands of layer hens held in each facility. A handful of firms owns multiple farms or contracts with a number of large layer operations, the majority of which house their birds in small cages that are stacked from floor to ceiling. In 2013, only 11.3 percent of layer hens were in cage-free houses on farms with at least 30,000 birds.[71] In 2014, the largest four firms controlled nearly one third (30.3 percent) of the hens that lay the eggs that most Americans eat.[72] When a few firms dominate the marketplace, the major players can collude and manipulate prices and drive practices that are more intensive and larger scale. In 2009, some of the largest egg companies were implicated in a scheme to manipulate the price of eggs at the grocery store by allegedly colluding to artificially reduce egg production and drive up retail prices.[73]

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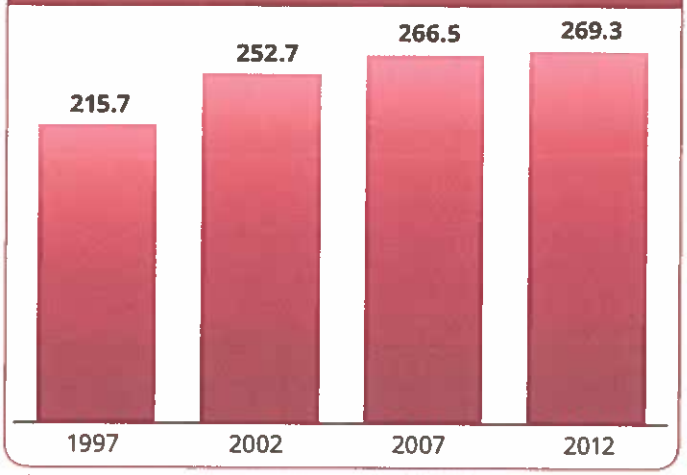
The number of egg-producing layer hens increased by one fourth (24.8 percent) over 15 years, rising from 215.7 million in 1997 to 269.3 million in 2012. (See Figure 9.) Because each hen can lay about 260 eggs a year, the additional 53.5 million hens added since 1997 produced an additional 19 billion eggs.[74] In total, the layer hen flock produced an estimated 70 billion eggs in 2012 — enough for every person to eat 220 eggs every year.

Egg production is concentrated in only a few states. Just under half the hens in 2012 were located in the top five states: 50.6 million in Iowa, 24.1 million in Ohio, 23.7 million in Indiana, 18.0 million in California and 16.1 million in Texas. Ten states had no industrial-scale layer operations at all in 2012.

Increasing Size

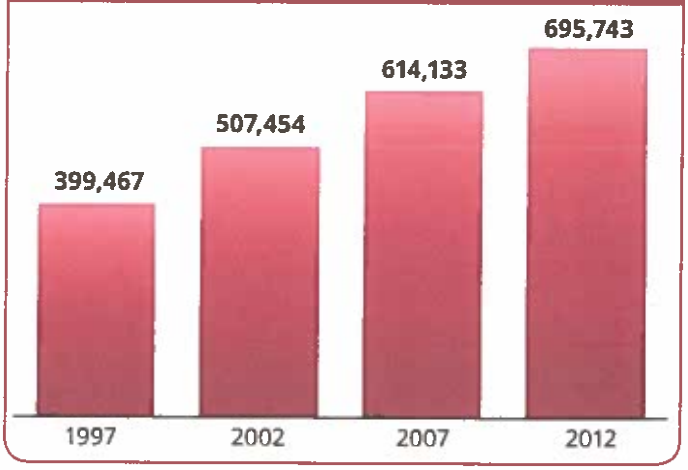
The average size of layer operations increased by 74.2 percent from 399,000 in 1997 to more than 695,000 in 2012. (See Figure 10.) The six states with the largest layer operations in 2012 (Missouri, Florida, Michigan, Iowa, Maine and Wisconsin) all averaged more than 1 million hens per farm. (See Figure 11.) These operations were both

Figure 9 • Factory Farmed Egg-Laying Hens
(in millions)



SOURCE: FOOD & WATER WATCH ANALYSIS OF USDA DATA.

Figure 10 • Average Size of Factory Farm Layer Operations



SOURCE: FOOD & WATER WATCH ANALYSIS OF USDA DATA.

Figure 11. Average Size of Egg Factory Farms in States with Largest Layer Operations

SOURCE: FOOD & WATER WATCH ANALYSIS OF USDA DATA.

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considerably larger than the national average and grew much faster over the 15-year period (only Maine declined from its 1997 high).

Litter Overload

Large layer facilities generate tremendous volumes of manure and manure-tainted litter. Some operations have been found to violate environmental rules. The millions of layer hens packed into some counties can produce as much litter as the sewage from major metropolitan areas. The layer hens in Mercer County, Ohio produce as much waste as the populations of the Cleveland, Cincinnati, Columbus and Dayton metropolitan areas combined. (See Table 7.)

Bad Policy Driving the Growth of Factory Farms

Industrial-scale livestock production emerged over the past quarter century, but it has accelerated rapidly over the past decade. Between 2002 and 2012, about 4.7 million livestock units were added to America's largest livestock operations. The number of factory-farmed dairy cows, beef cattle, hogs, broiler chickens and layer hens all increased, and the average size of most operations grew significantly. Although the number of beef cattle on feedlots and broiler chickens declined modestly between 2007 and 2012 because of high feed prices and a persistent large-scale drought, the general trend over the past 15 years was for more livestock of all types to be packed onto larger factory farms, concentrated in specific regions of the country.

This growth was not due to a superior business model or to some breakthrough in efficiency; it was facilitated by poor public policy. The two largest costs of industrial livestock production — feed and manure management — have been artificially reduced by federal policies. Feed has been sold at extremely low prices, often below the cost of production, for much of the past 15 years, as a result of farm programs that promote overproduction of corn and soybeans. Although feed prices rose sharply after 2008 and remained high and volatile through 2012, prices were expected to fall in 2015 and to remain low for the foreseeable future, encouraging a renewed factory farm building spree. And while this was happening, federal and state environmental authorities turned a blind eye to the growing pollution from factory farms, allowing bad management practices to become the industry standard.

These policy changes allowed livestock operations to balloon in size, and the shift was cemented by rapid consolidation in the meatpacking and livestock processing industries.[75] (See Figure 12.) Over the past 30 years, regulators approved a wave of mergers between the largest firms in the beef, pork, poultry, egg and dairy sectors. Their concentrated market power allowed the biggest firms to exert tremendous leverage over farmers. They could lower the prices they paid to farmers because there were so few firms to bid for livestock. The big firms also pressed farmers to enter contracts — often with unfair terms and prices — that reduced meatpackers' need to buy animals on the open market, such as a livestock auctions. As farmers received less for each steer, hog, chicken or gallon of milk, they added more livestock on factory farms to try to recoup their losses from low prices with increased volume.

TABLE 7 • Top Factory Farm Egg Counties and Human Sewage Equivalent

Top Factory Farm Egg Counties	Number of Layer Hens	Human Population Sewage Equivalent (millions)	Comparable Metropolitan Area
Ohio/Mercer	15,003,845	7.2	Cleveland + Cincinnati + Columbus + Dayton
Iowa/Sioux	7,598,093	3.7	6 x Des Moines
Indiana/Jay	6,556,487	3.2	Indianapolis + Gary + Lafayette
Pennsylvania/Lancaster	4,898,157	2.4	Pittsburgh
Ohio/Darke	3,914,047	1.9	Columbus
Iowa/Hancock	3,799,046	1.8	3 x Des Moines
Iowa/Wright	3,799,046	1.8	3 x Des Moines
California/Merced	3,488,943	1.7	Fresno + Stockton
Indiana/Dubois	3,278,243	1.6	8 x Lafayette
Mississippi/Smith	10,729,243	3.6	6 x Jackson, MS

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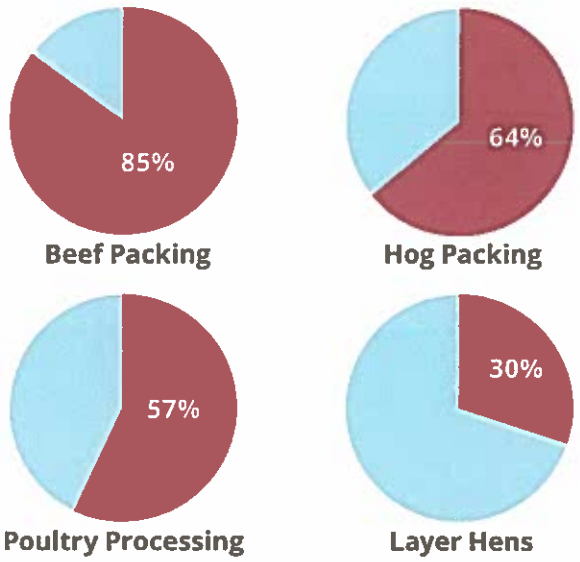
The High Cost of Low-Priced Feed

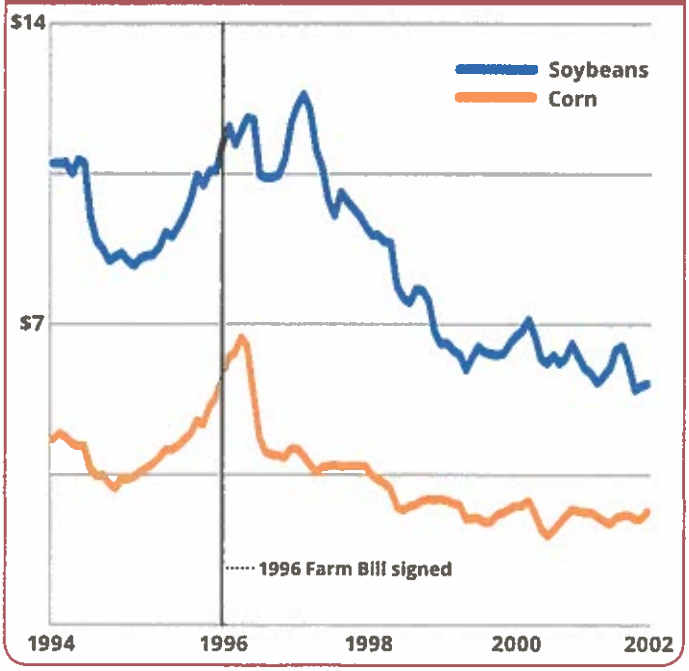
Traditionally, most farmers raised livestock on pasture and also grew the feed they needed to sustain their animals over the winter. Farmers continued to pasture and cultivate feed for their animals because, prior to the 1990s, buying feed was expensive. Factory farms, however, must purchase enough grain to feed the thousands of animals that they keep at each site. Over the past 20 years, changes to federal farm policy have largely promoted the overproduction of feed crops such as corn and soybeans, which drove prices down from the late 1990s through the late 2000s. This reduction in feed price was an indirect subsidy for factory farm operators.

Figure 12 • Market Share of Top Four Firms



SOURCE: USDA GIPSA; USDA ERS, *WATT EGG INDUSTRY.*

Figure 13 • Real Price of Corn and Soybeans
($/Bu. in 2014 dollars)



SOURCE: USDA NASS, BUREAU OF LABOR STATISTICS.

The 1996 Farm Bill, called the Freedom to Farm Act, marked the end of policies designed to stabilize farm prices. It eliminated the requirements to keep some land idle as a way to manage supply and prevent overproduction. Instead, farmers could plant crops on as much land as they wanted. Additionally, the government eliminated reserves of grain, allowing all the grain produced onto the market at once, which can drive prices down. Even the system of loans to farmers was reworked. Farmers could no longer forfeit a portion of their crops to the government as repayment for their loans if crop prices fell below the cost of production. Farmers instead sold their entire crop, further flooding the market and prices.

As a result of this drastic increase in production and timing of sales, crop prices plunged. Between 1996 and 1997, real corn prices dropped by 28 percent.[76] (See Figure 13.) The crop price free fall continued for years. By 1999, the real price of corn was 50.0 percent below 1996 levels, and the soybean price was down by 40.9 percent. As prices fell, farmers planted additional acres to try to make up for their lost income, which then caused more supply and further price drops. The Freedom to Farm Act thus became known in farm country as "Freedom to Fail."

To quell criticism after prices collapsed, Congress authorized emergency payments to farmers that reached $20 billion in 1999.[77] However, these payments could not make up for the decline in prices. Even with the payments, U.S. net farm income declined by 16.5 percent from 1996 to 2001.[78] In the 2002 Farm Bill, Congress voted to make these "emergency" payments permanent.

The 2002 and 2008 Farm Bills continued to replace supply and price management policies that had characterized federal farm policy since the 1930s with income supports designed to compensate for low prices generated by overproduction. Instead of programs that could put a brake on collapsing prices, government payments make up the difference between the low price that agribusiness pays farmers for crops, and the farmers' cost of sowing, growing, harvesting and transporting the crops. Permitting crop prices to fall below their production costs and then paying farmers some of the difference with taxpayer dollars indirectly subsidizes discounted commodity purchases by meatpackers, factory farms and food processors.

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Grain and oilseed prices rose sharply in 2008 and remained higher than in the prior decade until the passage of the 2014 Farm Bill. Climate change-driven weather disruptions and drought, the increased demand for crop-based biofuels and stronger consumer buying power in rapidly industrializing developing countries established the foundation for the 2008 price spike, which was accelerated by Wall Street investment firms that started to view farm production as a new investment vehicle.[79]

Crop prices generally remained volatile but high between 2008 and 2012.[80] The 2014 Farm Bill was enacted in this high-price environment, allowing Congress to further weaken the farm safety net and to set the stage for a potential replay of the meltdown after the 1996 Farm Bill. The 2014 Farm Bill shifted emphasis further from the traditional farm programs into subsidized, private crop insurance that protects farmers from declining yields but not declining prices.[81]

These policies driving overproduction of the main ingredients in animal feed saved industrial livestock producers billions of dollars when crop prices declined. Until 2007, when commodity prices began to rise, factory farms could actually buy feed on the market at a price lower than what the grain cost to produce. A 2007 Tufts University study found that factory farms saved $34.8 billion between 1997 and 2005 because they were able to buy feed at below-production cost.[82] This indirect subsidy has been a key element of the so-called efficiency of factory farming.

When commodity prices rose in 2007 and 2008, meatpackers, industrial feedlots and poultry processors saw significant drops in profit as the cost of their major input — feed — started to rise. By 2014, crop prices began to fall again and were projected to remain low for the foreseeable future.[83] The forecast of a long-term, low-priced feed environment has encouraged a resurgence of factory farm construction for hogs and broiler chickens.[84]

Weak Environmental Regulation

Weak environmental oversight reduces the cost of running factory-farmed livestock operations. Municipal sewer systems must treat the wastewater that is discharged into waterways, and factories cannot simply pump ammonia and hydrogen sulfide gas out their smokestacks without some kind of treatment. Although factory farms pay the cost of storing manure in lagoons and spraying waste on their fields, the weak environmental oversight of how manure is ultimately disposed of allows tremendous environmental and public health burdens to be put on communities surrounding factory farms.

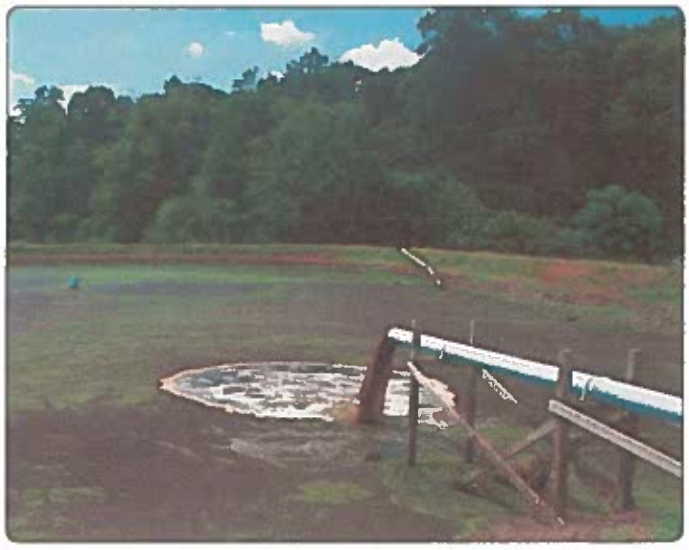

PHOTO BY USDA NRCS

Water Pollution

The Clean Water Act (CWA), passed in 1972, gave the EPA the authority to regulate any entity discharging pollution into national waterways, including Concentrated Animal Feeding Operations (CAFOs), the official government terminology for factory farms. The CWA set a strong and simple standard that polluting is illegal and that the national goal is *zero* discharge of pollution into our public waterways.[85] Short of actually achieving zero discharge, the CWA set limits on discharges. The EPA has considered CAFOs a "point source" of water pollution since the 1970s,[86] but it initially focused its efforts on industrial sites and sewage treatment plants, leaving CAFOs virtually unregulated for years.[87]

Insufficient Permitting

The EPA, or a state agency under the EPA's authority, sets "specific limits and conditions" on how CAFOs discharge waste into local bodies of water.[88] The most recent EPA regulations for CAFOs, released in 2008, have significant weaknesses. One of the most critical is that the rules allow individual CAFO operators to determine if they discharge or intend to discharge and thus whether they should apply for a permit.[89] According to a 2003 U.S. Government Accountability Office (GAO) report, however, "EPA officials believe that most large operations either discharge or have a potential to discharge animal waste to surface waters and should have discharge permits."[90]

Yet, according to an EPA file from 2011, an estimated 41 percent (approximately 7,600 out of 18,500) of eligible CAFOs actually had discharge permits. At the state level, the estimated number of permitted CAFOs ranges from zero to 100 percent. Thirteen states reported permitting fewer than 10 percent of their estimated CAFOs, including

states with large numbers of facilities such as Iowa, Illinois, North Carolina, Arkansas and Oklahoma.[91] Even worse, of the 38 states that issue permits to CAFOs, their regulations vary widely, with some states still not meeting the EPA's rules from a decade ago.[92]

Just as worrisome as the inconsistent permitting is the lack of information that the EPA possesses about CAFOs. Neither the EPA nor any other federal agency collects comprehensive data on the number of CAFOs or their size or location. Without that information, the EPA simply cannot regulate CAFOs effectively.[93] In 2013, a coalition of environmental, consumer and community groups filed suit against the EPA over the agency's failure to create an accurate, publicly available database of all CAFOs in the United States.[94] As of spring 2015, a decision in the case was pending.

The debate over the EPA's data collection grew even more intense when, in 2013, the American Farm Bureau Federation and the National Pork Producers Council filed a lawsuit against the agency to try to block it from releasing data related to factory farms and their pollution under the Freedom of Information Act (FOIA). The case was based on the industry's claim that information about factory farms — such as business names and addresses — should be private and shielded from public view.[95] The industry groups sued the EPA after the agency released factory farm data in response to FOIA requests filed after the agency withdrew a rule that would have collected basic information about the location of factory farms.

The EPA responded to industry criticism about the release of information under FOIA by recalling all of the data that it had already released and replacing it with heavily redacted data.[96] After several environmental and community organizations were allowed to intervene in the case, a judge dismissed the industry lawsuit in early 2015.[97] The industry groups wasted no time in appealing the dismissal, and, in the spring of 2015, the case was headed to a higher court.[98]

Subsidizing Pollution Cleanup

The main costs of factory farms are what goes in — feed — and what comes out — manure and other livestock waste. But as the number of animals on factory farms has ballooned, federal and state environmental officials largely have ignored the growing pollution burden on rural communities, waterways and aquatic ecosystems.

The USDA offers a direct subsidy to factory farms under the Environmental Quality Incentives Program (EQIP). The 2002 Farm Bill dedicated 60 percent of program funding to livestock operations, including manure management systems.[107] Taxpayers paid $179 million between 2003 and 2007 to cover manure management costs just for industrial dairy and hog operations under EQIP.[108] The most recent Farm Bill increased the maximum payment for EQIP from $300,000 to $450,000 per contract, allowing for larger industrial-scale projects to be covered under the program.[109]

EPA Oversight of State Permit Programs

Iowa and Illinois, two states with more than 1,450 factory hog farms and cattle feedlots,[99] have such failed permitting systems that the EPA intervened to try to correct the course of permitting factory farms in these states.

Iowa: In 2007, several environmental groups filed a petition to the EPA requesting investigation of improper handling of CAFO discharges in Iowa.[100] The EPA's preliminary report found that in nearly half of cases it reviewed, the Iowa Department of Natural Resources (DNR) either "failed to act or did not follow its enforcement policy" in cases of permit violations. Additionally, Iowa DNR did not enforce adequate penalties against CAFOs for violations, nor was it consistent in requiring permits.[101] In 2013, the EPA and Iowa DNR reached an agreement.[102] The final agreement was less stringent than a proposed EPA draft, however, and watchdog groups continue to report slow progress in meeting the agreement.[103]

Illinois: The Illinois Citizens for Clean Air & Water petitioned the EPA to remove Illinois' authority to manage its permit program in 2008. The EPA found that Illinois' program did not "meet minimum thresholds for an adequate program," failing in several measures.[104] In 2013, the EPA and the Illinois EPA agreed to prioritize issuing permits to previously unpermitted CAFOs that may have been in violation of the Clean Water Act.[105] The initial report declared that Illinois needed to "develop and maintain a comprehensive inventory of CAFOs and evaluate their regulatory status," an ironic recommendation when the EPA fails to do so nationally.[106]

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Air Pollution

Federal law requires all facilities — factories or factory farms — to report any *significant* accidental releases of certain dangerous air pollutants, like ammonia.[110] In practice, the EPA does almost nothing to prevent factory farms from releasing dangerous air pollutants.

In 2005, the EPA announced a compliance agreement with the large-scale livestock industry that exempted participating operations from air quality violations if they joined a study on factory farm air emissions.[111] This was a sweetheart deal for factory farms. The EPA managed a program of university researchers that monitored air pollution from a small number of participating operations, while all participating operations would be excused from provisions of the EPA's air quality enforcement.[112] According to the EPA, approximately 90 percent of the "largest" factory farms signed the agreement.[113]

The EPA claimed that, without the study, it did not have enough data on air emissions to apply the Clean Air Act to factory farms.[114] Yet, according to the GAO and the EPA's own science advisers, this study might not even provide the necessary information to oversee air pollutants because of incomplete data collection and a distorted sample of facilities.[115]

In 2008, the EPA announced that all but the very largest factory farms and those already participating in the compliance agreement were to be exempt from reporting large releases of hazardous chemicals into the air.[116] Industry groups, apparently not realizing that factory farms previously had been required to report emissions, sued the EPA. The industry claimed that the reporting requirements for a fraction of factory farms was a new obligation, rather than the massive deregulation that it was.[117] A coalition of environmental groups sued the EPA to remove the exemptions, but the court sent the rule back to the EPA in 2010 after the agency said it would reconsider the exemptions. Because the EPA never reconsidered its rule, the groups sued again in 2015, asking the court to re-open the challenge to the exemptions.[118]

PHOTO BY USDA-NRCS

As of 2015, the EPA's studies continue without any clear end point. Meanwhile, the factory farms that agreed to be part of the study still maintain their exemptions from any compliance measures if they are found to be polluting — and regulatory initiatives remain on hold.[119]

The High Costs of Factory Farms

Water Pollution and Manure Spills

Manure from factory farms poses a significant risk to communities and the environment. According to the EPA, agriculture remains a major source of water pollution.[120] And according to the GAO, "manure and wastewater from animal feeding operations can adversely impact water quality through surface runoff and erosion, direct discharges to surface water, spills and other dry-weather discharges, and leaching into the soil and groundwater."[121]

States have identified animal feeding operations specifically as the polluters of almost 20,000 miles of rivers and streams and over 250,000 acres of lakes, reservoirs and ponds.[122] While livestock waste in appropriate quantities can serve a useful purpose as fertilizer for crops, the huge concentration of animals in factory farms leads to excessive concentrations of waste.[123]

Unlike in cities, where human waste ends up at a sewage treatment plant, untreated livestock waste is flushed out of confinement buildings into large cesspools, or lagoons. These waste pools can leak or burst, especially during storms, spilling into local waterways, killing fish and spreading waste and odor across communities. Manure from lagoons is applied to fields as fertilizer, but when the application exceeds the ability of fields to absorb the nutrients, the residual nutrients from manure — mostly nitrogen and phosphorus — and bacteria leach off fields and into groundwater and rivers.[124]

The long list of contaminants making their way from manure into drinking water includes heavy metals, antibiotics and pathogenic bacteria.[125] Six of the 150 pathogens found in animal manure are responsible for 90 percent of human food- and water-borne diseases: *Campylobacter, Salmonella, Listeria, E. coli* 0157:H7, *Cryptosporidium* and *Giardia.*[126]

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Even small amounts of pathogenic bacteria in drinking water can lead to disease.[127] For example, in 2006, an early thaw leached *E. coli* and bacteria from the 260 million gallons of manure produced by 41,000 dairy cows in Brown County, Wisconsin. It polluted more than 100 nearby wells.[128] Residents of the town of Morrison, Wisconsin suffered from chronic diarrhea, stomach illnesses and ear infections, and one household that tested its tap water found *E. coli*, coliform bacteria and other contaminants associated with livestock manure.[129] In 2014, liquid manure from a 4,000-cow dairy farm in New York contaminated six residential water wells with *E. coli*.[130]

Air Pollution and Odors

Factory farms can release significant volumes of toxic chemicals into the air. Decomposing manure releases ammonia and hydrogen sulfide gases in concentrations that are potentially harmful to nearby residents.[131] The GAO reported that storing large quantities of livestock manure on factory farms could cause emissions of "unsafe quantities" of ammonia, hydrogen sulfide and particulate matter.[132]

Overexposure to hydrogen sulfide can cause dizziness, nausea, headaches, respiratory failure, hypoxia and even death.[133] Factory farm hydrogen sulfide releases have contributed to excess diagnoses of respiratory and digestive disturbances; workers in factory farm facilities experience high levels of asthma-like symptoms, bronchitis and other respiratory diseases.[134] In liquid manure holding pits, releases of hydrogen sulfide can exceed lethal levels when waste from the lagoons is agitated prior to being pumped out of the facility.[135]

A Fine Mess

My wife and I have lived on the Door Peninsula in the same neighborhood for 36 years. It is the thumb on Wisconsin that sticks out into Lake Michigan. Door County is billed as the "Cape Cod" of the Midwest, with over 300 miles of shoreline along Green Bay and Lake Michigan, serving as a major tourist destination.

On the morning of September 16, 2014, we learned that the dairy farm a quarter mile west of us had a manure system malfunction that resulted in 640,000 gallons of liquid manure flowing across fields into Sugar Creek. This was one of the largest manure spills in Wisconsin history, and the second manure spill by a large farm within a week in the county.

The days following the spill demonstrated how inept, ill-equipped and incompetent various county departments and state agencies such as the Department of Natural Resources were in dealing with the spill. It took the county health department eight days after the spill to notify residents that we should take precautions such as testing wells and buying bottled water to drink. One week after the spill, and following some rain over the ensuing weekend, state environmental officials ordered the farmer to remove the retaining dikes in the creek, allowing the remaining effluent (now swelled to over 3 million gallons) to simply flow downstream into a bay that connects to Lake Michigan. No attempt was made to inform property owners further downstream of the mess headed their way.

A simple check valve in the manure system that would have prevented the whole mess was reportedly not installed, evidently with the permission of county soil and water officials who approve the design of manure systems. To date, no county employees have been held accountable for their role in these incidents, including the poorly designed system and the failure to enforce compliance with required nutrient management plans. To top this off, the county had no manure spill emergency plan.

But despite the inept response by county and state departments, it is clear that taxpayers will take a financial hit in the aftermath of this spill — paying for personnel to supervise the cleanup, the cost of testing well water and the impact on tourism and other costs of the further degradation of state waters by all this effluent being allowed to simply flush downstream.

– John Bobbe

Executive Director of the Organic Farmers' Agency for Relationship Marketing, Inc., an organic grain and livestock marketing cooperative with members in 19 states

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Too Much Manure: Spills, Foam, and Explosive Bubbles

Storing vast quantities of manure, whether liquid in lagoons or solid in piles, creates the opportunity for spills. These spills can unleash thousands or even hundreds of thousands of gallons of waste that contaminates drinking water, kills wildlife and ruins recreational activities. Manure storage also presents unique hazards for regulators and communities to manage.

Overwhelming Spills

Nebraska: In 2012, a beef feedlot housing 83,000 cows agreed to pay a $145,000 civil penalty for 13 violations for spills that released a total of 140 million gallons.[146] That works out to only a dollar for almost every 1,000 gallons spilled.

Minnesota: In 2013, a dairy farm spilled approximately 1 million gallons of manure from a football-field-sized lagoon.[147]

Wisconsin: 2013 was the worst year for manure spills in the state in seven years, with over a million gallons spilled. One farm's manure digester alone discharged 300,000 gallons directly into a local creek.[148]

Health Concerns

Maryland: In 2009, a 1,000-cow Frederick County, Maryland dairy operation reimbursed the county and a local city $254,900 for providing emergency water supplies, testing and other costs after a 576,000 gallon manure spill in 2008 polluted the town's water supply, which had to be shut off for two months.[149]

Michigan: In 2014, an estimated 20 million gallon lagoon released an unknown amount of raw manure that polluted a local creek, leading to a health advisory to avoid any contact with the water.[150]

Fish Kills and Environmental Damage

Iowa: Manure discharges from Summit Dairy in O'Brien County polluted a 28-mile length of a stream that killed more than 860,000 fish. The Iowa Department of Natural Resources estimates the value of the fish to be nearly $160,000.[151] A trench built to drain water from a construction site at the dairy exacerbated the problem.[152]

Minnesota: In 2009, a 250,000 to 300,000 gallon manure spill from a 660-head Pipestone County, Minnesota dairy leaked into a tributary after a pipe

(continued on next page)

One 1,500-cow dairy in Minnesota released so much hydrogen sulfide gas in 2008 that the state evacuated nearby residents and declared the dairy a public health hazard.[136] Although residents had complained about odors from the dairy for years, the Minnesota Pollution Control Agency did not install a monitor to measure emissions until the spring of 2008.[137] Emissions levels remained high throughout the summer. That October, the Minnesota Department of Health declared the Excel Dairy a public health hazard, the first time that Minnesota declared a large livestock operation a public health risk.[138]

Exposure to a variety of pollutants from factory farms can lead to lung problems such as irritation and impaired breathing.[139] Children exposed to factory farm pollutants face higher likelihood of having asthma or taking medication for wheezing.[140] Workers at hog facilities experience more bronchitis and asthma than average.[141]

In addition to the health risks, factory farm odors diminish the quality of life for neighbors who can no longer hang their laundry out to dry, picnic in their yards, sit on their porches or even open their windows. Odors from factory farms have been associated with physical symptoms such as headaches, eye irritation and nausea.[142] In North Carolina, hog factory farms are most often located in lower-income, minority communities, disproportionately affecting those with the least ability to stand up to adverse conditions imposed by neighboring facilities.[143]

In 2010, a Missouri jury awarded $11 million to neighbors of Premium Standard Farms who complained of odors from the 1.8 million hogs produced annually on the company's Missouri operations.[144] The significant nuisance of living near the overwhelming stench of factory farms even erodes the financial health of the facilities' neighbors. A 2008 study of house sales in Iowa found that homes within three miles or downwind of a factory farm received lower prices when selling their homes.[145]

Impact on Farmers

The consolidation of economic power in the meat industry harms the livelihoods of independent, medium-size and smaller farmers and slaughterhouse workers. As factory farms increase in number, research shows that rural employment and income decline. A 2003 study of nearly 2,250 rural counties

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(Too Much Manure *continued from page 23)*

between manure basins clogged. The spill killed fish and closed a state park to swimmers for Memorial Day weekend after heightened levels of fecal coliform bacteria were found in the park's waters.[153]

Wisconsin: In 2014, a dairy farm accidentally released 50,000 gallons of manure into a local stream that "killed all the fish in that part of the stream." Even though the farm promptly reported the spill to the Department of Natural Resources, the environmental damage was extensive.[154]

Idaho: In 2010, the EPA ordered a Grand View feedlot containing between 30,000 and 65,000 head of beef cattle to cease discharging fecal bacteria-contaminated water from its stock watering system into a tributary of the Snake River. The EPA noted that the feedlot "discharges a tremendous volume of contaminated water into a river already impaired by bacteria and nutrient pollution."[155]

Iowa: In 2009, 25,000 gallons of manure released over a farm field at a Mitchell County hog operation killed 150,000 fish over four miles of a local stream.[156]

Virginia: In 2010, the EPA ordered a 100,000 broiler chicken operation to cease discharging pollutants from large piles of uncovered chicken manure that were leaching nitrogen and phosphorus into a tributary of the Shenandoah River.[157]

Unique Hazards

Manure Lagoon Bubble: In 2010, at a 1,650-cow Randolph County, Indiana dairy operation, a manure lagoon liner detached, floated to the surface of the lagoon and became inflated with decomposing manure gases.[158] The manure bubbles were large enough to be seen from satellite photos, but the operator, who had declared bankruptcy after milk prices collapsed, could not afford to repair the liner.[159] After the county shut down local roads and banned school buses from the surrounding area because of the risk posed by potential noxious gas releases or explosions, Indiana environmental officials deflated the bubbles.[160]

Manure Foam: Manure foaming is an unpredictable, and as yet unpreventable, process in which bubbles form in manure, creating an unusual "thick, mucous consistency." The manure foam bubbles contain methane and hydrogen sulfide, posing a risk of explosions and fire. Release of the gases themselves can harm people and animals. Attempts to treat manure foam in hog facilities have had mixed success.[161] In Minnesota alone since 2009, foaming manure conditions on at least 20 hog factory farms have caused fires or explosions.[162] One explosion lifted a hog barn off the ground and threw the farmer 20 feet from the building. A study of hog farms in Minnesota, Iowa and Illinois found that 25 percent of the surveyed farms had foam in their manure pits. Researchers are still investigating the causes of manure foam and strategies to manage it safely.[163]

PHOTO BY USDA-NRCS

Natural Disasters: In 1999, Hurricane Floyd hit North Carolina. The storm flooded 50 lagoons and caused 3 of them to burst, which led to the release of millions of gallons of manure mixed with the rising floodwaters. Approximately 30,500 hogs, 2.1 million chickens and 737,000 turkeys drowned.[164]

Manure Digester Explosions: Some farms use anaerobic digesters to store manure and generate energy from the methane gas that manure releases as it decomposes. Methane is flammable, however, and that can lead to problems.[165] In Wisconsin, a faulty 1.25 million gallon dairy farm manure digester was linked to manure spills and a major explosion.[166] A methane leak on another dairy farm digester in Oregon sparked a fire in 2012.[167]

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Figure 14 • Number of Iowa Hog Farms

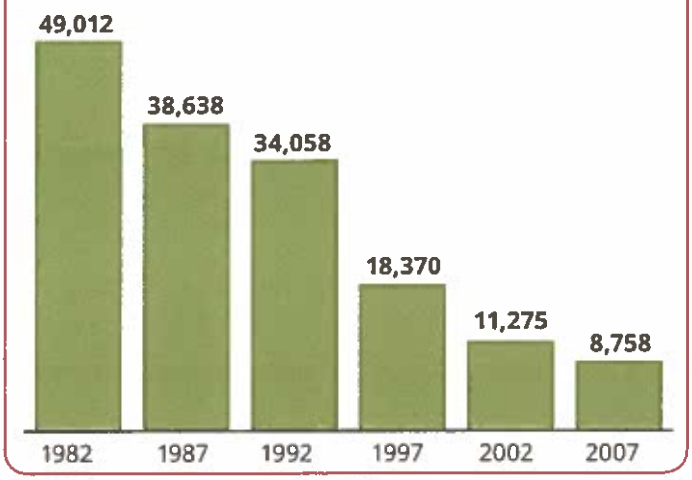


Figure 15 • Average Number of Hogs Sold per Iowa Farm

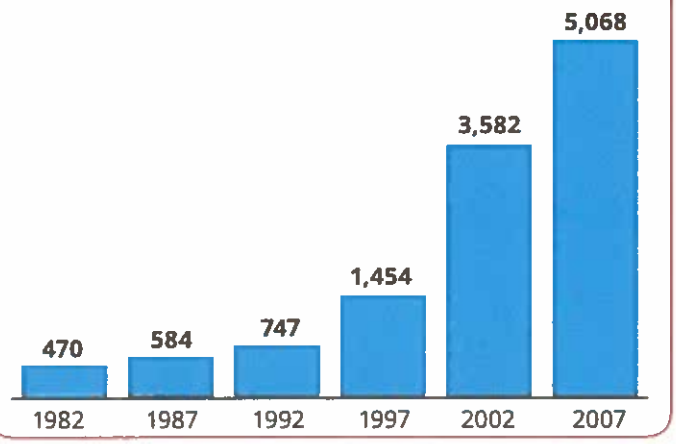
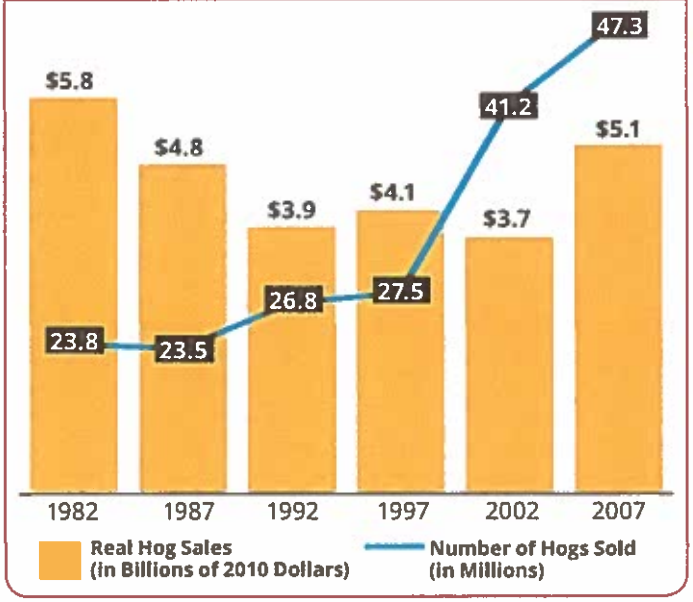


Figure 16 • Value of Real Hog Sales Falls as Total Number of Hogs Sold Doubles



SOURCE – FIGURES 14, 15 AND 16: FOOD AND WATER WATCH *ECONOMIC COST OF FOOD MONOPOLIES.*

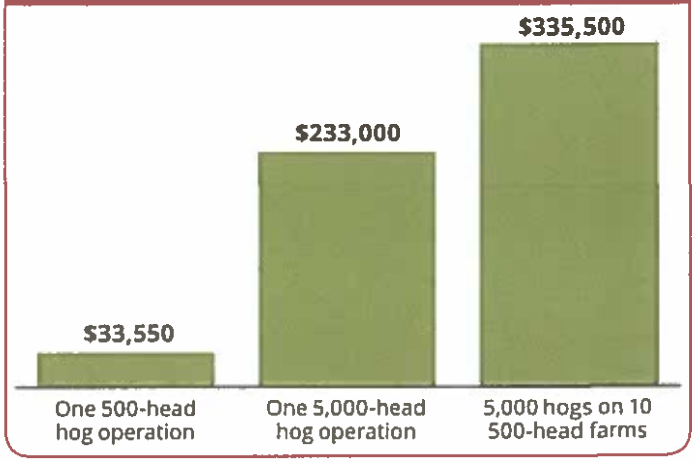
nationwide found that counties with larger farms had lower levels of economic growth, suggesting that larger farms make smaller contributions to local economies.[168]

As a longtime player in U.S. hog and pork production, Iowa is a prime example. Between 1982 and 2007, the number of hog farms in the state plunged from just over 49,000 to just under 9,000 (see Figure 14), while the average number of hogs per farm rose from just under 500 to just over 5,000, a 10-fold increase (see Figure 15).[169] The economic value of the hog industry in the state declined, even as it sold more hogs from fewer farms. Hog sales more than doubled between 1982 and 2007, but the total inflation-adjusted value of the hogs dropped by 12 percent. (See Figure 16.) Iowa shed 41.6 percent of its farm jobs between 1982 and 2007, amounting to 64,000 positions statewide.[170]

Between 2004 and 2011, the plants owned by the top four pork-packing firms slaughtered 9 out of 10 hogs in Iowa.[171] Even accounting for hog sales across state lines, Iowa farmers sold their hogs into a market where the four largest firms slaughtered 4 out of 5 hogs, which makes Iowa considerably more concentrated than the national market.[172]

Both agricultural workers and their surrounding communities can feel the impacts of this concentration. While independent medium- and small-scale farmers are more likely to buy their supplies locally,[173] circulating earnings across local communities and generating an economic "multiplier effect,"[174] large-scale farms rely far less on local sources. A University of Minnesota study revealed that smaller livestock operations (less than $400,000 in income) spent between 60 and 90 percent of their purchases locally, compared to less than 50 percent of the purchases by farms with income over $600,000.[175] (See Figure 17.)

Figure 17 • Local Spending by Hog Farms



SOURCE: ALBELES-ALISON & CONNER 1990.

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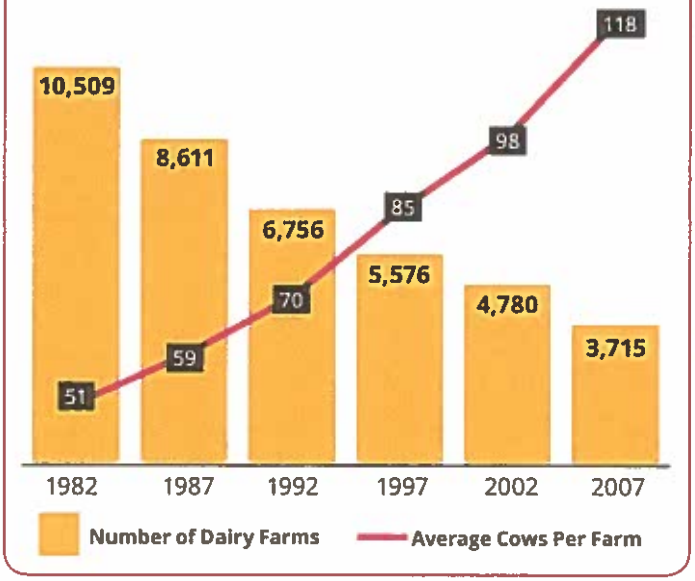
New York's dairy industry has seen a similar transition, losing 65 percent of its dairy farms between 1982 and 2007, while the average herd size doubled. A 2012 study of two New York counties revealed an inverse correlation between dairy farm sizes and real median household income levels, real total personal incomes and the number of small businesses.[176] (See Figure 18.) Between 1982 and 2007, St. Lawrence County saw the loss of 77 percent of its dairy farms, while its remaining dairy farms grew 183 percent larger. In contrast, Yates County, which doubled its number of dairy farms, maintained a low number of cows per farm. Yates County experienced better economic indicators over that time period compared to St. Lawrence County, including a fivefold increase in small businesses.[177]

Impact on Communities

With all of the harmful environmental, social, economic and public health impacts of factory farming, it comes as no surprise that citizens and communities near factory farms have attempted to fight back against the spread of these facilities. Some municipalities and counties have tried zoning restrictions and siting requirements for new factory farms, while others have tried to prevent corporate and foreign ownership of farms. However, in many parts of the country, agribusiness has been able to exert considerable influence, and state legislatures have acted on behalf of corporate agriculture by taking control away from local governments and handing it over to state agencies that are heavily influenced by factory farming interests.

Figure 18 • Number of Dairy Farms and Average Farm Size, 24 New York Dairy Counties



SOURCE, FIGURES 14, 15 AND 16: FOOD AND WATER WATCH *ECONOMIC COST OF FOOD MONOPOLIES*.

In Ohio, proponents of industrial livestock production launched an offensive in 2009 designed to wrest oversight of livestock operations from state agricultural and environmental agencies and shift it to a commission that could be easily dominated by special interests representing factory farms. In 2009, a referendum backed by major agribusiness interests, including the Ohio Farm Bureau and the Ohio Pork Producers Council,[178] changed the Ohio state constitution by establishing an appointed Livestock Care Standards Board that would have unchecked power to establish standards for livestock and poultry in the state. Because agribusinesses outraised the critics of the referendum by more than 50 to 1, the initiative passed and successfully provided the industry with a way to regulate itself.[179]

In 2005, the Pennsylvania legislature essentially eliminated local control of agriculture when it passed the Agricultural, Communities and Rural Environment Act, a bill that allowed the state's attorney general to sue municipalities on behalf of factory farm owners if local ordinances "restricted" agricultural operations or ownership.[180]

Also in 2005, Indiana governor Mitch Daniels announced his intention to double pork production in the state by 2025.[181] With minimal public input, Governor Daniels and his new Department of Agriculture quickly established rules to increase the number of factory farms in the state.[182] The rules included limiting citizens' ability to sue factory farms for losses in their property values,[183] creating model zoning restrictions to facilitate siting new factory farms,[184] and fast tracking hog factory farm permits through the Indiana Department of Environmental Management.[185] In return, residents have experienced rivers polluted by millions of gallons of spilled manure,[186] tens of thousands of dead fish,[187] and community strife and unrest.[188]

Community organizations in Missouri have had to repeatedly fight to maintain local government control over factory farms. For more than a decade, agribusiness has attempted to push measures through the Missouri legislature that would eliminate local control, and each time, citizens have successfully preserved their right to protect their communities. According to Rhonda Perry, a livestock and grain farmer and program director of the Missouri Rural Crisis Center, "Missouri's family farmers, rural citizens and landowners have seen firsthand what these corporate-controlled industrial livestock operations have done to local economies, the environment and rural health. In response, our local elected officials have exerted 'local control' by passing health ordinances and making

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these operations more accountable to the people, taxpayers and environment of the county. At the state legislature, corporate agribusiness lobbyists and their allies attempt to take away local control from our counties and their citizens, but every year family farmers and rural people stand up and say 'NO! Government is best when it is closest to the people.'"[189]

The battle over local control shows the lengths that agribusiness will go in order to have its way. By trying to resist local democratic processes, the industry is trying to consolidate not only the markets for livestock, but also its control over public policy.

Impact on Consumer Prices

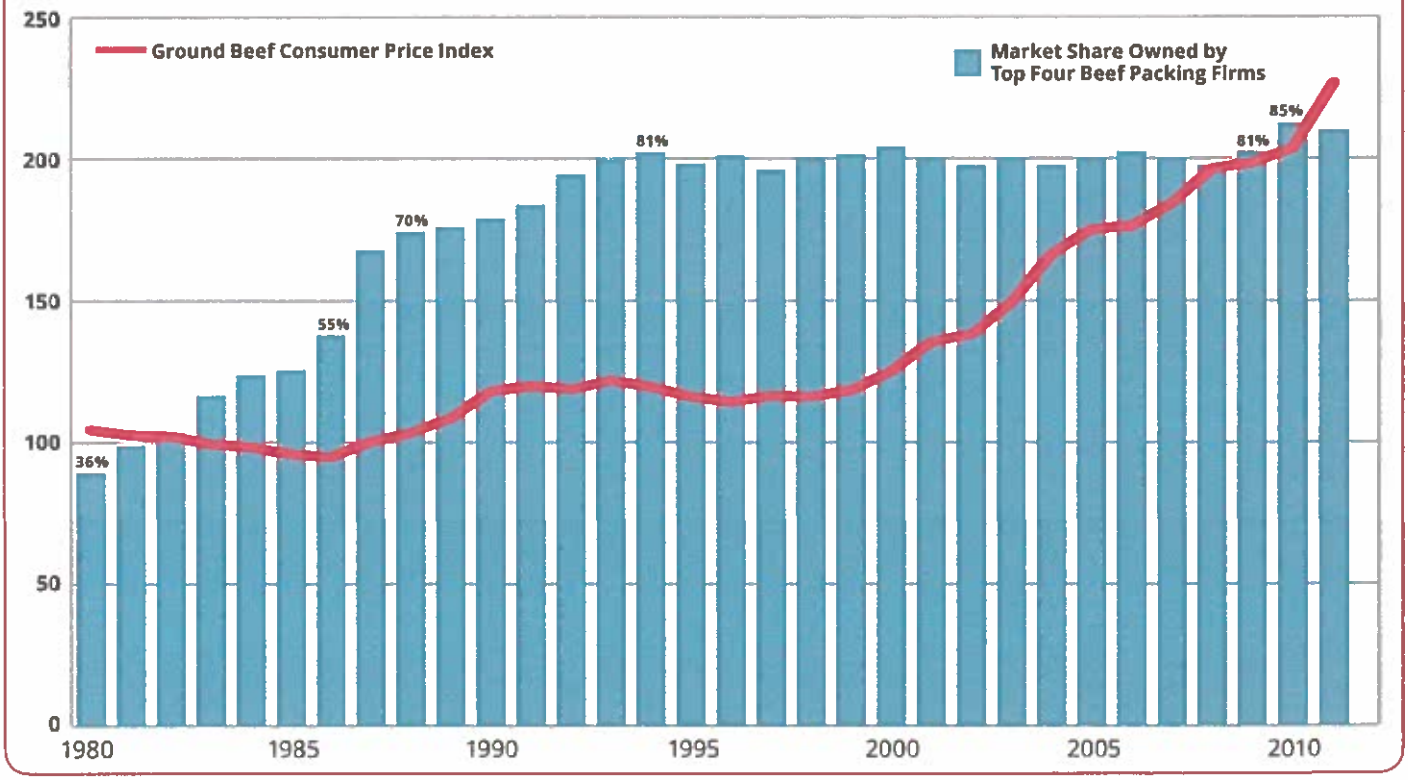
Despite claims about the supposed efficiency gains of the factory farm model, the real prices that farmers received for their livestock have been falling for decades, and few of these savings are passed on to consumers. The largest meat and milk companies, along with the big grocery chains, can seize more of the margin between the farmgate and retail prices. Since the mid-1980s, the inflation-adjusted cost of a market basket of groceries has risen relatively steadily.[190] In contrast, the farmer's share of the same market basket of groceries remained at about a third of the retail grocery sales between 1960 and 1980, but then declined sharply to 24 percent in 1990 and about 16 percent in recent years.[191]

Consolidation is a big contributor to rising grocery prices. When more rivals compete for shoppers' attention, they tend to compete by offering the best prices possible, but when there are few rivals, there is no competitive pressure to keep price hikes in check. Once consolidation becomes entrenched, prices seem to rise steadily.[192] (See Figure 19.)

Between 1980 and 1995, the market share of the top four beef packing firms essentially doubled. The biggest four firms slaughtered one out of three beef cattle in 1980 but four out of five in 1995, and ground beef prices rose modestly by about 11 percent. Since 1995, the beef packing industry has remained significantly consolidated, with the largest firms controlling about 85 percent of the market. Consumer prices for ground beef almost doubled from 1995 to 2011.

Dairy products present the starkest picture of the disconnect between what consumers pay in the grocery store and what farmers get paid. When milk prices collapsed between 2007 and 2009, the price that consumers paid for dairy products fell only modestly — if at all. Between July 2007 and June 2009, the real price that farmers received

Figure 19 • Ground Beef Prices and Beef Packing Consolidation



SOURCE: USDA GIPSA; BLS.

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for milk fell by 49 percent, but the retail price for milk fell only half as fast (by 22 percent), and the price of cheddar cheese increased by 6 percent.[193] (See Figure 20.) As the Utah Commissioner of Agriculture noted, "We are concerned that retailers have not reduced the retail price of milk to reflect the huge reduction in the wholesale level."[194] Very little of the money that consumers pay for milk ends up in the hands of farmers. In 2012, farmers received only $1.50 for every $4.89 gallon of milk.[195]

Impact on Public Health

Even people who don't live in rural communities are harmed from factory farming. Practices common on factory farms can lead to foodborne illness, including *E. coli* and *Salmonella* contamination and the risk of mad cow disease. The large number of animals raised in cramped conditions creates a perfect breeding ground for the formation of new diseases, and the routine use of antibiotics in factory farms can lead to the creation of deadly antibiotic-resistant bacteria.

E. coli

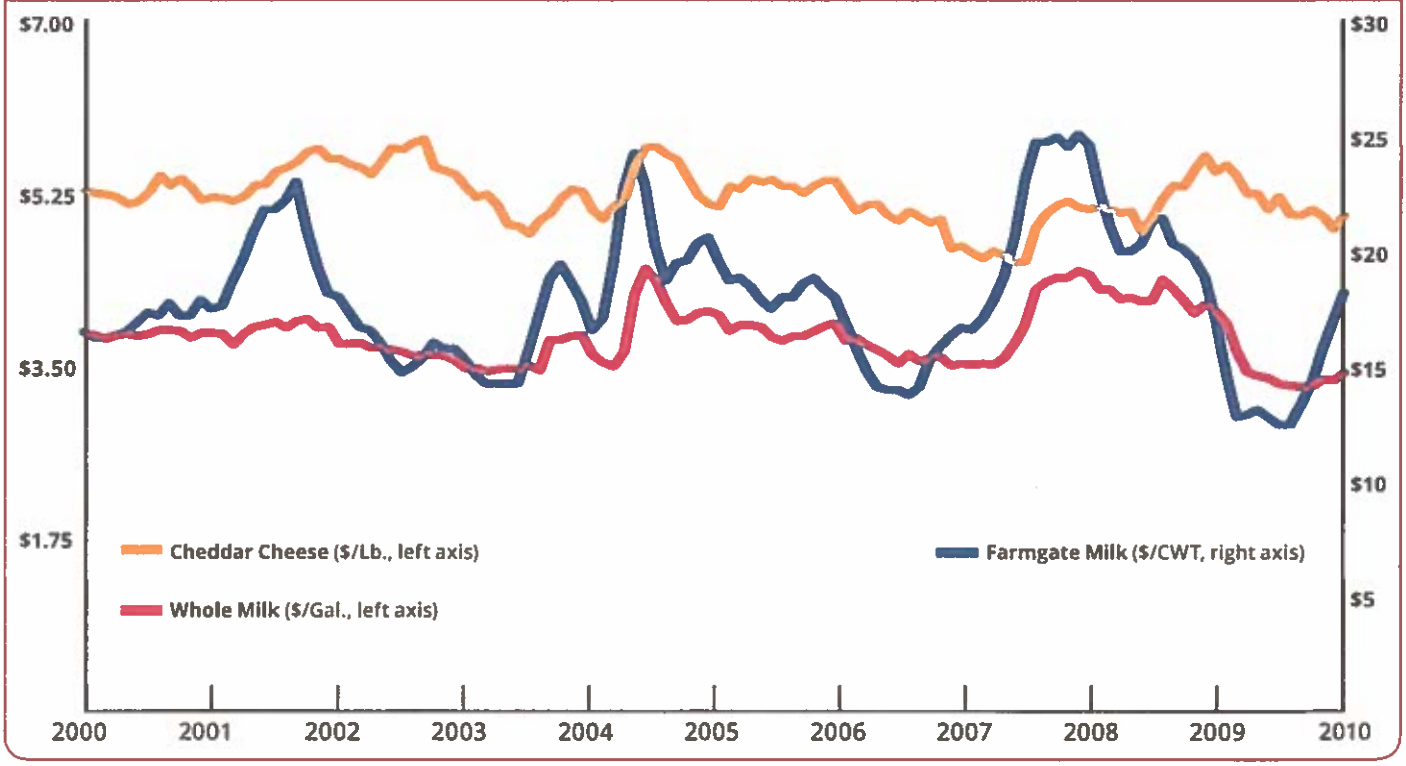
Cattle are uniquely suited to eat grass, but cattle finished in factory farm feedlots are instead fed grains like corn and soybeans. This practice has serious human health impacts. The diets fed to factory farm animals increase the concentration and the length of time that *E. coli*, including dangerous strains like O157:H7, survives in manure.[196] Not only does the bacterium pass on to meat from the intestines, hides and hooves of cattle that stand in their own feces all day,[197] but it also can contaminate other food sources, such as vegetables.[198] Agricultural sources also have been shown to be a considerable source of *E. coli* in recreational waters, potentially sickening people who swim.[199] Antibiotic-resistant *E. coli* in food has been implicated as a cause of urinary tract infections across multiple states.[200]

Salmonella

One of the most common causes of foodborne illness, *Salmonella* is a bacteria found in the intestinal tracts of animals.[201] Meat, poultry and eggs are common sources of *Salmonella* infection for people, although produce also has been contaminated with the bacteria. The tight confinement and crowded conditions found in U.S. operations are thought to increase the risk of *Salmonella*. Surveys done in the European Union led researchers to conclude that "cage production as well as a larger flock size were associated with a higher risk of positivity [for *Salmonella*]" in eggs.[202]

In addition to the threat of foodborne illness posed by *Salmonella*, the medical community has worried that the

Figure 20 • Real Farmgate Milk and Retail Milk and Cheddar Cheese *(in inflation-adjusted 2014 dollars)*



SOURCE: USDA NASS; BLS.

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overuse of antibiotics in livestock production could make these illnesses harder to treat (see below).[203] Although *Salmonella* can run its course without treatment, it also can cause severe complications, especially in the very young, elderly and immune-compromised. Antibiotic resistance makes this threat significantly worse.[204] In 2013, a *Consumer Reports* magazine study of 316 chicken breasts from across the country found that nearly 11 percent tested positive for *Salmonella* and 38 percent of the *Salmonella* showed resistance to multiple antibiotics.[205] In July 2014, the USDA rejected a proposal to list four types of antibiotic-resistant *Salmonella* as adulterants in ground meat and poultry, a designation that triggers stronger enforcement mechanisms.[206]

Three outbreaks demonstrate the damaging impact of *Salmonella*:

- **Foster Farms Chicken:** A major outbreak of antibiotic-resistant *Salmonella Heidelberg* linked to chicken from a company called Foster Farms sickened 634 people over the course of more than a year, mainly in California.[207] The USDA issued a public health alert about products from three Foster Farms plants in October 2013 after 278 people in 18 states had contracted *Salmonella Heidelberg*. Yet the plants remained open, and no recall was issued.[208] Foster Farms finally issued a recall of 170 different products in July 2014,[209] months after the initial outbreak.
- **Cargill Ground Turkey:** In the face of an illness outbreak caused by antibiotic-resistant *Salmonella*, Cargill voluntarily recalled 36 million pounds of ground turkey in August 2011, and an additional 185,000 pounds the next month.[210] This recall represented several months' worth of production from one plant in Arkansas.[211] In total, 136 people across 34 states were infected, yielding 37 hospitalizations and one death.[212] A disproportionate number of people infected were hospitalized due to the bacteria's resistance to antibiotics.[213]
- **Wright County Egg:** In the summer of 2010, more than half a billion eggs were recalled from two large Iowa egg companies that sickened nearly 1,500 people.[214] This case offered a stark example of how the scale of large factory farm operations can make bad management practices at just a few facilities trigger dramatic health impacts on a huge portion of the country's food supply.

Antibiotic-Resistant Bacteria

Factory farms are not only a source of foodborne pathogens, but they administer antibiotics to livestock in such a way that promotes antibiotic resistance. The Food and Drug Administration reported in 2011 that 80 percent of antibiotics in the United States are sold for agricultural purposes, and agriculture uses drugs from every major class of antibiotics used in human medicine.[215]

Livestock and poultry producers typically mix low doses of antibiotics, below the amount used to treat an actual disease or infection, into animals' feed and water over long periods of time.[216] The low doses of antibiotics kill some bacteria, but not all, leaving the antibiotic-resistant bacteria to survive and thrive. Antibiotic-resistant bacteria can even share resistance genes with neighboring bacteria, worsening the problem.[217]

Multiple studies have found antibiotic-resistant bacteria in many types of retail meat and poultry products.[218] In other words, when you buy meat at the grocery store, there's a decent chance that it has antibiotic-resistant bacteria on it. The Centers for Disease Control and Prevention (CDC) estimates that over 400,000 Americans experience an antibiotic-resistant infection from pathogens spread through food every year.[219]

One particular antibiotic-resistant strain of bacteria has been tied directly to livestock. Methicillin-resistant *Staphylococcus*, or MRSA, is a deadly strain of staph infection that is resistant to certain antibiotics. Researchers have strong evidence that a strain of MRSA originated in humans, migrated to pigs where it acquired resistance to antibiotics commonly used in the pigs, and now is infecting humans again.[220] A study has found farmworkers and pigs carrying the same strains of MRSA on conventional pig farms, but not on farms that do not use antibiotics in raising pigs.[221] Researchers have even found an increased

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likelihood of rural residents experiencing MRSA skin infections if they live near fields treated with swine manure.[222]

Most livestock waste stored in lagoons is applied to nearby fields as fertilizer, introducing antibiotic-resistant bacteria into the local environment.[223] The antibiotic-resistant bacteria not only spread, but share genes with naturally occurring bacteria in local fields, streams, ponds and even groundwater. These bacteria are adapted to their environment, just as the fecal bacteria are adapted to living in the digestive tracts of livestock, and may carry on reproducing with these new traits.[224] Thus, antibiotic-resistant bacteria from livestock contribute to a reservoir of antibiotic resistance in the environment.

Arsenic

For several decades, U.S. poultry farmers used drugs containing arsenic (a known poison) to control the common disease coccidiosis.[225] The chicken industry discovered that the arsenic-based drug roxarsone also promoted growth, increased feed efficiency and improved pigmentation of the meat.[226] Between 1995 and 2000, 70 percent of chicken producers used roxarsone feed additives.[227] Thanks to intervention from consumer, public health and environmental groups, arsenic use in feed is almost entirely a thing of the past.

The chicken industry maintained that arsenical drugs were safe for decades.[228] Yet, while arsenic levels in meat fed arsenical drugs were too low to cause an immediate toxic response, any exposure to arsenic adds to a person's overall risk of getting cancer over a lifetime.[229] Arsenic not absorbed into the animal flesh is passed out of the animal in its waste, then used for fertilizer, bringing arsenic as a contaminant into fields and rural communities and water supplies.[230]

In 2011, an FDA study compared two groups of chickens, raised under the same conditions, except one group was fed the maximum dose of the arsenical drug roxarsone and the other was not.[231] The livers of chickens fed roxarsone contained substantially more arsenic than the livers of chickens that were not, creating a "completely avoidable exposure to a carcinogen," according to the FDA. Indeed, the results were so dramatic that Pfizer, the manufacturer of roxarsone, decided to remove roxarsone from the market pending further investigation.[232]

In the spring of 2012, the Maryland State Legislature passed a ban on arsenic use in poultry feed,[233] another sign of waning trust in the safety of arsenical drugs. In 2013, the FDA withdrew its approval for three of the most

common arsenicals: roxarsone, carbarsone and arsanilic acid. In April 2015, the agency announced its plan to withdraw the last remaining arsenical drug, nitarsone, from the market at the end of 2015.[234]

Mad Cow Disease

Animal feed has long been used as a vehicle for disposing of animal byproducts.[235] Scientists believe that "mad cow disease," or bovine spongiform encephalopathy (BSE), is spread when cattle eat nervous system tissues, such as the brain and spinal cord, of other infected animals.[236] Variant Creutzfeldt-Jakob disease (vCJD), which causes dementia and ultimately death in humans, is believed to be caused by eating BSE-infected beef.[237] Keeping mad cow disease out of the food supply is particularly important because, unlike most other foodborne illnesses, it cannot be eliminated by disinfection or by cooking the meat.[238]

Four cases of mad cow disease have been confirmed in cattle in the United States — in December 2003, June 2005, March 2006 and April 2012.[239] In the fall of 2006, the USDA decided to scale back testing for mad cow disease by over 90 percent, claiming that the testing was expensive and that detection of infected cows was rare.[240]

In 1997, the FDA instituted a rule that banned certain animal proteins from cattle feed, but it continued to allow those proteins in other animal feed[241] and it did not ban blood products and poultry litter from cattle feed.[242] In 2008, the FDA updated the rule to ban the entire carcasses of BSE-positive cattle, as well the brains and spinal cords of cattle 30 months of age or older, from all animal feed.[243] A safer policy for consumers would be to remove all cattle tissues from the feed system, regardless of their age or BSE status, and also to ban restaurant plate waste, cattle blood and poultry litter from cattle feed.

Growth Hormones

In 1993, the FDA approved the use of a genetically engineered artificial growth hormone called recombinant bovine growth hormone (rBGH) to increase the milk yields of dairy cows.[244] This artificial hormone's known side effects include increased udder infections (mastitis) and reproductive problems in cows.[245]

In addition, research suggests a link between drinking milk from rBGH-treated cows and certain types of cancer in humans. Dairy cows treated with rBGH increase production of a protein called insulin-like growth factor-1 (IGF-1).[246] Humans naturally produce their own IGF-1, but humans drinking milk from treated cows will consume more IGF-1 than they otherwise would. Research shows that when present in the human body at elevated levels, IGF-1 increases the risk of breast, colon, prostate and other cancers.[247]

In 2007, the most recent data collected by the federal government, nearly 43 percent of large-scale dairy farms (over 500 head), 30 percent of mid-sized dairy farms and 9 percent of small dairy farms used rBGH on their cows.[248] Yet rBGH has never been approved for commercial use in Canada or the European Union (EU) due to concerns about the drug's impact on animal health and welfare,[249] and it also is banned in Japan and Australia.[250]

Impact on Animal Welfare

Chickens and hogs raised in factory farms usually have no access to the outdoors, fresh air or natural light, and may spend much of their time confined in crates that are so restrictive that the animals cannot stand up, turn around or fully extend their limbs or wings.[251] Dairy and beef cattle on factory farms do not have access to pasture where they could express their natural behavior (and ideal diet) of grazing.[252] With 100,000 chickens or 1,000 hogs in one building, and thousands of cattle held together on one dirt lot, industrial livestock conditions make animals vulnerable to disease.

In addition to the burden put on animals from densely crowded conditions, most livestock breeds have been bred for specific production traits such as rapid weight gain, larger breasts on chickens, or high milk or egg production. For example, since the 1920s, changes to broiler chicken breeding and production have resulted in chickens that grow twice as big in half the time.[253] This selective breeding, which emphasizes high production over animal fitness or welfare, has created animals that are prone to structural deformities such as lameness and bone deformities, metabolic problems and susceptibility to infections.[254]

Growth Promotion

Selective breeding that makes livestock prone to health problems is coupled with pharmaceuticals designed to make animals grow faster, such as the use of artificial growth hormones that can cause additional stress and side effects.

As an example, two drugs designed to make animals grow lean meat faster — ractopamine and Zilmax — are controversial because of animal welfare concerns. Ractopamine mimics stress hormones in pigs and stimulates increased aggressive behavior.[255] Not only are the pigs more likely to attack each other, but their handlers also are more likely to handle aggressive animals roughly, which is dangerous for the pigs and the workers.[256] The drug's manufacturer Elanco acknowledged that, because of aggressive behavior, pigs treated with ractopamine are at increased risk of injury during transport.[257] In over 200,000 reports to the FDA, livestock producers reported pigs treated with ractopamine experiencing "hyperactivity, trembling, broken limbs, inability to walk and death," leading the FDA to require that a warning label be added to the drug.[258]

While 27 countries including the United States, Canada, Mexico and Japan allow ractopamine use, 160 countries — including the EU member nations and China — do not.[259] The U.S. government intends to force global acceptance of ractopamine, by challenging bans on the drug as illegal trade barriers.[260] The livestock industry insists that foreign opposition to ractopamine stems from protectionism, not food safety concerns.[261] Three food safety and environmental organizations filed suit against the FDA in 2014, claiming that the agency approved ractopamine with insufficient safety and environmental testing.[262]

Zilmax, a very similar drug to ractopamine, has raised similar concerns. Meat producer Tyson rejected animals raised with Zilmax, citing concerns such as cattle arriving at slaughterhouses unable to walk.[263] In 2014, Zilmax manufacturer Merck Animal Health suspended sales of the drug in order to audit its use, while still touting its safety.[264] The FDA has approved adjustments to the drug label that would require lower doses, a likely precursor to returning Zilmax to the market.[265]

Biotechnology and Cloning

If the biotechnology industry has its way, livestock production and aquaculture soon will incorporate even more exotic technologies that could impact the welfare of animals. As of the spring of 2015, the FDA continues to consider the regulatory application of AquaBounty Technologies' genetically engineered (GMO) salmon, which, if approved, would be the first biotech animal to enter the food supply anywhere in the world. Among other problems, the very limited available scientific research on GMO salmon suggests that the fish experience unique health problems and higher rates of abnormalities compared to unmodified salmon.[271]

The FDA already has approved cloning of food animals and declared cloned animals to be safe for human consumption.[272] Cloning animals is an inexact science with survival rates as low as 5 percent.[273] A New Zealand biotechnology company ended its cloning program in 2011 due to unacceptable death rates.[274] Internal hemorrhaging, digestive problems and multiple organ failure are some of the most common causes of death among cloned animals in the first week of life.[275] Regulators have typically brushed aside potential health impacts for people eating these engineered or cloned food animals, or for the welfare of the animals themselves due to deformities and susceptibility to disease.

These technologies represent more dramatic attempts by meat companies to force animals into their preferred production models instead of adapting production systems that maximize animal welfare, ensure the wholesomeness of the food produced there or protect the environment.

Secrecy: "Ag Gag" Laws

For years, investigations by animal welfare activists have revealed conditions on some factory farms that result in extreme animal suffering, sometimes resulting in criminal convictions and loss of business for the farms. Rather than develop better systems for oversight of animal welfare on factory farms, however, some states have responded by making certain types of activism illegal through so-called "ag gag" laws. Ag gag laws can ban undercover videotaping of farms or require that any video tapes be immediately delivered to authorities, preventing groups from gathering sufficient evidence to demonstrate a pattern of inhumane livestock treatment.[266]

Seven states — Idaho, Iowa, Kansas, Missouri, Montana, North Dakota and Utah —have passed "ag gag" laws.[267] But these changes are not happening without a fight. In 2013, ag gag legislation in 11 states was defeated, as animal welfare groups have joined with civil liberties groups and others to oppose these harmful bills.[268] The governor of Tennessee vetoed an ag gag bill passed in the state legislature, citing weaknesses in the bill that threatened prosecution of animal cruelty cases.[269] In addition, both Idaho's and Utah's ag gag laws are being challenged by lawsuits.[270]

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False Solutions to Factory Farm Pollution

Several recent proposals are aimed at filling the void created by the EPA's failure to regulate water quality problems related to factory farms. But these approaches continue the trend of not requiring factory farms to reduce pollution and fail to hold the companies that drive these operations accountable for their waste.

- **Water Quality Trading:** Water quality trading allows one polluter to reduce pollution by a certain amount and to sell that "right" to pollute to someone else. A farmer might implement certain best management practices to reduce runoff of poultry waste applied to fields. That practice generates "pollution credits," based on an estimated amount of pollution reduction, to sell to a sewage treatment plant, allowing the plant to release more nutrients into a waterway.[276] Yet measuring offsets is a vague and politicized process, and trading may lead to pollution "hotspots" where credits are used to avoid reducing pollution.[277]
- **Manure Transport:** One example of how states try to manage the pollution burden from a concentration of factory farms is by shipping manure out of an overloaded watershed. For example, in the Chesapeake Bay watershed, home to about 44 million factory-farmed chickens, Maryland subsidizes the cost of shipping poultry manure elsewhere to the tune of up to $20 per ton.[278] Transporting manure can alleviate local concentrations of manure, but it fails to address the larger problem of having too many factory-farmed animals in one area.[279]
- **Factory Farm Waste-to-Energy Plants:** Proponents of burning animal waste claim that incineration plants can turn excess manure, especially poultry litter, into energy. But despite claims that this is a positive alternative to putting excess manure on fields, proposals for incineration facilities remain stalled due to opposition from environmental and social justice groups, dubious financial viability and well-documented health and environmental hazards of burning chicken litter.[280] Building new power plants to burn this waste only provides another band-aid for a broken agricultural system. Moreover, such projects are not economically feasible without significant government subsidies.[281] Similarly, manure digesters are designed to convert the methane from decomposing manure into a fuel source for generating electricity, but they have been plagued by performance problems and require tax subsidies to be economically feasible.

Conclusion

The dominance of factory farm production in the United States is neither mysterious nor accidental. The growth of factory farming is the result of bad farm policies that often have subsidized artificially cheap feed; lax regulatory enforcement that enabled factory farm expansion without addressing the environmental and human impacts of their massive quantities of waste; and unchecked corporate consolidation that allowed giant agribusiness companies to drive up the size of farms raising food animals.

Factory farms cause extensive environmental damage and exploit natural resources. Agribusiness interests prevent citizens from exercising democratic control in their communities and have left communities with fewer independent family farms, unsafe water, reduced air quality and depressed economies. Instead of benefiting from the supposed efficiencies in this system, consumers instead face foodborne illness outbreaks and public health threats such as antibiotic-resistant bacteria.

Congress, regulatory agencies and states need to put a stop to the policies that have allowed these facilities to proliferate, and they must create and enforce policies that allow food to be produced in a way that enables farmers to make a living and does not harm communities, the environment or public health.

Food & Water Watch recommends:

- The EPA and states should establish a moratorium on the construction of new factory farms and on the expansion of existing facilities;
- The EPA and states should establish and enforce strong air and water pollution and water use standards, as well as pollution reporting requirements;
- The EPA and the USDA should not replace enforceable regulations on factory farm discharges with water pollution trading or other market-based efforts to create pay-to-pollute schemes;

What About Organic?

The USDA sets standards for certified organic food. For meat, poultry, eggs and dairy to be certified organic, they must come from animals that eat only organic feed (raised without synthetic fertilizers or pesticides and from crops that were not genetically engineered), and they cannot be given growth hormones or antibiotics. The organic standards do say that animals should be able to express their natural behaviors and that organic production must minimize environmental impacts. However, organic standards do not include specific animal welfare conditions, and they do not restrict the size of livestock operations.

In 2010, after years of controversy, and inaction by the USDA, the organic standards were updated to specify how much "access to pasture" organic cattle must receive and how this requirement could be enforced.[282] Requiring organic dairy and beef cattle to spend a significant portion of their time on, and to receive a significant portion of their nutrition from, pasture was a major step toward making sure that organic products live up to consumer expectations.

For "organic" to be even more meaningful to consumers, the USDA needs to specifically address animal welfare with standards that require outdoor access for chickens and hogs, end the use of synthetic feed additives meant to replace the nutrients that chickens would get from foraging outdoors, and outline specific animal welfare practices for stocking density, handling and transportation.

- States, the USDA and the EPA should not subsidize waste-to-energy programs for manure that enable the continued concentration of too many factory-farmed animals in one region;
- The Department of Justice should reassess the impact of major agricultural mergers and rectify any anticompetitive developments that have occurred as a result of those mergers. Further, the department should enact a moratorium on any proposed agricultural and food company mergers by the top four firms in any sector of the food system;
- The USDA should work to end unfair contract practices used in the livestock sector as well as address the unfair power exerted by meatpackers over livestock producers through marketing agreements and packer ownership of livestock;
- The FDA should ban non-therapeutic use of medically important antibiotics in livestock as well as the use of the artificial growth hormone rBGH and beta-agonist growth promoters;
- Congress should reform federal farm policies to stop encouraging overproduction of corn, soybeans and other commodities that frequently have resulted in cheap feed for animals in factory farms. This includes establishing commodity reserves to reduce price volatility and to manage the supply of agricultural commodities, and reforming the policies that set milk prices to prevent overproduction and price manipulation;
- Congress should cap payments made to farms under the Environmental Quality Incentives Program to ensure that the program no longer serves as a subsidy for factory farms;
- State legislatures should enact laws that affirmatively allow local governments to retain the authority to impose strict health and zoning regulations for factory farms and to restore them in states that previously had taken away local control.

Appendix

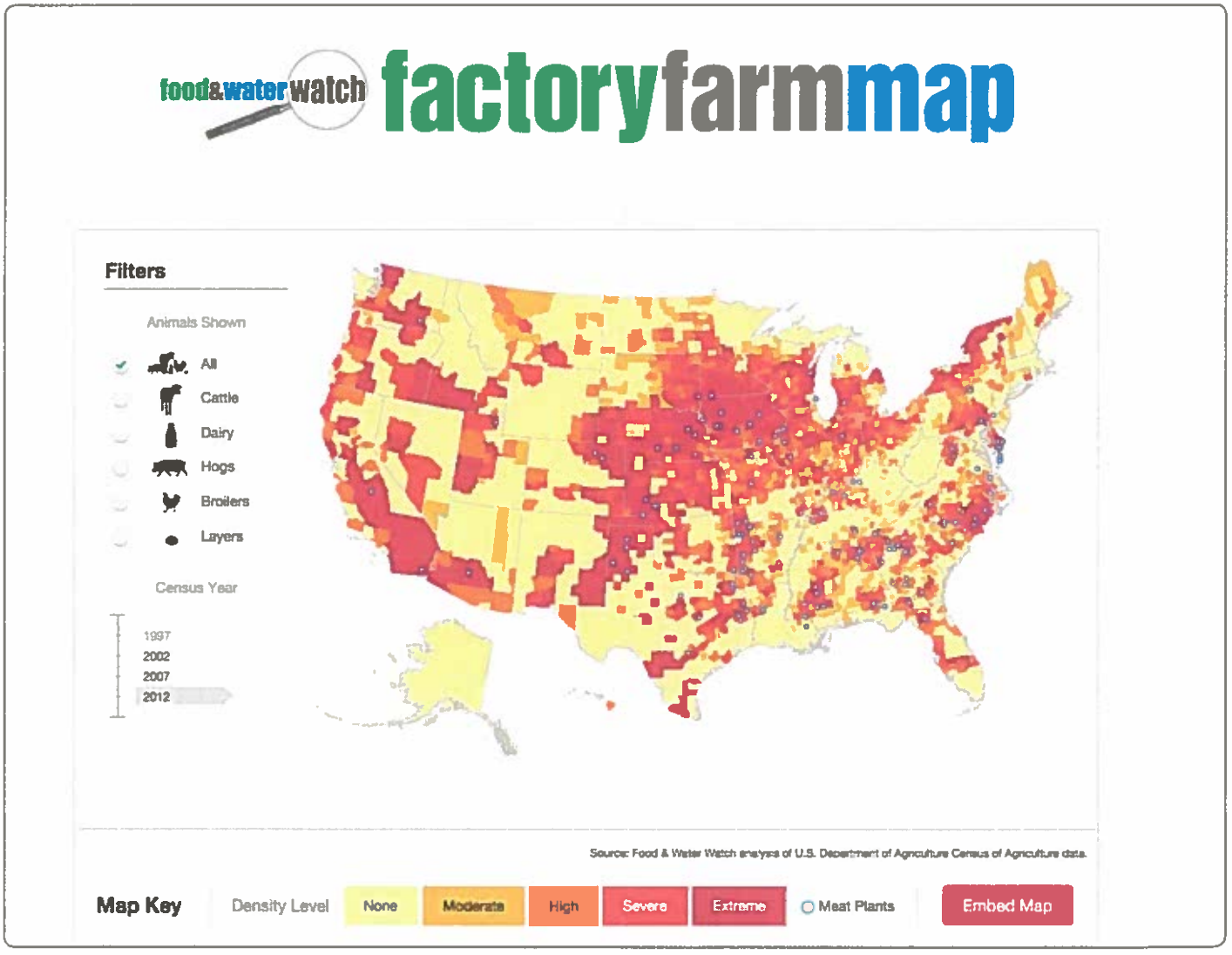
Factory Farm Map Methodology

Food & Water Watch compiled the data on the largest livestock farms from the USDA *Census of Agriculture* — a five-year survey of America's farms — from 1997, 2002, 2007 and 2012. The *Census of Agriculture* collects and reports data from livestock operations for every county and state in the United States, including the number of operations (farms) and the number of livestock. The USDA also reports the distribution of the number of livestock on different-sized farms by state and by county. For this map, Food & Water Watch analyzed only the number of livestock on the largest categories of operations for beef cattle, dairy cows, hogs, broilers (chicken) and layers (eggs). The *Census of Agriculture* is available online at http://www.agcensus.usda.gov/.

Definitions

Food & Water Watch analyzed the county-level data for the USDA's largest categories of farms based on the number of livestock — either the inventory of livestock on an operation or, in the case of broiler chickens, the annual number of birds sold. The livestock operations that were analyzed for the map and report have at least:

Factory Farm Size Definitions	
Beef cattle	500 or more beef cattle "on feed"
Dairy	500 or more dairy cows
Hogs	1,000 or more hogs
Broiler chickens (broilers)	annual sales of 500,000 or more broiler chickens
Egg-laying hens (layers)	100,000 or more egg-laying hens



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"All Livestock" Calculation

Food & Water Watch compared the total number of livestock across different animal types — comparing chickens to cattle and hogs — by using the USDA definition of a "livestock unit," which measures different kinds of livestock animals on the same scale based on their weight. A livestock unit is a comparison of 1,000 pounds of live weight based on the type of animal. One beef cattle is the equivalent of approximately two thirds of a dairy cow, eight hogs or four hundred chickens.[283]

The average livestock units per farm were calculated by dividing the total livestock units by the number of livestock operations. (This may slightly underestimate the size of livestock operations because some farms may raise more than one type of livestock, although it has become significantly less common for farms to have diversified livestock production.) Because the USDA did not report beef cattle on feed prior to 2002 (see below), the "all livestock" measurement covers only 2002 through 2012.

Livestock Density

The map displays the number of livestock on the largest operations in every county, by type of livestock, which is displayed on the density color scheme. The map displays five levels of livestock density, which reflect the 2007 distribution of the number of livestock by type and by county broken into four equal parts (quartiles). These levels are applied to the prior years and to 2012, which shows how livestock operations grew in size over the studied decade and a half.

Average Size

The average size of operations was calculated by dividing the number of livestock on the largest operations by the number of these large operations. The USDA *Census of Agriculture* does not disclose these figures if the number of operations in any one county is very low (about one or two operations) because doing so would effectively disclose private or proprietary information about a specific farm. For counties where the number of operations is reported but the number of livestock is not disclosed, Food & Water Watch calculated an average size of the county operations based on state figures.

In most cases, Food & Water Watch calculated a residual average within each state by subtracting the disclosed county livestock numbers from the state total livestock numbers (for the largest size category of each type of animal) and then dividing the remaining unaccounted for animals by the number of farms with undisclosed livestock numbers (total state livestock – disclosed county livestock numbers within that state / number of operations with undisclosed livestock numbers). This provides a close average for the number of livestock on operations that do not disclose the number of animals.

In some cases, the USDA does not disclose the state total for the largest-size category of livestock, but it does disclose the total number of livestock on operations of any size in the state. In this case, Food & Water Watch subtracted all of the disclosed livestock for the smaller size categories from the state total, leaving a remainder of uncounted animals in the largest size category, and then divided by the total number of large operations to get an average largest-size operation. For states that did not disclose animal numbers for smaller-size categories, Food

Factory Farm Map Density Table

Density	Map Color	All Livestock (Animal Units)	Dairy Cows	Beef Cattle on Feed	Hogs	Broiler Chickens Sold	Egg-Laying Hens
Extreme	Dark Red	More than 13,200	More than 4,200	More than 17,400	More than 48,500	More than 2.75 million	More than 1.25 million
Severe	Red	5,200–13,200	2,100–4,200	7,300–17,400	19,000–48,500	1 million–2.75 million	750,000–1.25 million
High	Orange	2,000–5,199	1,200–2,099	2,175–7,299	9,500–18,999	350,000–999,999	500,000–749,999
Moderate	Light Orange	Fewer than 2,000	Fewer than 1,200	Fewer than 2,175	Fewer than 9,500	Fewer than 350,000	Fewer than 500,000
Low	Yellow	None	None	None	None	None	None

& Water Watch used the median value (for example, using 150 for the 100–199 size range), and multiplied that by the number of operations to get a size category estimate before subtracting from the state total.

In a few cases, the USDA did not disclose the size of any operations in the state (if there are too few or if the few that do exist are dispersed among many counties) and did not disclose the livestock totals in the state. For states where operational size was not disclosed, Food & Water Watch used the threshold figure for the largest size of operations (500 for beef and dairy cattle and 1,000 for hogs) for the counties with operations.

Poultry operation sizes were not disclosed for any county, and these averages are calculated by dividing the total number of broilers or layers by the total number of farms (see below).

Slaughterhouses and Processing Plants

The map also shows the county location of the slaughter facilities and poultry processing plants for the top four beef, pork and poultry processing companies in the United States. The top four companies and their locations were taken from industry sources (*Cattle Buyers Weekly*, the National Pork Board and *Watt PoultryUSA*).[284] The displayed location on our Factory Farm Map reflects only the county where the facilities are located; it does not reflect the exact geographic location of the facility. In counties where there is more than one slaughter or processing facility, the map display represents an even distribution of facilities. Again, this does not reflect the exact location of the plants.

Cattle on Feed

Until 2002, the USDA did not separately report the number of beef cattle operations that finish cattle on feed, which distinguishes feedlots from younger cattle on cow-calf, backgrounder and stocker operations that pasture their cattle or those that are entirely grass-fed and do not spend any time on a feedlot. The inventory of "cattle on feed" was a new item in the 2002 *Census of Agriculture* and refers to cattle being fattened on feedlots with grain prior to slaughter. The map and analysis does not display data for 1997 for cattle on feed, and, as a consequence, it cannot report total animal units for 1997 because there is no comparable information.

Broilers and Layers

The USDA's *Census of Agriculture* does not report the number of chickens by county, but it does report state totals for broilers and layers. For broiler and layer operations, Food & Water Watch divided the total number of birds in each state by the number of operations and attributed the state average to every operation in the state. This necessarily is a less precise average than for some other livestock average size figures, but it does reflect the average in that state.

For broiler operations, the USDA does not report the number of birds on the farm by size class; it only reports the annual sales of broiler operations by size class. The largest category of broiler operations sold at least 500,000 broiler chickens. To determine the average size of these operations, Food & Water Watch divided the total state number of broilers sold on the largest operations by 5.5 (the number of flocks of broilers sold annually by typical operations), which generates the statewide broiler inventory. The statewide broiler inventory was divided by the number of broiler operations to calculate the average broiler inventory.

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Endnotes

1 Unless otherwise specified, all of the data in this report is taken from Food & Water Watch's analysis of the state- and county-level five-year *Census of Agriculture* data collected and published by the U.S. Department of Agriculture (USDA) National Agricultural Statistical Service (NASS). USDA NASS. 1997 *Census of Agriculture*. AC97A-A-51. March 1999; USDA NASS. 2002 *Census of Agriculture*. AC-02-A-51. June 2004; USDA NASS. 2007 *Census of Agriculture*. AC-07-A-51. February 2009, Updated December 2009; USDA NASS. 2012 *Census of Agriculture*. AC-12-A-51. May 2014. For more information on the source and analysis of this data, *see* the Methodology section at page 35.

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Community and occupational health concerns in pork production: A review[1]

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ABSTRACT: Public concerns relative to adverse consequences of large-scale livestock production have been increasingly voiced since the late 1960s. Numerous regional, national, and international conferences have been held on the subject since 1994. This paper provides a review of the literature on the community and occupational health concerns of large-scale livestock production with a focus on pork production. The industry has recognized the concerns of the public, and the national and state pork producer groups are including these issues as an important component of their research and policy priorities. One reason large-scale livestock production has raised concern is that a significant component of the industry has separated from traditional family farming and has developed like other industries in management, structure, and concentration. The magnitude of the problem cited by environmental groups has often been criticized by the pork production industry for lack of science-based evidence to document environmental concerns. In addition to general environmental concerns, occupational health of workers has become more relevant because many operations now are employing more than 10 employees, which brings many operations in the United States under the scrutiny of the US Occupational Safety and Health Administration. In this paper, the scientific literature is reviewed relative to the science basis of occupational and environmental impacts on community and worker health. Further, recommendations are made to help promote sustainability of the livestock industry within the context of maintaining good stewardship of our environmental and human capital.

Key words: environment, health, swine

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INTRODUCTION

Since the ending of hunter-gatherer societies and the beginning of agricultural societies, there has been a trade-off between the process of producing food for society, and stress on the natural environment and people that provide the food. Furthermore, the advent of the industrial revolution in the early 1800s charted a path of increasing intensification of agricultural and nonagricultural industry that has further stressed the natural environment that we live in. The latter not only challenges the urban environment, but also our rural environments, as urban discharges and emissions reach the streams and air of our rural residents that connect urban and rural landscapes. As the economies of industrialized nations grew strong and basic necessities of life were generally cared for, the political and social controversies have increased as fewer people are involved in production agriculture.

Research has indicated that water and air pollution are now global issues, projecting environmental issues into the international arena. As production agriculture has become more concentrated into larger and more intensive operations, awareness and attention has increased from the public and regulatory agencies regarding water, air, and soil contamination and related community and worker health concerns. Emotions are increased among people who are concerned, complicating specific diagnoses for persons who claim to suffer health problems from these exposures. On the other hand, a large portion of the production agricultural community feels threatened that their industry has been negatively portrayed, and they fear excessive regulation will unnecessarily economically burden their operations, making it impossible to farm. For all these reasons, rural health professionals, livestock producers, veterinarians, and animal scientists should be as aware and concerned about environmental issues and their potential health effects, as are their urban counterparts.

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My objective is to review current scientific information to help create, to the extent possible, an unbiased awareness on the part of readers, enabling them to be better prepared to participate in informed public debate and provide information regarding the nature and prevention of resulting community and occupational health effects associated with livestock production and principally swine production. My overarching objective is to provide information that will assist in the sustainability and profitability of livestock production.

ANIMAL FEEDING OPERATIONS

The proliferation of animal feeding operations (**AFO**) has been a feature of the increased intensity, concentration, specialization, and consolidation that has been occurring in agriculture in industrialized countries over the past 3 decades. The US Environmental Protection Agency (**EPA**) has a specific definition of AFO that includes the confinement of animals for at least 45 d in a 12-mo period, and in a structure or lot where vegetation or crops will not grow. The term confined animal feeding operation (**CAFO**) is used to describe AFO over a specified size that are a risk as a point source for water pollution and, therefore, require regulation (US EPA, 2009). In regard to water, air, and solid waste pollution, CAFO have similar environmental concerns to other agricultural operations. However, there are special concerns for CAFO because of the sheer size, the concentration of animals, feed, manure (usually handled in liquid form), dead animals, flies, associated gases, particulates, odors and odorants, and infectious diseases all concentrated on a small land area. There also are concerns that the manure cannot be recycled without pollution on such a small area and that local and regional air and water quality suffers.

Public concerns relative to adverse consequences of livestock production have been increasingly voiced since the late 1960s (Thu and Durrenberger, 1998). Numerous regional, national, and international conferences and commissions have been held on the subject since 1994 (Thu, 1995; Merchant et al., 2002; Donham et al., 2007). The Pew Foundation recently published its Commission report on Industrial Farm Animal Production 2008 (Pew Commission on Industrial Farm Animal Production, 2008).

Although general water and air quality issues have been raised as concerns by the public, scientists, and regulatory agencies, this paper concentrates on the potential occupational and community health consequences from air emissions of large-scale livestock operations. Physical health as well as social and economic concerns of individuals and communities are considered. A broad definition of health is used here as defined by the World Health Organization (**WHO**). The WHO states that health is "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity" (WHO, 1972).

One reason large-scale livestock production has raised public concern is that it has separated from traditional family farming and has developed like other industries in management, structure, employment, and concentration. One of the concerns of the public is that in the US there is 130 times more animal waste produced (by weight) yearly than human waste and this waste generally is not treated sanitarily as is human waste before it is returned to the environment (Esteban, 1998). In the subsequent discussion, the scientific literature is reviewed, and this updates a previous review published in 2006 (Donham and Thelin, 2006), with a focus on the assessed health effects of air contaminants from swine CAFO on community residents and the occupational health of pork producers and employees.

COMMUNITY HEALTH ISSUES

Air Emissions from CAFO

Merkel et al. (1969) published the first qualitative assessment of gases emitted from liquid swine manure. Nearly 200 compounds emitted from animal manure have been detected (O'Neill and Phillips, 1992). These compounds can be grouped into the following chemical classes: mercaptans, sulfides, disulfides, amines, organic acids, phenols, alcohols, ketones, indole, skatole, carbonyls, esters, and nitrogen heterocycles. The health risks of most of these substances, at the concentrations present in swine manure, are not known. Some of these substances have a very low odor threshold [e.g., 1 part per billion (**PPB**)]. Ammonia and hydrogen sulfide are the most important emittants from livestock waste in regard to direct human health risks. Methane and carbon dioxide are important greenhouse gases.

The primary sources of gaseous compounds originate from the degradation of feces and urine applied to land and from animal wastes stored in liquid or solid phase. Ammonia is a by-product of almost any treatment method of animal waste. Other fixed compounds and trace compounds come primarily from the anaerobic decomposition of manure in liquid storage systems.

In addition to gases, often overlooked are the particulate substances that are emitted from livestock feeding operations. There is a large quantity of organic dust generated from feed sources and pigs (e.g., hair, dander, and dried feces). This dust contains bioactive substances, including endotoxin and glucans, 2 very important inflammatory substances (Donham et al., 1986; Schulze et al., 2006). Also, there is a bioaerosol component of this dust. Many gram-negative and gram-positive bacteria, fungi, and molds have been identified (Thorne et al., 1992). Some of these organisms also grow within confinement buildings, contributing to concentrations of organisms that are also found in the air outside the building (Kiekhaefer, 1995). The vast majority of organisms identified in the air are saprophytic, and very few pathogens are identified. They are combined with

dust that becomes a part of the total aerosolized particulates. The size of the particulates emitted is relatively small. Approximately 50% are less than 10 μm, which means they are inhalable and will penetrate to the airways.

Odors, Odorants, and Particulates

Most of the public concern on CAFO has been about odor (Nimmermark, 2004; Radon et al., 2004). An odor is an unpleasant sensation in the presence of an odorous substance or odorant. The odorant may or may not have additional harmful toxic effects. Ritter and Chirnside (1984) identified the classes of compounds from animal manure that are odorants, as previously mentioned. Ammonia and H_2S, among the fixed gases, are also odorants. Riskowski (1991) described an odor phenomenon associated with the livestock environments where NH_3 and H_2S are detected at lesser odor threshold concentrations than previously published, apparently due to interactions within the mixture of emitted chemicals and particulates.

Researchers have looked at the fixed gases (e.g., NH_3 and H_2S) as potential surrogates for emissions and odors. However, the results of several researchers have shown that there is a poor correlation between NH_3 and H_2S and odor strength (Payne, 1994; Smith and Kelly, 1996).

Goodrich (1975) showed, relative to background, increased amount of viable organisms downwind of manure sprinklers, as well as inside beef and turkey facilities. Pickrell (1991) showed swine barn environments to have significantly greater particle and microbe concentrations compared with other livestock environments. These concentrations are up to 10^6 times greater inside swine buildings compared with outside (Kiekhaefer, 1995). Very little is known about hazardous concentrations of odorants in outdoor air around CAFO. We do know there are worker health problems caused by H_2S and NH_3 and dust in the interior; however, it is difficult to infer health risks outside these buildings based on occupational health studies. Available data (Reynolds et al., 1996) indicate NH_3 and H_2S are on the order of 10^3 times greater inside buildings compared with outside.

Concerns about odors from livestock facilities can be considered a nuisance, which is often how courts treat them. However, there is growing evidence that odors may cause physical illness (Nimmermark, 2004; Radon et al., 2004; Wing et al., 2008). Schiffman et al. (1995) indicated that odors may cause nausea, vomiting, headache, shallow breathing, coughing, sleep disorders, upset stomach, appetite depression, irritated eyes, nose and throat irritation, and mood disturbances including agitation, annoyance, and depression. Ackerman (1990) reported that odors can result in strong emotional and physical responses, particularly after repeated exposures. Schiffman et al. (1995) studied the profile of mood states of 44 people living near large animal facilities. Compared with controls, they found that people living near the facilities were more angry, confused, tense, depressed, and fatigued. To determine acceptable odors relative to distance from the source, Walsh et al. (1995) surveyed persons living in a 5-km area surrounding a large cattle feedlot. Walsh et al. (1995) measured odors according to an odor panel and found acceptable odor levels within the 5-km radius. Results of other research indicate that the physical symptoms (which are more relevant to worker exposure than community residents) may also be caused by chronic inflammation secondary to inhaled dust, and gases (Pickrell, 1991; Donham et al., 1995).

Physical Health

When considering the health hazards of residents living in the vicinity of CAFO, there is relatively sparse dose-response or objective evidence of physical damage to human tissues from air emissions. For example, Jacobson (1997) and (Davidson et al., 1987) reported H_2S concentrations in the vicinity of CAFO, well under the threshold limit value (**TLV**) for occupational health set at 10 ppm (**PPM**). Also, in a study by Reynolds et al. (1997), concentrations of NH_3 in the vicinity of swine CAFO were generally less than 1 PPM. Concentrations of endotoxin and dust were near the minimum limits of detection of the instrumentation used, which was around 10 endotoxin units/m^3 of air and <0.5 mg of dust/m^3 of air). However, several studies have reported findings of excess respiratory symptoms in community residents compared with controls, including symptoms of bronchitis and asthma (Merchant et al., 2005; Sigurdarson and Kline, 2006; Radon et al., 2007). Possible reasons for this observation include the fact that residents live in the area more than 8 h/d. Also, there may be vulnerable populations that react at much less concentrations than occupational limits. For example, several states have limits for H_2S at 20 to 50 PPB, 3 orders of magnitudes below the occupational exposure limit, and the EPA and Agency for Toxic Substances and Disease Registries limit is 30 PPB for long-term community exposures (Merchant et al., 2002).

Kilburn (1997) reported on neurobehavioral effects of H_2S gas. This small study reported neurological deficits in 16 exposed persons, including decreases in balance, reaction times, visual field performance, color discrimination, hearing, cognition, motor speed, verbal recall, and mood states. Hydrogen sulfide is a toxin with several effects, including tissue irritation and poisoning of cellular respiration mechanisms with a predilection for brain cells. However, the health effect of chronic exposure in the vicinity of CAFO to reduced concentrations of H_2S remains uncertain.

These studies of physical and mental health concerns of residents near CAFO have reported similar findings. These were controlled studies of self-reported symptoms, and no attempts were made to document objective correlates of health impairment (Schiffman et al.,

1995; Thu et al., 1997; Donham et al., 2007). Thu et al. (1997) reported respiratory symptoms (almost identical in type and pattern to workers in CAFO) at a statistically significant increased rate relative to unexposed community comparison populations. Schiffman et al. (1995) reported excessive mood alterations in CAFO neighbors. There are numerous instances of similar studies in other environmental settings, including concerns of communities around paper pulp mills, hazardous waste sites, refineries, and solid waste disposal sites (Shusterman, 1992). Although most of these studies have not documented objective findings of toxic physical insult to humans, a few studies have reported subtle objective findings, such as increased concentrations of urinary catecholamines or mucosal immune alterations (Avery et al., 2004). Additionally, most of these studies have not shown evidence of known toxic concentrations of substances in the environment.

Extra-Toxic Mechanisms

Although the concentrations of potentially hazardous air contaminants are usually below known harmful amounts, adverse health symptoms are commonly reported by community residents. One possible explanation for this is the phenomenon described by one researcher as extra-toxic effects of decreased concentrations of emissions (Shusterman, 1992). This literature has focused on trying to explain symptoms of community members who may be exposed to waste sites, sewage treatment plants, and other large population-based community exposures. Medical research and regulatory agencies have difficulty dealing with these situations because they are not clear-cut. Clear-cut findings would include an objective finding (e.g., a measurable effect, such as an altered blood chemistry or abnormal radiograph) of an adverse health effect, measured toxic substances at known toxic concentration, and an obvious dose-response relationship. These community exposures are much more complex because they are a mix of physical, mental, emotional, and social stressors. Genetic memory and other very basic limbic-level self-preservation mechanisms may be involved. The following paragraphs will review some of the literature that helps to explain adverse health symptoms that people in the community may experience where there is an absence of objective health and toxicological data.

The Somatasization of Adverse Odors

Two cranial nerves innervate the nasal mucosa: the first cranial nerve (i.e., the olfactory nerve) and the fifth cranial nerve (i.e., the trigeminus nerve; Shusterman, 1992). The olfactory nerve is primarily responsible for odor detection. The trigeminus nerve has many branches that penetrate the oral mucosa and provide additional information to the brain on odor sensation, such as irritation or pungency, which trigger protective responses including decreased respiratory rate, rhinitis, tearing, cough, gag reflex, and bronchoconstriction. These are all warning indicators that something associated with the odor may be harmful, and our genetically based instinctive-protective mechanisms tell us to make physiologic changes to meet the impending insult or to get out of the area (Shusterman et al., 1988; Shusterman, 1992). Therefore, it makes sense that odors can result in symptoms of mucosal irritation, including respiratory symptoms, nausea, and feelings of "dis-ease" (Shusterman et al., 1988, Shusterman, 1992).

Complexed with these physiological responses to small amounts of irritants and odors, there are behavioral interactions (e.g., perceived loss of property value, loss of control of personal space) that may explain health symptoms of illness associated with odors. There are 5 theoretical mechanisms for extra-toxic odor-related physical symptoms (Shusterman, 1992).

Innate Odor Aversions

As a basic protective mechanism, our body wants to avoid certain odors that may signify potential harm. For example, odors in putrefaction gases (e.g., H_2S, mercaptans, and other sulfur-containing chemicals) are common substances that stimulate physiologic effects and the drive to avoid those substances at less than toxic concentrations. These gases may be associated with spoiled food, but are also associated with animal manure, as are many of the odors associated with these innate odor responses.

Negation of Normal Pheromonal Phenomena

Pheromones stimulate physiologic responses, especially around sexual reproduction. These are most overt for insects, but many mammals, including humans, respond to them. Some odors may destroy normal positive pheromone responses, resulting in impaired sexual function for people living in the vicinity of CAFO. (Shusterman et al., 1988; Shusterman, 1992; Schiffman et al., 1995)

Exacerbation of Underlying Conditions

Previous research has shown that workers with underlying conditions (e.g., asthma, atopy, bronchitis, heart conditions) are more susceptible to the CAFO environment than others (Schiffman et al., 1995). Furthermore, it is now evident that individuals differ genetically in their susceptibility to endotoxins. Research by Meggs et al. (1996) and Rylander (2004) also lends strength to the theory that underlying conditions, such as asthma, may amplify exposures.

Aversive Conditioning

Some people previously exposed to increased concentrations of odorous gases causing toxic effects may respond physiologically to less than toxic amounts (i.e.,

slight odor) of this substance in future exposures. The condition described as multiple chemical sensitivity may have similarities to aversive conditioning (Bell et al., 1992).

This author has observed this condition in several cases of CAFO workers who experience symptoms and anxiety when smelling CAFO odors after a severe CAFO gas exposure episode. This conditioned stimulus is probably an innate protective mechanism. This can also happen with exposures to decreased amounts over a long period of time (i.e., acquired odor intolerance; Meggs et al., 1996).

Stress-Induced Illness

Odor-related stress-induced illness has been discussed as a component of what is known as environmental stress syndrome. This phenomenon has been seen after disaster sites such as Three Mile Island (Shusterman et al., 1988). Studies have shown there are increased urinary catecholamines in affected individuals (Davidson et al., 1987). Affected individuals also have a feeling of depression, helplessness, and an increased degree of environmental worry, which is exacerbated by detection of the offending odor. Community members may be excessively worried that their property values are falling because of the odor source in their neighborhood. Odors can act as a cue for these individuals stimulating adverse physiologic risks relative to an associated exposure. Long-term stress can be associated with muscle tension, headaches, coronary artery disease, and peptic ulcers.

Summary of Extra-Toxic Mechanisms

In studies of physical health complaints in communities around CAFO, it would be expected that objective findings of toxicity would be difficult to obtain. However, that does not and should not discount the fact that people experience valid symptoms. The reasons have to do with complex interactions of the brain and somatic systems. First of all, odors may initiate somatic symptoms based on enervations of the trigeminus nerve. Furthermore, odors may initiate physiologic activity as a response to primordially acquired (limbic-level) aversions to toxic substances. These responses may be modulated and exacerbated by the person as the person worries about environmental threats and the frequency with which odors are experienced. Furthermore, these conditions may be exacerbated by previous toxic exposures to the substances in question, creating a learned response of avoidance even when minimal exposures are present. Further exacerbation may occur when combined with a feeling that the person has no control over the situation, with fears of declining property values. The combined physical and psychological effects have been described as resulting in environmental stress syndrome. If an individual has an underlying health condition, such as asthma, further complications may be present.

OCCUPATIONAL HEALTH OF SWINE PRODUCERS AND EMPLOYEES

Research on the health and safety of people working in swine confinement environments first began in 1977 (Donham et al., 1977). Potentially hazardous dust and gases are present in many swine CAFO buildings. The following paragraphs will review the air exposures, their sources, known health effects, and prevention. There are additional occupational health concerns noted that consist mainly of acute injuries, noise, or infection. These latter conditions will not be addressed in this article.

What Toxic Dusts and Gases Are Found in Confinement Houses?

The dust in CAFO is a complex mixture of agents that are generated primarily from the animals (i.e., hair and dander), dried feces, and feed (Donham and Gustafson, 1982; Nilsson, 1982; Donham et al., 1985; Donham and Popendorf, 1985). Additional to the dust, gases are generated inside the building that arise from decomposition of animal urine and feces (i.e., NH_3 and H_2S). In those buildings with manure storage under slatted floors, H_2S is a greater acute health risk. Furthermore, fossil-fuel-burning heaters present in some farrowing and nursery facilities may emit CO at toxic concentrations. The respiration of the animals and the fossil-fuel-burning heaters emit CO_2. These dusts and gases often accumulate to concentrations that may be acutely or chronically hazardous to human and animal health (Donham and Gustafson, 1982). The mixture and concentrations of dusts and gases inside CAFO vary depending on numerous factors including management practices, ventilation and other engineering controls, the age, number and type of animals in the building, and the design and management of the feeding and waste handling systems.

Dust particles in CAFO contain approximately 25% protein, and range in size from <2 μm to 50 μm in diameter (Donham and Popendorf, 1985). One-third of the particles are within the inhalable size range (i.e., <10 μm in diameter; Nilsson, 1982; Donham and Popendorf, 1985). Fecal material particles are quite small (i.e., ≤ 10 μm) relative to other dust components and consist of increased concentrations of gut-flora bacteria and exfoliated gut epithelium. This component of the dust constitutes a major burden to small airways and alveoli. The larger particles are mainly of feed grain origin and primarily affect the upper airways. Also present are animal dander, broken bits of hair, bacteria, endotoxins, pollen grains, insect parts, and fungal spores (Donham et al., 1985; Donham, 1986). In recent years, researchers have focused on the micro-

bial by-products contained in this dust as the primary hazardous substances. Endotoxin and 1,3-β-D-glucan, respectively, originate from the cell wall of gram-negative bacteria and certain yeasts, molds, and bacteria. They are known toxins and inflammatory mediators. The dust absorbs ammonia and possibly other toxic or irritating gases, adding to the potential hazards of the inhaled particles (Donham and Gustafson, 1982; doPico, 1986; Sigurdarson et al., 2004). A recent study has shown that the mixed exposure to dust and NH_3 in CAFO results in 2 to 4 times the health hazard (assessed by decline in pulmonary function over a work period; Donham et al., 2002).

At least 160 different gases are generated in anaerobically degenerating manure. However, H_2S, NH_3, CH_4, CO_2, and CO are the primary hazardous gases present (Donham et al., 1982; Donham and Gustafson, 1982; Donham and Popendorf, 1985). These gases may escape into the work environment in buildings with manure pits under the building. Furthermore, 40% of the NH_3 measured in-building is released by bacterial action on urine and feces on the confinement house floors (Donham and Gustafson, 1982). Carbon monoxide and CO_2 are generally not produced in hazardous concentrations from the manure pit but may rise to toxic concentrations from fossil-fueled heating systems in winter as well as by the respiration of the animal (i.e., CO_2; Donham and Gustafson, 1982). These latter gases are usually only hazardous when the heaters or ventilation systems malfunction. Methane is not a respiratory hazard in these buildings. However, CH_4 may be an occasional fire or explosive hazard in some buildings.

Who Is Exposed to These Dusts and Gases, and When?

In the United States, an estimated 700,000 people work in livestock and poultry confinement operations (Donham, 1990). This number includes owner-operators, hired farm workers, women, children, veterinarians, and service technicians. Included in the hired farm workers in the United States are minority populations, including those of Hispanic, Asian, and Bosnian descent, among others. The risk of acute and chronic respiratory health effects in CAFO workers are related to the relative genetic susceptibility to endotoxin or allergens of the individual, the length of time the person has worked, whether the person smokes or not, whether they have other respiratory conditions, and the concentration of exposures in these buildings. Although some individuals may have adverse health effects within the first week of work, most will not develop symptoms unless they have worked more than 2 h daily and for 6 or more yr (Donham et al., 1977, 2000; Donham and Gustafson, 1982).

Dust and gas concentrations increase in winter when houses are tightly closed and ventilation rates are reduced to conserve heat (Donham et al., 1977). Also, dust concentrations increase when animals are being moved, handled, and fed, or when buildings are being cleaned by high-pressure spray washing or sweeping (Nilsson, 1982). Ventilation systems are designed to control heat and humidity in the building and often will not reduce dust or gas adequately to ensure a healthful environment for humans. During the cold seasons, should the ventilation systems fail for several hours, CO_2 from animal respiration, combined with CO_2 and CO from heaters and manure pits, can rise to toxic or asphyxiating amounts. In the warm seasons, the greater risk to animals from ventilation failure is heat stress from elevated temperature and humidity. Although massive animal losses have been attributed to these latter situations, they would not create an acute human health threat because they are not so acute as to prevent workers from leaving the building in a safe time.

Hydrogen sulfide may pose an acute hazard whenever the liquid manure slurry is agitated (Osbern and Crapo, 1981; Donham et al., 1982). During agitation, H_2S can be released in seconds from usual ambient levels of <5 PPM to lethal levels of >500 PPM (Donham et al., 1988). The greater the agitation, the more rapid and greater the amount of H_2S that is released. Animals and workers have become seriously ill or died in swine CAFO when H_2S has risen from agitated manure in pits under the building. Several workers have died when entering a pit during or soon after the emptying process to repair pumping equipment or clean out solids (Donham et al., 1982; Beaver and Field, 2007). People attempting to rescue these workers also have died. Workers may be exposed to increased H_2S concentrations when they enter the pit to retrieve animals or tools that have fallen in or to repair ventilation systems or cracks in the cement. Hydrogen sulfide exposure is most hazardous when the manure pits are located beneath the houses. However, an acutely toxic environment may result from outside storage facilities if gases backflow into a building, due to inadequate gas traps or other design fault, or if a worker enters a separate confined-space storage facility.

How Commonly Does Excessive Exposure Occur?

Typical dust concentrations in swine CAFO are 2 to 6 mg/m^3 (Donham et al., 1985). Buildings with dust concentrations at 10 to 15 mg/m^3 may be seen during cold weather or when moving or sorting the pigs. The maximum recommended safe concentrations of dust to prevent chronic respiratory conditions is 2.5 mg/m^3 (Donham et al., 1995; Reynolds et al., 1996), which is considerably less than the 15 mg/m^3 for nuisance dust set by the Occupational Health and Safety Administration for industrial standards. The greater relative toxic nature of this dust is due to its high degree of its biological activity, its inflammatory nature, and the additive and synergistic actions of the mixed dust and gas exposures. Nearly 60% of swine confinement workers who have worked for 6 or more years experience

one or more respiratory symptoms (Clark et al., 1983; Donham et al., 1989). Prevalence of respiratory symptoms among workers in CAFO is 25%, compared with approximately 12% in nonconfinement swine workers (Donham, 1990).

Respiratory Effects of Inhaling Confinement House Dusts and Gases

Human health effects of work in swine CAFO were first described in veterinarians by Donham et al. (1977). Since that time, numerous studies by many different authors in various countries around the world have been published regarding the complex set of respiratory responses that include symptoms of acute and chronic bronchitis, nonallergic occupational asthma, mucous membrane irritation, and organic dust toxic syndrome (Mustajbegovic et al., 2001). These inflammatory and toxic processes may occur alone or in combination in combination, resulting in one or perhaps several conditions simultaneously (Donham et al., 1989; Prior et al., 2001).

Cigarette smoking, along with other risk variables mentioned previously, increases the risk and severity of symptoms. In general, the symptoms are more frequent and severe among smokers (Donham and Gustafson 1982; Markowitz et al., 1985) and in those working in larger swine operations (related to longer hours working inside CAFO buildings) or working in buildings with increased amounts of dusts and gases (Donham et al., 1995, 2000; Reynolds et al., 1996).

Although irreversible airway obstruction has not been a general finding in confinement house workers, there is objective evidence that long-term lung damage may be occurring. Pulmonary function studies show evidence of air trapping in the lungs. Lavage studies of bronchial fluids show a persistent leukocytosis, and sputum studies show persistent inflammatory cells and epithelial cells (Schwartz et al., 1990; Djuricic et al., 2001). Baseline pulmonary function studies [i.e., forced vital capacity and forced expiratory volume in one second ($\mathbf{FEV_1}$)] of healthy confinement workers usually show that pulmonary function does not differ significantly from those of workers in conventional swine buildings (Donham et al., 1989, 1990). However, flow rates at 25 to 75% of lung volume ($\mathbf{FEF_{25-75}}$) are significantly less. Furthermore, work shift declines in FEV_1 and flow rate values are seen in most confinement house workers after a 2- to 4-h exposure. These findings indicate that chronic obstructive pulmonary disease may occur among these workers in future years (Schwartz et al., 1990). Although end-stage lung damage in CAFO workers has not yet been systematically studied, the authors have experienced many anecdotal case studies in which workers have quit because of health reasons. One study of owner-operators revealed a dropout rate of 10% over a 6-yr period for respiratory health reasons (Holness et al., 1987).

A point to note is that it is rare to find producers or workers who have allergic asthma (also called atopic asthma) from swine house exposures. This is thought to be the result of early exposures in life to these dusts and, thus, the acceptance of the body of these foreign substances (hygiene hypothesis; Ernst and Cormier, 2000; Riedler et al., 2001). An additional explanation is that workers who are allergic may leave the job early, leaving a healthy workforce.

Although respiratory exposures are extremely common among CAFO workers, there are several other occupational hazards that should be considered. There are certain infectious agents involving the respiratory tract that humans may contract from animals in CAFO. These include, but are not limited to, swine influenza, erysipeloid, *Streptococcus suis*, and methicillin-resistant *Staphylococcus aureus* (Holness et al., 1987; Smith et al., 2009). Injuries to CAFO workers from animals, pinch points in gates and pens, cuts, and needle sticks are common. Furthermore, increased noise levels in these facilities can lead to noise-induced hearing loss. These hazards are discussed elsewhere (Donham and Thelin, 2006).

Prevention

Health hazards associated with confinement houses must be addressed through improvements in the environment through 1) decreased generation of dusts and gases by improved management procedures and engineering controls, 2) dilution of contaminants once in the air (e.g., ventilation), and 3) proper protection of the individual with respirator use. A prevention model for confinement house problems, based on education and industrial hygiene consultation, has demonstrated its effectiveness (Donham et al., 1990). Some examples of management practices to reduce the sources of dusts and gases include 1) delivering feed by extension spouts into covered feeders, rather than letting feed fall freely several feet from automatic delivery systems into open feeders; 2) using extra fat or oil in the feed to reduce dust; 3) sprinkling or misting the environment with vegetable-based oil, and regular (every 3 to 4 wk) washing of buildings with power sprayers (operators must use respiratory protection during this procedure); 4) using flooring that is relatively self-cleaning (e.g., plastic-coated wire mesh); and 5) assuring that heating units are clean, vented, and functioning properly. Details of control measures are published elsewhere (Donham, 1991). Effectiveness of control techniques can be assessed by measuring dust and gas concentrations. These buildings should be routinely monitored to assure air contaminants are within healthful limits.

Because it is economically impossible to completely eliminate the formation of dusts and gases in CAFO, techniques for removing contaminants from the air of confinement houses are critically important. Ventilation will help reduce dusts and gases to healthful amounts.

Ventilation systems must be properly designed and maintained and ventilation rates adjusted to include consideration of air quality. Operators often reduce these rates in winter because of concerns for conserving heat, causing dust and gas concentrations to rise. Several engineering techniques (e.g., use of heat exchangers, which allow increased ventilation while capturing some waste heat) have been tried with varying degrees of success (Donham, 1993).

Anyone working in a swine or poultry confinement house for 2 or more hours per day should be advised, at a minimum, to wear a National Institute for Occupational Safety and Health (**NIOSH**)-approved N-95 2 strapped dust mask, even if the concentrations of dusts and gases are below Occupational Safety and Health Administration threshold exposure limits. Recent research has shown that different tasks in pork production operations have greater exposures than others. Because it is inconvenient and uncomfortable for workers to wear respirators 100% of the time while working, we recommended wearing dust respirators at a minimum during the following tasks: 1) processing piglets, 2) feeding, 3) moving and sorting hogs, and 4) load out (O'Shaughnessy et al., 2010). Persons exposed to houses with increased dust or gas concentrations, or persons with respiratory conditions, may need to use a more sophisticated respirator, such as a half-mask cartridge respirator or powered air-supplying respirator (e.g., 3M air helmet).

Preventing exposure to increased concentrations of H_2S from manure pits requires stringent controls. General safety measures include constructing manure pits outside of the confinement building, constructing openings so that lids or other objects cannot fall into the pit requiring a worker to enter the pit for retrieval, and erecting safety guards around open pits and warning signs. Whenever a pit that is under a confinement house is being agitated, people should stay out of the building, ventilation of the house should be maximized, and animals should be removed or observed from outside the building.

Even when not being agitated, manure pits can seldom be entered safely. If entrance is imperative, adequate protection is only assured when a self-contained breathing apparatus is worn by an individual trained in its use. All operators should understand that increased concentrations of H_2S cannot be smelled and that H_2S greater than 1,000 PPM produces unconsciousness and respiratory arrest in only 1 to 3 breaths. A variety of H_2S gas alarms give an accurate indication of hazard.

Poor air quality in the confinement house has also been shown to be associated with health problems and reduced productivity in swine (Donham, 1991). Advising this economic fact to a swine producer may be the most expedient way to create environmental improvement that would help the person, the animals, and the economics of the operation. Two relevant comprehensive multifactored prevention programs, the Swine Confinement and Respiratory Health Project and the Certified Safe Farm program, have been trialed with success in pork production (Ferguson et al., 1989; Gjerde et al., 1991; Kline et al., 2007). These programs incorporate the combination of environmental assessment, education, health screening, safety audit, health and safety goals setting, with incentives for achieving objectives. These programs work to reduce the risks of adverse occupationally related health incidents and reduce health care costs to address them; however, they do require a commitment and resources to administer and maintain them.

SUMMARY AND CONCLUSIONS

Michael Savitz suggests that sustainability of any industry depends on a positive "triple bottom line" that includes not only economic viability, but also environmental preservation and care and advancement of its human capital (i.e., the producers and employees; Savitz and Weber, 2006). There will always be ups and downs in agricultural commodity markets. However, Savitz suggests that to help ensure long-term sustainability of the industry, the other 2 legs of the triple bottom line need to be integrated into the daily business of the industry. This author thinks there are sufficient science and program examples to guide this action, and advances are being made in the industry in this regard. However, it seems apparent that broader and more integrated implementation is a work in progress that should be encouraged.

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MESA

GLOBAL ENVIRONMENTAL HEALTH AND SUSTAINABILITY (JM SAMET, SECTION EDITOR)

Industrial Food Animal Production and Community Health

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Abstract Industrial food animal production (IFAP) is a source of environmental microbial and chemical hazards. A growing body of literature suggests that populations living near these operations and manure-applied crop fields are at elevated risk for several health outcomes. We reviewed the literature published since 2000 and identified four health outcomes consistently and positively associated with living near IFAP: respiratory outcomes, methicillin-resistant *Staphylococcus aureus* (MRSA), Q fever, and stress/mood. We found moderate evidence of an association of IFAP with quality of life and limited evidence of an association with cognitive impairment, *Clostridium difficile*, *Enterococcus*, birth outcomes, and hypertension. Distance-based exposure metrics were used by 17/33 studies reviewed. Future work should investigate exposure through drinking water and must improve exposure assessment with direct environmental sampling, modeling, and high-resolution DNA typing methods. Investigators should not limit study to high-profile pathogens like MRSA but include a broader range of pathogens, as well as other disease outcomes.

Keywords IFAP · CAFOs · Air pollution · Asthma · Zoonotic disease · Odor

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Introduction

The 20th century saw unprecedented transformation in the scale and practices associated with food animal agriculture. The resulting industrial model first emerged in US poultry production over the 1930s–1950s [1], with parallel developments in Europe [2]. Industrial food animal production (IFAP) today [2] is characterized by large-scale, highly specialized, densely stocked operations designed to maximize output at minimal cost to producers. In the USA, for example, the majority of swine and laying hens are confined to operations with inventories of over 5000 swine or 100,000 birds [3]. Production relies heavily on inputs, including specially formulated feeds, pharmaceuticals, and synthetic hormones (in cattle), the use of which has been implicated in the presence of environmental, occupational, and/or food-borne hazards [4, 5]. This model has become increasingly globalized, with multinational

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corporations expanding operations in Southeast Asia, Mexico, Eastern Europe, and other parts of the world [1, 6].

Figure 1 illustrates how IFAP can lead to adverse health effects in nearby communities via the generation and spread of microbial and chemical hazards. Studies have identified bacterial pathogens, such as antibiotic-resistant strains of *Staphylococcus* and *Enterococcus*, in and around IFAP operations, including colonizing animals and surfaces [7–10], in manure [11–16], and carried by flies [17, 18] and rats [19] near operations. IFAP is also a source of airborne pathogens [8, 20–22], endotoxins [23], particulate matter (PM) [24], hydrogen sulfide (H_2S), ammonia, odorous chemicals, and other contaminants [23, 25–28], which may be spread from operations to the downwind environment, e.g., via ventilation fans and emissions from decomposing manure [7, 8, 26, 27, 29–32]. IFAP workers are subject to heightened exposures to these hazards and have been shown to exhibit elevated rates of respiratory illness [33, 34], psychological distress [35, 36], and colonization/infection with resistant pathogens [5, 37, 38], the latter potentially transmissible to workers' communities. Spreading IFAP waste on agricultural fields—a common method of disposal—presents further opportunities for microbial [13, 39–43] and chemical [44] contaminants (e.g., nitrates, antibiotic residues, heavy metals, and excreted hormones) to be transported through environmental media, including ground and surface waters. Failed containment and extreme weather events may also lead to the discharge of stored waste into nearby water sources [45]. Taken together, these and other exposure pathways have been implicated in adverse health outcomes among nearby residents.

The breadth of research on the community health effects associated with IFAP has not been the subject of a recent review [46–49]. A 2010 systematic review [49] examined evidence of respiratory, gastrointestinal, and mental health outcomes; however, this review reflects a limited subset of the broader body of research. Furthermore, the review was funded by two major industry groups and may have been subject to bias from competing interests.

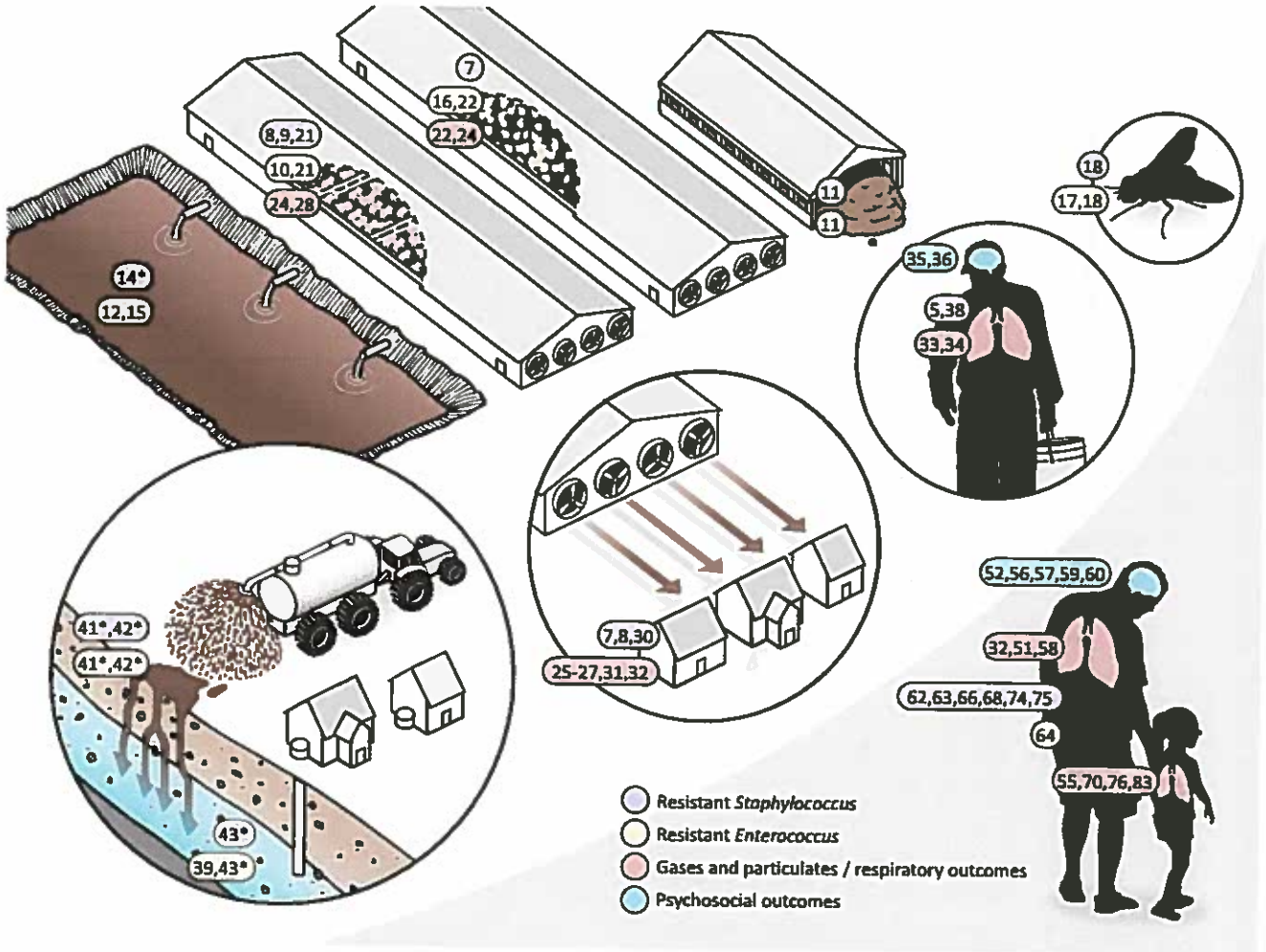

Fig. 1 Studies that document selected hazards associated with IFAP, illustrating potential pathways through the environment, and adverse health outcomes in nearby populations. *Numbers* indicate study citations. *Study investigated the presence of resistance genes, which could be acquired by *S. aureus*, *Enterococcus*, or other pathogens

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For this review, we identified studies published after the year 2000 by searching PubMed and Google Scholar using key words related to animal production including IFAP, concentrated animal feeding operation (CAFO), livestock operation, and agriculture and key words related to health outcomes, including health, infection, asthma, stress, and aquatic health. We scanned the reference lists of the identified studies for additional papers missed by our search strategy. We included all studies that addressed health outcomes, either clinical or subclinical, either in humans or in animals. Several related areas of research were excluded or mentioned only briefly because they were beyond the scope of this review: studies of people living or working on a farm, measurement of environmental hazards without an associated health outcome, exposures related to meat consumption, issues of environmental justice, and climate change implications. In this article, we review 33 studies completed since 2000, identified from our search of the scientific literature, that characterize health effects in communities near IFAP. We also discuss methodological challenges, policy implications, and future research directions.

Exposure Assessment

Both infectious and noninfectious disease can occur as a result of a single exposure via a single pathway, but more commonly, diseases are multifactorial and several pathways may act simultaneously (e.g., odor, air pollution, weather, community characteristics, and socioeconomic status) to influence the relationship between IFAP and health outcomes. This systemic causation partially explains why few studies have linked direct environmental measurements to human health outcomes [50•, 51, 52]. Studies have used a variety of tools to assign exposure to study populations: self-report, aggregation to a specified geographical area, distance-based methods, interpolation from sampled points to estimate those not sampled, direct environmental sampling, and microbiologic methods [53] (Fig. 2a).

Self-Report

To evaluate exposures, many studies asked participants to report presence, severity, and/or duration of livestock odor [27, 50•, 51, 52, 54–56]. Four studies, two in Germany [57, 58] and two in the Netherlands [59, 60], asked participants about annoyance due to livestock odor. Few studies used self-reported livestock odor as the only exposure variable [56, 57]; many also incorporated direct measurements or used dispersion modeling to estimate individual-level exposure [27, 50•, 51, 52, 59, 60]. Self-reported odor has the potential to bias estimates away from the null if those experiencing health outcomes are more aware of and report more exposure, a particular issue with retrospective data collection (i.e., recall bias) [61]. Study design can reduce risk of bias. For example, Deiters et al. and Larsen et al. [62, 63•] supplemented self-reported livestock contact with microbiologic analysis of methicillin-resistant *Staphylococcus aureus* (MRSA) strains.

Geographical Aggregation

Five studies aggregated IFAP exposure to the zip code [64, 65], municipality [63•, 66], or county [67] level. Two included population density to account for differences in characteristics of the aggregated units that might influence the outcome [66, 67]. Feingold et al. also assessed spatial variation in risk and clustering of livestock-associated MRSA cases.

Distance-Based Exposure and Interpolation

Likely due to simplicity, interpretability, and data availability, distance-based measures were the most common way to estimate exposure (17/33 studies reviewed). Three types of distance metrics were used: (1) buffers around IFAP with radii varying from 800 to 3200 m [54, 56, 57, 64, 68–71], (2) proximity measures [55, 58, 72, 73], and (3) gravity models (i.e., inverse distance-squared model) [74–77]. Pavilonis et al. [76] also incorporated wind direction in their gravity model [76].

In regions where some air pollution monitors are available, but not at the study subject's exact residence, researchers have estimated exposure using validated [78] local and long-range models [59, 60].

Direct Environmental Sampling

Direct sampling most closely captures human exposure. Researchers in North Carolina set up a central monitoring trailer for 2 weeks in study participants' neighborhoods and continuously measured H_2S, semivolatile PM_{10}, and PM_{10} [27, 50•, 51, 52]. In 2008, Wing et al. reported a significant positive association between H_2S concentration and self-reported odor, adding credence to studies using self-reported odor as an exposure measure [27]. In a comprehensive investigation of a Q fever outbreak that originated at a goat dairy in the Netherlands, Hackert et al. took environmental samples from the barn; blood samples from veterinarians, farmers, and their close contacts; and aerosamples 1000 m from the barn to characterize many phases of exposure [79•].

Microbiologic

Microorganisms sampled from IFAP and the community must be characterized with high-resolution DNA typing methods to determine whether isolates found in people with no livestock exposure are linked to the livestock reservoir. Over the years, several typing methods have been used, including phenotypic

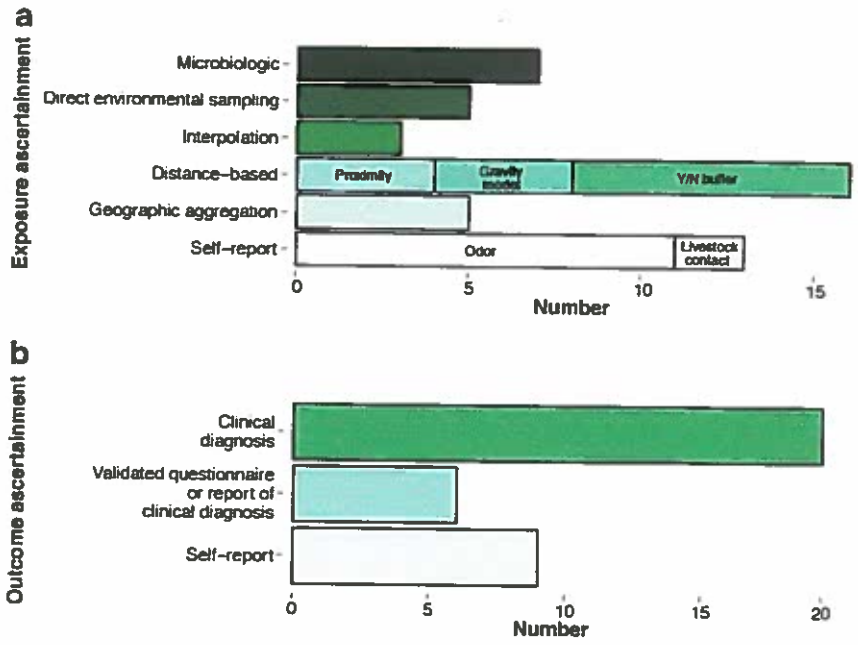

Fig. 2 Methods of exposure assessment and outcome ascertainment in reviewed health outcome research since 2000. a Main method of exposure assessment (n=33 studies); all are mutually exclusive except for self-report, which complemented other methods in many studies. b Main method of outcome ascertainment (n=33 studies); all are mutually exclusive

characterization, DNA fingerprinting, single-locus and multilocus sequence typing, DNA microarrays, optical mapping, and whole-genome sequence typing (WGST) [80]. The increased use of WGST is bound to improve our understanding of the relationship of microorganisms at the animal-human interface in the coming years. Its discriminatory power has already been shown in a number of retrospective outbreak investigations, but the technology still has to be translated from a research tool into one that is useful in routine surveillance programs and early warning systems.

Outcome Ascertainment

In studies reviewed, outcome ascertainment methods were less variable than exposure assessment. Researchers used just three types: self-reported outcome, self-report of clinical outcome or a validated questionnaire, or a medically documented clinical diagnosis (Fig. 2b). Clinical diagnoses were most common (18/33 reviewed studies) and the only method used for zoonotic pathogen research.

Empirical Work on IFAP and Health Outcomes

Respiratory Outcomes

A small number of studies in a few locations (Iowa [70, 76] and North Carolina [50•, 51, 55] in the USA, as well as northwestern Germany [32, 58] and the Netherlands [77]) have examined relationships between IFAP and the occurrence of respiratory outcomes in nearby residents or schoolchildren. All studies included swine operations, though some also included other animal species (chickens, cows, goats, sheep, and mink).

Assessed respiratory outcomes varied across studies. Most studies used self-reported wheeze/whistle, medication use or prescription, or asthma diagnosis, collected through questionnaires [32, 51, 55, 58, 70, 76]. Fewer studies also used objective clinical measurements of lung function, including forced expiratory volume in one second (FEV_1) and peak expiratory flow (PEF) or clinical diagnosis codes [32, 51, 58, 77]. A study of children attending schools near IFAP examined functional limitations (in the form of missed school or activity limitations) stemming from asthma symptoms [55].

With some exceptions, the limited available evidence suggests a relationship between exposures to air pollutants from IFAP and respiratory morbidity (Table 1). One strength of this small database includes the notion that using multiple variations of exposure assessment (proximity- or density/gravity-based, objective pollutant measurement, and subjective odor monitoring) yields generally consistent relationships between exposures and outcomes related to asthma (diagnosis, wheeze, and medication use). Another strength is that many of the observed effects (asthma, wheezing, and COPD) are consistent with those seen in hog confinement workers who are more highly exposed [81]. Despite these strengths, some limitations exist, especially in regard to study design; the majority of the studies available are cross sectional. Only one prospective cohort study of respiratory outcomes was identified [51], and while its findings were consistent with other findings, the overall confidence in the relationships would be bolstered with additional prospective studies. In addition, the literature has focused on swine, making it difficult to draw conclusions

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Table 1 Summary of health outcomes and proportion of studies reporting an association between living near industrial food animal production and poor health outcomes

Health outcome	Study design	Proportion with greater than or equal to one significant association with IFAP	Weight of evidence	References
Respiratory				
Asthma	Observational/Cross sectional	3/4		[51, 58, 70, 76, 77]
	Longitudinal	1/1		
Wheeze	Observational/Cross sectional	2/4	Mostly consistent evidence of an association, stronger for asthma and lung function	[32, 51, 55, 58, 70]
	Longitudinal	1/1		
Lung function (FEV_1, PEF, and COPD)	Observational/Cross sectional	2/3		[32, 51, 58, 77]
	Longitudinal	1/1		
Allergic rhinitis	Observational/Cross sectional	1/3		[32, 58, 77]
Cognitive impairment	Experimental	0/1	Weak evidence of an association	[69, 87]
	Observational/Cross sectional	1/1		
Stress/Mood	Experimental	0/1	Sufficient evidence of an association	[52, 54, 59, 60, 69, 87, 88]
	Cross sectional	4/4		
	Longitudinal	2/2		
Quality of life and activities of daily living	Ethnography	1/1	Moderate evidence of an association	[27, 56, 57, 59, 71]
	Observational/Cross sectional	4/4		
Zoonotic disease				
MRSA	Observational	6/6	Sufficient evidence of an association	[62, 63•, 66, 68, 74, 75]
C. difficile	Observational/Longitudinal (humans) and Observational (swine)	1/1	Insufficient evidence of an association	[85]
Enterococcus	Observational	1/1	Insufficient evidence of an association	[64]
Q fever	Observational/Cross sectional	1/1	Sufficient evidence of an association	[72, 73, 79•]
	Longitudinal	2/2		
Birth outcomes	Ecologic	1/6	Insufficient evidence of an association	[65, 67]
Blood pressure	Observational/Longitudinal, short term	1/1	Weak evidence of an association	[50•]

about broiler, egg layer, cattle, and dairy operations with regard to respiratory health. Of the few studies that relied upon objective pollutant measurements to characterize exposure, H_2S and fine PM were found to be predictors of reporting chest tightness and wheeze, respectively [51]; a different study relying on interpolated estimates of measured ammonia concentrations did not find significant associations with wheeze [32].

Two other studies painted a blurrier picture of the relationship between IFAP and respiratory outcomes. One study which built upon an earlier investigation that did find significant relationships relied upon interpolated ammonia exposures from area monitors to assign exposure and did not find associations with wheeze or allergic rhinitis but did show a significant increase in allergen sensitization and a significant decrease in FEV_1 [32]. Another study in the Netherlands used electronic health records and multiple methods of farm pollution exposure assessment and found significant inverse relationships with asthma, allergic rhinitis, and COPD [77].

The European GABRIEL Advanced Studies have shown a protective effect against asthma and atopic sensitization for children who grew up on a farm that both raised cows and cultivated feed crops, though associations were less clear for atopy [82]. In contrast, research in Iowa found higher prevalence of asthma among children growing up on a farm raising swine (with an elevated effect for swine farms that use antibiotics), even among those with lower rates of atopy and personal histories of allergies [83]. Many studies of respiratory outcomes in our database did not account for farm contact/residence in assessment of relationships between respiratory outcomes and animal operations.

Zoonotic Diseases in Humans Living in Close Proximity to IFAP

IFAP is an enormous reservoir of zoonotic bacteria (including those resistant to important antimicrobials for human use) such as *Salmonella* spp., *Campylobacter* spp., *Escherichia coli*, and *Enterococcus* spp., *Coxiella burnetii*, *S. aureus* (including MRSA), and *Clostridium difficile*. Although food animals are the primary hosts of these microorganisms, they may also be present in IFAP workers and in the surrounding

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environment, which could put people living in close proximity at risk for acquisition and infection.

In particular, *C. burnetii*, the cause of Q fever in humans, and MRSA have been increasingly recognized as important pathogens in people living near IFAP. Sheep, goats, and cattle are considered the most common reservoirs of *C. burnetii*, which is excreted in milk, urine, feces, and birth material from infected animals [84]. In the Netherlands, Smit et al. demonstrated a strong association between human Q fever and the number of goats within a 5-km radius of the residential address [73]. In another study of a large single-point source outbreak of Q fever in the Netherlands, Hackert et al. showed that most community cases were scattered downwind from the index farm and that the risk of *C. burnetii* exposure and development of Q fever increased with residential proximity to the index farm [79•]. Most recently, Hermans et al. demonstrated a strong spatiotemporal relationship between residential proximity to goat-manure-applied crop fields and human Q fever in the Netherlands [72]. Taken together, these studies support the conclusion that exposure to a contaminated environment is a primary source of Q fever in community settings.

Several studies from Europe have shown that the distribution of human cases of MRSA strains belonging to clonal complex 398 (MRSA CC398) is concentrated in rural areas where food animals are raised [62, 63•, 66]. Worryingly, a substantial proportion of these people have no direct animal contact, suggesting that MRSA CC398 is spreading from IFAP into surrounding communities [62, 63•, 66]. In Denmark, living in the same municipality as an IFAP worker with MRSA CC398 infection was associated with a 2.5-fold higher risk of developing an MRSA CC398 infection in the general population [63•]. It remains unclear how spread into the community occurs. While MRSA usually spreads through human-to-human contact, it is possible that other modes of transmission play a role, including spread via contaminated environmental media, pests, and fomites. A study from Germany found low numbers of MRSA CC398 in air samples (<15 bacteria/m^3) and on soil surfaces downwind of IFAP operations [8]. It is unknown, however, whether these concentrations are high enough to represent a risk for human acquisition and development of infection. In the USA, living in close proximity to IFAP operations and manure fields has been associated with an increased overall risk of MRSA infection and carriage [68, 74]. Nearby IFAP operations and manure fields were not sampled and MRSA isolates from the patient populations were not available for typing due to the retrospective study designs, thereby hindering molecular tracking of the source. In a prospective study, some MRSA types seemed to predominate in people living in close proximity to IFAP [75], but again, there was no sampling of local IFAP operations. US studies were unable to directly control for livestock contact and therefore did not exclude IFAP workers from the analysis. However, Casey et al. showed that adjusting for the prevalence of livestock workers at the community level did not change the results [74].

Only a few studies have investigated whether other microorganisms can spread from IFAP into the surrounding communities. In the Netherlands, Goorhuis et al. found that the human infections with *C. difficile* ribotype 078 were concentrated in more rural areas where pigs are raised and that isolates from pigs and humans were closely genetically related [85]. Kelesidis and Chow showed that daptomycin-nonsusceptible enterococci cases lived in close proximity to animal and crop operations in Los Angeles County, but this study did not attempt to track the source of these microorganisms [64]. Conversely, Odoi et al. found no link between cattle density or intensity of manure application IFAP and human *Giardia lamblia* infection in Ontario [86].

Few studies have directly measured the transmission of antibiotic-resistant zoonotic pathogens into communities proximal to livestock production. The most robust studies have been conducted on livestock-associated MRSA, and these show strong evidence for transmission to communities near IFAP. Additional studies are needed to assess the risk due to other pathogens resistant to clinically important antibiotics.

Cognitive Impairment, Stress, and Mood

Only two studies evaluated cognitive impairment from exposure to IFAP, providing weak evidence [69, 87]. In an experimental design, Schiffman et al. found no effect of acute (1 h) exposure to swine IFAP air (i.e., air containing elevated levels of H_2S, NH_3, PM, and endotoxin) compared to exposure to 1 h of clean air on attention, memory, or mood [87]. During short-term exposure, volunteers did experience increased headaches, eye irritation, or nausea. Kilburn et al. compared people living <3 km from a hog manure lagoon (n=25) to those living >3 km (n=22), to evaluate chronic exposure to IFAP, and found significantly more neurobehavioral abnormalities in those living <3 km [69]. They also reported worse moods (as measured by the Profile of Mood States, e.g., tension, depression, anger, vigor, fatigue, and confusion) among those living <3 km from manure lagoons. When restricting analysis to those <3 km from a lagoon, shorter distances to a lagoon were not associated with stronger effects, perhaps due to low power, unobserved confounding, or selection bias.

Several studies in the USA have evaluated the effect of exposures to swine IFAP on stress or mood, using cross-sectional [69], experimental [87], and longitudinal designs [52, 54]. Horton et al. used a community-based, longitudinal design among 101 participants living near swine IFAP operations and found self-reported odor, and directly sampled H_2S, and semivolatile PM_{10} were each associated with feelings of stress or annoyance and nervousness or anxiety [52]. In an earlier community-based study, Avery et al. had 15 participants living <1.5 mi from a swine operation take twice-daily

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salivary samples after rating livestock odor and found evidence that exposure to odor reduced the function of the mucosal immune system (as measured by secretory immunoglobulin A) [54]. Although not directly measured, they hypothesized that this association was mediated by stress caused by odor exposure.

European studies have focused on odor annoyance due to exposure to livestock (i.e., swine, poultry, and cattle) and cross-sectional studies have consistently reported odor annoyance among participants living in areas with high livestock density [58–60, 88], with attenuated affects for those living or working on a farm [57, 59, 60]. Hooiveld et al. also noted that while self-reported symptoms (e.g., respiratory, gastrointestinal, and stress) were associated with higher self-reported odor annoyance, few participants sought health care services to resolve their concerns [88]. This finding highlights the importance of measuring symptoms directly or carefully selecting health outcomes for research that are available in the health care record.

Despite differences in exposure assessment, outcome ascertainment, and study design, six out of seven studies reported at least one significant association between IFAP exposure and cognition, mood, or stress, providing sufficient evidence of an association. Schiffman et al. did not observe any effects of an acute laboratory exposure, suggesting that chronic, unpredictable exposures are more salient [87].

Quality of Life

Three studies in the USA [27, 56, 71] and two in Europe [57, 59] have considered the relationship between odors from IFAP and quality of life. Four of the five studies assessed exposure by proximity to livestock operations and self-reported odor; one used modeled annual ammonia concentration at the household [59]. All studies used self-reported outcomes.

Wing et al. provided early evidence by interviewing 100 individuals in North Carolina who lived near swine or cattle operations and 55 who did not (N=155) [71]. Of all symptoms recorded, the greatest differences between communities were seen on quality of life questions; for example, those living within 2 mi of a swine operation reported being unable to go outside 15.4 times (on average) in the prior 6 months, compared to 2.1 times for those not living near an operation. Radon et al. assessed quality of life with the Short-Form 12 Health Survey (SF-12), a reliable and valid measure of physical and mental health in a variety of contexts. In analyses adjusted for factors like age, sex, schooling, and smoking, they reported a strong association between odor annoyance and reductions in physical and emotional SF-12 scores [57].

Blanes-Vidal et al. found evidence supporting a coping hypothesis: Odor leads to behavioral interference (e.g., disruption of lifestyle or unwanted changes in social behavior), mediated by annoyance perception [59]. In a Danish sample, they reported that modeled ammonia exposure was associated with increased odds of behavioral interference and health risk perception and that odor annoyance mediated 81 and 44 % of the relationships, respectively. Two community-based participatory research projects also found support for this hypothesis where residents living near swine operations commonly changed their activities, including social interactions, physical activities, and sleep, due to odor [27, 56]. Tajik et al. reported that even in the absence of odor, participants felt stress and anxiety regarding the potential impact to daily routines or embarrassment if guests were present when odor occurred [56]. Taken together, these studies provide moderate evidence that exposure to IFAP impacts activities of daily living or quality of life.

Other Studies

Two ecologic studies evaluated the effect of geographically aggregated livestock exposure on indices of infant health and mortality [65, 67]. Sneeringer conducted a time-series analysis using two decades of US, nationwide, county-level data on livestock numbers (i.e., beef, dairy, swine, and poultry) and infant births and deaths [67]. While accounting for county-level confounding variables, she found that a 100,000 head increase in livestock was associated with a 7.3 % increase in county infant mortality rate. No association was seen between livestock count and four birth outcomes: continuous birth weight, low birth weight, 5-min Apgar score, or preterm birth. The author proposed an underlying air pollution mechanism based on several secondary analyses. Similarly, Blake did not find an association between zip code-level counts of dairy cows in the San Joaquin Valley in California and birth weight but found cow density to be associated with higher nitrate levels in well water [65].

We also identified a single study of the relationship between air pollution from animal operations and blood pressure [50•]. Using a case-crossover design, Wing et al. found that, after adjusting for stress, increases in community H_2S measurements, but not PM, were significantly associated with rising systolic blood pressure. This finding provides support for a psychophysiological mechanism where stress from odor triggers physiological response.

Susceptibility/Vulnerability Factors

Certain populations, including the young and old, the immune-compromised, the uninsured, racial and ethnic minorities, and the poor and those living in deprived communities, are at particular risk of health effects from IFAP exposure. These susceptible or vulnerable populations may lack neighborhood resources necessary to buffer or avoid IFAP exposures [89]. Indeed, several studies have suggested that

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livestock operations are more likely to be sited in communities of color or low socioeconomic status [55, 90–92]. This environmental injustice contributes to health disparities [93].

Aquatic Toxicology Studies

Animals living near IFAP experience similar exposures as humans. Aquatic toxicology studies, which describe effects in high-exposure animals, can inform us about IFAP-associated health risks in both human and animal populations. Several studies have evaluated the effect of steroidal hormones from beef cattle feedlot runoff on aquatic life [94–99]. The body of evidence suggests that androgens, specifically trenbolone acetate used to promote muscle growth in cattle and its metabolites 17α-trenbolone and 17 β-trenbolone, which appear relatively stable in manure [100], bind readily to fish androgen receptors [101] and have been detected in waterways near feedlots [95, 97, 99] and can cause problems in fish.

Leet et al. found that fathead minnows exposed to an IFAP effluent mixture for 45 days were significantly heavier and longer than the controls and further analysis revealed ovaries in the testes of 84 % of exposed males, compared to 0 % of controls [96]. In IFAP ditchwater-exposed wild fish, Leet et al. also observed lower species richness, faster growth, and worse reproductive conditions compared to reference site fish [95]. The authors reported a male-skewed sex ratio in fathead minnows exposed to IFAP ditchwater for their first 6 weeks of life (60.4± 3.3 % males in the IFAP-exposed group vs. 48.7±3.9 % males in control group). They did not detect an estrogenic effect (measured by vitelloeginin activity) in fathead minnows during a 7-day in situ exposure, suggesting that androgens might have a greater impact on aquatic life [95]. These ecotoxicological studies could have implications in humans reliant on impacted groundwater.

Methodological Issues in Community Health IFAP Studies

Access to Populations and Health Outcomes

IFAP is usually sited in rural areas, which have lower population densities, more diffuse health care, and a population that may have medical skepticism [102] or indirect involvement in IFAP [103], all of which present potential barriers to their involvement in research. Wing and colleagues in North Carolina have effectively used community-based participatory research [104] to engage community members in academic health research [27, 50•, 51, 52, 54, 56, 71]. In the USA, state and national agencies do not require reporting of most diseases associated with IFAP (with the exception of Q fever), so data acquisition on diseases of interest is challenging. Despite this barrier, most studies utilized a clinically diagnosed outcome (Fig. 2b). Casey et al. used data from the Geisinger Health System, which provides medical care in an area covering 69,000 km^2 to study associations of IFAP and MRSA infection [74, 75]. Databases available in several European countries also enabled studies on individuals dispersed across large geographies.

Exposure Characterization

In comparison to outcome assessment, access to information about IFAP is extremely limited. In the USA, swine and poultry operations are generally vertically integrated, privately owned, and inaccessible to researchers. Unlike in some European countries, almost no information exists about antibiotic type, quantity, or duration of use in US IFAP [105]. Most studies reviewed relied on self-report or distance-based exposure estimates, sometimes paired contemporaneously with self-reported outcomes, potentially biasing results of either or both measurements.

In addition, in the few studies that were able to measure environmental media, samples were restricted to indicator pollutants (e.g., H_2S, PM, or ammonia) or bacteria (e.g., MRSA) [27, 50•, 51, 52]. IFAP exposures are multifactorial, including not only air pollution but also water pollution, odor, and potential impacts on housing values [106] that might have additive, multiplicative, or nonlinear effects on health outcomes.

Establishing Causality

Randomized experiments allow causal inference by allowing us to assume that exposed individuals represent what would have happened to the unexposed if they had been exposed. However, in environmental health, randomizing people to a harmful exposure is not an option. In IFAP research, as in many observational studies [107], it might not be possible to fully account for individual-level characteristics, like income or education, that are also related to health and to living near IFAP (i.e., confounding bias). Additionally, sicker individuals or people with certain health behaviors might be more likely to live near to IFAP (i.e., selection bias).

To investigate how IFAP impacts health, researchers should take advantage of available data, natural experiments [108], and creative sensitivity analyses. Government agencies often collect wind data, which future studies should consider incorporating in distance-based models, since bacteria, antibiotics, and antibiotic-resistant genes are more common downwind from farms [8, 30, 31] and wind can affect the spread of air pollution and odor [25, 31, 109]. In a sensitivity analysis, Casey et al. assessed the odds of an MRSA infection in those living near a manure-applied crop field compared to those living near any crop field and found that risk was only associated with manure-applied crop fields [74]. For acute outcomes, researchers have used cases as their own controls in a short-term longitudinal design to reduce the number of necessary participants and to handle unmeasured confounders [27, 50•, 51, 52, 54, 87]. Long-term longitudinal designs to

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establish temporality and reduce selection bias are another important step toward causal inference.

Discussion and Future Directions

Some important strides have been made in characterizing the public-health burdens placed on communities by IFAP. We found sufficient evidence of an association between living near IFAP and respiratory outcomes, MRSA, Q fever, and stress/mood. To date, much of the existing epidemiologic literature describes investigations that follow on observational, cross-sectional design. While these studies are useful, more prospective studies, especially those that involve primary data collection for both exposures and outcomes, are needed to generate additional, stronger evidence.

In addition, characterization of chemical exposures typically involves measurement of a narrow set of indicator pollutants, while it is well understood that emissions from IFAP operations tend to be complex multipollutant mixtures [81, 110, 111]. More sophisticated approaches that examine the spatiotemporal patterns of mixtures and that may not track well with traditionally used indicator chemicals are needed [112]. Building on improvements in exposure characterization, novel approaches aimed at disentangling the contributions of individual contaminants and multicontaminant synergies within mixtures [113] should be applied in the context of IFAP. These techniques have increasingly been used in the urban context for air pollution research but may also be useful in evaluating exposures to rural mixtures.

Future studies should explicitly investigate community exposure through water pollution. Given the potential for land-applied animal waste to impact groundwater [65, 114–116], and the reliance of rural communities on these sources for drinking water [117], it is prudent to directly consider their potential contributions to morbidity and mortality.

One strength of the existing body of literature is that it includes community-driven studies [50•, 51, 55, 118]; these studies build upon established trust between researchers and communities by meaningfully involving community members to design, conduct, contextualize, and disseminate research [119]. Continued use of this approach holds promise for answering questions relevant to community-identified needs.

In the case of microorganisms, future investigations should not be limited to high-profile antibiotic-resistant pathogens like MRSA but should also include a broader range of potentially infectious microorganisms to quantify the total infectious disease burden borne by people living near IFAP. New studies should include samples from IFAP operations, environmental media, and people with and without direct livestock contact and use high-resolution DNA typing methods to identify the transmission pathways into the community and risk factors for human colonization and infection. In addition, emphasis should be placed upon clinically relevant health outcomes such as infection, rather than colonization, especially for microorganisms where the risk of infection given colonization is not well understood. This knowledge would inform evidence-based intervention strategies to control the spread of these microorganisms into the community.

Conclusions

We reviewed 33 studies of community exposure to IFAP and human health outcomes, 17 published since the last review was conducted in 2010. Residence near IFAP has consistent positive associations with respiratory outcomes, MRSA infection and colonization, Q fever, and stress/mood outcomes. Future research should improve exposure assessment through direct environmental sampling, taking into account pollutant mixtures, and continued efforts at community-based participatory research.

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Compliance with Ethics Guidelines

Conflict of Interest Joan A. Casey, Brent F. Kim, Jesper Larsen, Lance B. Price, and Keeve E. Nachman declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This review contains studies by Joan A. Casey and Keeve E. Nachman that used electronic health record data on patients for which IRB approval was received. The review also contains a study by Jesper Larsen and Lance B. Price that used electronic records on humans which was approved by the Danish Data Protection Agency.

This article does not contain any studies with animal subjects performed by any of the authors.

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CAFOs and Public Health:
Emissions and the Respiratory Health of Neighbors

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Introduction

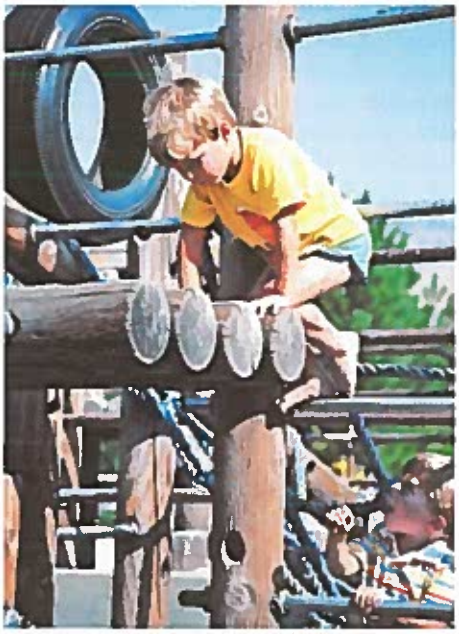
As animal agriculture increases in Indiana, so does the prevalence of concentrated animal feeding operations (CAFOs). CAFOs are facilities that hold and feed large numbers of animals in a confined area for 45 days or more out of the year (see "What is a CAFO?" for more information). These facilities have recently drawn attention from some Indiana citizens concerned about the impact that CAFOs may have on the public health of the surrounding communities. Among these concerns are CAFO emissions, namely hydrogen sulfide, ammonia, and organic dust, and the effects that these compounds may have on the pulmonary health of neighbors.

What follows is a brief summary of recent research examining CAFO emissions focusing on the possible interactions between CAFO emissions and respiratory illnesses in neighboring residents.

CAFO Emissions

There are three main compounds of concern in CAFO emissions: hydrogen sulfide, ammonia, and organic dust. Hydrogen sulfide (H_2S) is a colorless, flammable gas with a noxious odor. It is produced from the bacterial breakdown of organic material in animal wastes. Extremely high concentrations are fatal with exposure to low levels causing sore throat, coughing, shortness of breath, and fluid in the lungs.

Ammonia (NH_3) is a colorless gas with a distinct odor. It is naturally produced by microorganisms in manure and is also used as fertilizer for agricultural crops. As with H_2S, persons in close range to farms could receive more exposure to ammonia than others. Exposure to high levels of ammonia can cause irritation to the nose, throat, and lungs resulting in coughing, burning sensations, and other discomfort. Asthmatics are usually more sensitive to ammonia than others.



Organic dust typically comes from grain, straw, and livestock and can consist of bacteria, pesticides, and animal particles (dander, etc.). Organic dust can be high in endotoxin, a bacterial cell wall component that is highly allergenic in humans. Long-term exposure to organic dust can cause

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coughing, wheezing, and congestion. An extreme sensitivity to organic dust can prohibit working in confinement buildings (see reference 1 for more information on specific emissions).

Emission Concentrations at Residences Close to CAFOs

CAFO emissions are usually much lower at residences in the vicinity of the operation than within the confinement buildings themselves. In terms of actual concentrations, a group in Iowa compared emission levels at residences near large swine CAFOs with homes near smaller hoop structure (low-density, solid manure) swine farms as well as homes in areas devoid of livestock. The researchers found that the concentration of hydrogen sulfide (8.42ppb) was highest in homes located near large confinement operations. The concentrations of both carbon dioxide (449.6ppm) and ammonia (12.78ppb), however, were highest in homes located near the smaller, less confined operations[2]. Other studies have found concentrations of emissions to be low (less than 1ppm for ammonia, less than 1ppb for hydrogen sulfide) at property lines adjacent to swine CAFOs.[3]

A more recent study by another group in Iowa measured the levels of ammonia and hydrogen sulfide both inside and outside of residences located near a large swine CAFO. Ammonia concentrations outside the homes ranged from 12 to 55ppb. Ammonia concentrations were significantly higher inside the homes ranging from 29 to 95ppb.

The researchers concluded that sources such as pets and household cleaners contributed to the higher ammonia concentrations inside the houses. Hydrogen sulfide concentrations outside the homes (ranging from 0.4 to 2.4ppb) were statistically no different from concentrations recorded inside the homes (0.7 to 2.5ppb). The group noted that "as a frame of reference, the State of Iowa [uses] a Health Effects Value (HEV) for H_2S of 30ppb at a residence located at or beyond the regulated separation distance, not to be exceeded more than seven one-hour averages per year".[4]

CAFO Emissions and Respiratory Ailments in Neighbors

It has been documented that CAFO emissions can sometimes negatively impact the pulmonary health of those who work inside confinement buildings with poor ventilation for an extended period of time without respiratory protection.

It is problematic, however, to infer that similar effects can be found in neighboring residents as emission concentrations are usually very dilute by the time they reach nearby homes, and to date there are only a few studies available that specifically address CAFO emissions and respiratory illnesses in neighboring residents. A study at Duke University exposed healthy volunteers to air samples collected at a local swine CAFO. The samples were diluted to mimic concentrations that might be found at residences close to the CAFO (e.g., hydrogen sulfide, 24ppb; ammonia, 817ppb; odor 57 times above odor threshold).

Volunteers were exposed to the diluted air samples for one hour and researchers recorded objective health parameters such as blood pressure, temperature, heart rate, respiratory rate, lung function, nasal inflammation, mood, attention, and memory. The researchers also recorded perceived, or self-reported health symptoms.

There were no differences in the objective health measures between the group that was exposed to CAFO air versus the group that was not. Volunteers exposed to CAFO air did, however, have higher incidences of self-reported health symptoms such as headaches, nausea and eye irritation.[5]

There are a handful of studies that have examined CAFO emissions and their possible effects on the pulmonary health of neighbors in more real-life settings. One study that took place in Germany found no correlations between the frequency of odor annoyance and the prevalence of clinical asthma symptoms (non-self-reported), such as certain blood parameters and lung capacity. Increases in self-reported symptoms of asthma, however, (e.g., wheezing without an accompanying cold) correlated with increases in self-reported odor annoyance. That is, the more often the study participants complained of CAFO odors, the more often they reported experiencing asthma symptoms. The study did not examine specific emissions nor did it quantify their concentrations at participants' homes.[6]

Another study in North Carolina focused specifically on CAFO emissions and childhood asthma. It found that the prevalence of wheezing was slightly higher in children who attended schools close to swine confinement

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buildings and highest in children attending schools where livestock odor was noticeable at least twice per month.[7]

Another group comparing asthma in children in two different Iowa public schools found an increase in the prevalence of physician-diagnosed asthma in children attending a school located only one-half mile from a CAFO. There were no differences in the severity of asthma between the two groups and the authors cautioned that the differences in the number of physician-diagnosed asthmatics could be due to different sets of physicians in the two areas and physician bias.[8]

Conclusions

Determining the effect of emissions on the pulmonary health of neighbors is difficult because of the lack of published research in this area and conflicting results in the available studies. It is certain that CAFO emissions including hydrogen sulfide, ammonia, and organic dust can have a detrimental effect on the respiratory health of those who work inside the confinement buildings when they are exposed to high levels for long durations. Whether those same symptoms appear in neighbors where emissions are diluted, is unclear. Data from a handful of studies suggest that CAFO emissions can cause an increase in self-reported respiratory symptoms such as wheezing, headache, etc. To date, however, emissions have not been associated with increases in objectively measurable respiratory illnesses.

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Multidrug-Resistant and Methicillin-Resistant *Staphylococcus aureus* (MRSA) in Hog Slaughter and Processing Plant Workers and Their Community in North Carolina (USA)

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Background: Use of antimicrobials in industrial food-animal production is associated with the presence of antimicrobial-resistant *Staphylococcus aureus* (*S. aureus*) among animals and humans. Hog slaughter/processing plants process large numbers of animals from industrial animal operations and are environments conducive to the exchange of bacteria between animals and workers.

Objectives: We compared the prevalence of multidrug-resistant *S. aureus* (MDRSA) and methicillin-resistant *S. aureus* (MRSA) carriage among processing plant workers, their household members, and community residents.

Methods: We conducted a cross-sectional study of hog slaughter/processing plant workers, their household members, and community residents in North Carolina. Participants responded to a questionnaire and provided a nasal swab. Swabs were tested for *S. aureus*, and isolates were tested for antimicrobial susceptibility and subjected to multilocus sequence typing.

Results: The prevalence of *S. aureus* was 21.6%, 30.2%, and 22.5% among 162 workers, 63 household members, and 111 community residents, respectively. The overall prevalence of MDRSA and MRSA tested by disk diffusion was 6.9% and 4.8%, respectively. The adjusted prevalence of MDRSA among workers was 1.96 times (95% CI: 0.71, 5.45) the prevalence in community residents. The adjusted average number of antimicrobial classes to which *S. aureus* isolates from workers were resistant was 2.54 times (95% CI: 1.16, 5.56) the number among isolates from community residents. We identified two MDRSA isolates and one MRSA isolate from workers as sequence type 398, a type associated with exposure to livestock.

Conclusions: Although the prevalence of *S. aureus* and MRSA was similar in hog slaughter/processing plant workers and their household and community members, *S. aureus* isolates from workers were resistant to a greater number of antimicrobial classes. These findings may be related to the nontherapeutic use of antimicrobials in food-animal production.

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Introduction

Staphylococcus aureus (*S. aureus*) is an important pathogen that can cause serious and life-threatening infections in humans. Clinical problems caused by *S. aureus* range from localized illnesses, such as necrotizing skin infections and folliculitis, to systemic diseases, including toxic shock syndrome (Lowy 1998). *S. aureus* infections have become more dangerous and costly to treat over the past 20 years because of increasing prevalence of antimicrobial resistance. Of considerable concern is methicillin-resistant *S. aureus* (MRSA), as well as multidrug-resistant *S. aureus* (MDRSA) (Gordon and Lowy 2008). Several studies in hospitals in the United States have reported that MRSA is the most common cause of skin and soft tissue infections (King et al. 2006; Moran et al. 2006; Parchman and Munoz 2009), and MRSA carriage is associated with subsequent infection and increased morbidity and mortality compared with noncarriage (Datta and Huang 2008).

S. aureus colonizes skin and can persist in the nares; positive nasal carriage is indicative of exposure and is associated with an increased risk of clinical infection in hospitalized populations (Davis et al. 2004; Stevens et al. 2010). Based on risk factors associated with exposure, MRSA strains are often classified as health care–associated MRSA (HA-MRSA), or community-associated MRSA (CA-MRSA). Since 2001, the increases in MRSA exposures and infections in the United States are largely due to community-associated strains, such that MRSA can no longer be controlled solely on the basis of measures implemented within health care settings (Como-Sabetti et al. 2009; Stefani et al. 2012).

Within the category of CA-MRSA, studies in several countries have identified specific strains associated with livestock and which have been termed livestock-associated MRSA (LA-MRSA) (Armand-Lefevre et al. 2005; Bisdorff et al. 2012; DeBoer et al. 2009; Ogata et al. 2012; Smith and Pearson 2011; Waters et al. 2011). Studies have reported increased risks of MRSA carriage among persons working with livestock, including swine (Aubry-Damon et al. 2004; Denis et al. 2009; Geenen et al. 2012; Morcillo et al. 2012; Mulders et al. 2010; Nijsten et al. 1996; Voss et al. 2005); among veterinarians treating livestock (Garcia-Graells et al. 2012; Hanselman et al. 2006); and, more recently, among persons without direct livestock contact but residing in areas of high livestock density (Feingold et al. 2012). In addition, several recent studies have reported on the prevalence of MDRSA carriage among livestock, farm workers, and slaughterhouse workers (Khanna et al. 2008; Oppliger et al. 2012; Smith and Pearson 2011; VanCleef et al. 2010).

In comparison with the European Union, relatively fewer studies examining MDRSA and MRSA exposures in hog production have been conducted in the United States (Leedom Larson et al. 2010; Osadebe et al. 2013; Rinsky et al. 2013; Smith et al. 2009) and, to our knowledge, no studies have been published examining the prevalence of MRSA among workers in U.S. hog slaughter and processing plants or the household members

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of these workers. Therefore, we undertook a study of workers in a large hog slaughter and processing plant, their household members, and community residents. The objective of our study was to test the hypothesis that workers have a higher prevalence of carriage of nonsusceptible strains of *S. aureus*, including MDRSA and MRSA, compared with residents in the same area who do not work in hog slaughter and processing. We also tested the hypothesis that workers are more likely to carry *S. aureus* isolates that are resistant to more antimicrobials as compared with community residents from the same area. We included household members in this study based on studies of household transmission of *S. aureus* and MRSA that reported transmission rates within households as high as 43% (Davis et al. 2012). We hypothesized that household members of workers would also have greater exposure to nonsusceptible strains of *S. aureus* than community referents.

Methods

Study design and recruitment. We conducted a cross-sectional study between September and November 2011 in Tar Heel, North Carolina, the location of the Smithfield plant, the largest hog slaughter and processing plant in the United States. Tar Heel is sparsely populated [117 residents, according to the 2010 U.S. Census (U.S. Census Bureau 2011)], with most workers and community referents residing in nearby cities and towns in southern North Carolina and northern South Carolina. The workforce at the Tar Heel plant included approximately 4,500 workers and was unionized, which facilitated enrollment of workers in the study. Study participants were recruited through outreach efforts by our partner, the United Food and Commercial Workers International Union (UFCW) local 1208. Prior to data collection, we met with local and national officials of the UFCW, as well as with shop stewards of the local union (employees who represent the union at each work area within the plant). These individuals informed the union membership about the study. We asked workers to invite up to two members of their community (people who lived nearby, but who did not live with them or work at the plant), and up to two people living with them who did not work at the plant. Through these efforts we enrolled three categories of participants: *a*) plant workers, *b*) household members of plant workers (up to two per worker), and *c*) community residents. All data collection activities were conducted at the union office, located within one mile of the plant. Before initiating the study, we informed Smithfield about the study through telephone contact with the Vice President for Environmental Affairs.

Participant enrollment took place between Thursdays and Sundays in three waves. All workers had been at work within the past week and many came directly from work. Prior to enrollment, a verbal screening was conducted to determine eligibility of persons approaching the enrollment sessions: all participants were required to be ≥ 18 years of age, able to speak and understand either English or Spanish, reside in the local area (for community residents) defined as southern North Carolina and northern South Carolina, and were not working at a health care facility. Those who met these inclusion criteria were assigned a unique participant code and were directed to interview stations where oral informed consent was obtained prior to data collection. No personal identifiers were collected in order to protect confidentiality. The study was reviewed and approved by the Johns Hopkins Bloomberg School of Public Health Committee on Human Research.

Data collection and biological sampling. An extensive interview was conducted using a standardized questionnaire to collect information on demographic data, current and past occupational history, recent health history (including infections and any use of antimicrobials), contact with live animals (livestock and companion animals), and typical diet. Fluent English/Spanish speakers administered the questionnaire in both languages. We pretested the questionnaire in English and Spanish for clarity and consistency on six non-Hispanic and six Hispanic union members.

After completing the questionnaire, trained personnel collected a swab sample [BD Diagnostic Systems, (Sparks, MD) dual swab with Amies agar gel] from both nares of each participant. The rayon-tipped swab applicator was then placed into its plastic tube containing transport medium. The transport tube was labeled with the participant code, and shipped to our laboratory at Johns Hopkins by express courier service.

Microbiological and molecular analyses. Upon arrival at the laboratory, all samples were kept at room temperature until they were processed by the Johns Hopkins Hospital Laboratory of Medical Microbiology, within 72 hr of collection. Nasal swabs were cultured on BBL 5% sheep blood agar (SBA) and CHROMAgar Staph aureus plates (both from BD Diagnostic Systems) and incubated aerobically at 35°C for ≤ 48 hr before reading. Any suspected colony (β-hemolytic on 5% SBA or mauve colored on ChromAgar Staph aureus plates) was further subjected to Gram staining and the catalase assay and slide agglutination test (Rabbit Coagulase Plasma; ProLab, Richmond Hill, Ontario, Canada). Gram-positive cocci in clusters that were catalase positive and coagulase positive were identified as *S. aureus* (Becker and von Eiff 2011) and subcultured on 5% SBA to isolate pure colonies before being transferred into 30% glycerol and frozen at −80°C.

We transferred one isolate from each *S. aureus*-positive culture to our laboratory for antimicrobial susceptibility testing using the disk diffusion method [Clinical and Laboratory Standards Institute (CLSI) 2008]. Isolates were first regrown in Mueller Hinton broth and then examined for susceptibility to cefoxitin, ciprofloxacin, clindamycin, erythromycin, gentamicin, sulfamethoxazole/trimethoprim, quinupristin/dalfopristin, and tetracycline. We used the zone of growth inhibition around specific-antibiotic disks to assess the minimum inhibitory concentration (MIC). Based on these MICs and according to CLSI (2008) standards, we classified the isolates as susceptible, intermediate, or resistant to each antimicrobial except for cefoxitin, for which isolates were classified as either susceptible or resistant. Cefoxitin-resistant isolates were identified as phenotypic MRSA because resistance to cefoxitin predicts resistance to methicillin (Fernandes et al. 2005; Magiorakos et al. 2012).

We performed polymerase chain reaction (PCR) assays targeting *S. aureus nuc* (endonuclease) and *mecA* (penicillin-binding protein) genes, using the primers *nuc-1*: 5′-TCAGCAAATGCATCACAAACAG-3′; *nuc-2*: 5′-CGTAAATGCACTTGCTTCAG G-3′; *mecA*-1: 5′-GGGATCATAGCG TCATTATTC-3′ and *mecA*-2: 5′-AACG ATTGTGACACGATAGCC-3′ and methods previously reported (Poulsen et al. 2003). We defined as genotypic MRSA those specimens that were positive for the *mecA* gene. Because of variation in *mecA* sequences (Fluit 2011; García-Álvarez et al. 2011; Hanssen et al. 2004) that could lead to false negatives, we examined both phenotypically and genotypically characterized MRSA in our analyses. We performed multilocus sequence typing (MLST) of the seven housekeeping genes to identify *S. aureus* genetic strains as described by Enright et al. (2000).

Statistical analysis. The distributions of demographic, exposure, and outcome variables were examined and compared across the three categories of participants (workers, household members, community residents). As noted above, we classified isolates as either susceptible or resistant to cefoxitin; and as susceptible, intermediate, or resistant to other antimicrobials on the basis of MIC values (CLSI 2008). In addition, we also classified the isolates as either susceptible or nonsusceptible (the latter category including both intermediate and resistant isolates) as proposed by Magiorakos et al. (2012). Consistent with Magiorakos et al. (2012), we classified isolates as MDRSA if they were nonsusceptible to ≥ 3 classes of antimicrobials

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or were MRSA (i.e., resistant to cefoxitin). Although the susceptible and nonsusceptible categories may be more important for epidemiological purposes (Magiorakos et al. 2012) the CLSI definition is reliable in determining therapeutic failure (Kahlmeter et al. 2003). To facilitate comparison to the clinical literature, we examined both classifications.

The prevalence of *S. aureus*, nonsusceptible *S. aureus*, MDRSA, and MRSA was determined for each participant group and for the study population as a whole. We also determined the proportions of *S. aureus* isolates that were nonsusceptible, MDRSA, and MRSA among participants with positive *S. aureus* swabs. Depending on the number of individuals in each category, we used chi-squared or Fisher's exact tests to compare proportions across participant categories.

We used unadjusted and adjusted Poisson regression to compare the average number of antimicrobials to which *S. aureus* isolates were resistant (based on the CLSI definition) among workers, household members, and community residents. We also used unadjusted and adjusted log binomial regression models to compare the prevalence of MDRSA among workers, household members, and community residents. All multivariable models were adjusted for age (in groups), any self-reported use of antimicrobials in the previous 6 months (yes/no), and any self-reported visit to a medical facility in the previous 6 months (yes/no). A medical facility was defined as any place where medical care is provided, including hospitals, clinics, doctor offices, and nursing homes. The variables included in the adjusted models were selected based on *a priori* assumptions.

Finally, we examined the patterns of antimicrobial resistance found in the *S. aureus* isolates and the distribution of *S. aureus* and genotypic MRSA strains based on MLST analysis. All statistical analyses were performed using Stata version 11 (StataCorp, College Station, TX), with a significance level of 0.05.

Results

Study population. We enrolled 336 participants. Of those, 162 participants were hog slaughter/processing plant workers, 63 were household members from 50 different households, and 111 were community residents.

Community residents were more often white non-Hispanic (18%) than workers (3.1%) or their household members (1.6%) ($p < 0.01$) (Table 1). On average, workers were older than household members or community residents [mean = 41 vs. 38.6 and 32.3 years of age, respectively; analysis of variance, $F(2,2) = 9.01$, $p < 0.01$]. There were more women (58.5% overall) than men in each group, but there were no statistically significant differences among groups with regard to sex, visit to a medical facility or using antimicrobials in the last 6 months, having a MRSA diagnosis in the past year, or animal contact at home unrelated to hog slaughter and processing work.

Prevalence of S. aureus, nonsusceptible S. aureus, MDRSA, and MRSA. The overall prevalence of *S. aureus* nasal carriage among the study population was 23.5% (79/336) and was higher among household members (30.2%) than workers (21.6%) or community members (22.5%) ($p = 0.38$) (Table 1). We tested 78 isolates from the 79 *S. aureus*-positive participants for antimicrobial susceptibility (one isolate did not grow). The overall prevalence of nonsusceptible *S. aureus* was 19.4%, with similar prevalence between groups. The overall prevalence of MDRSA was 6.9% (23/335), with 8.0%, 6.5%, and 5.4% among workers, household members and community residents, respectively. The overall prevalence of phenotypic MRSA was 4.8% (16/335), with 5.6%, 4.8%, and 3.6% among workers, household members and community residents, respectively. Nine of the 16 phenotypic MRSA isolates were positive for *mecA*, providing an overall prevalence of genotypic MRSA of 2.7% (9/335); with a prevalence of 3.1%, 3.2%, and 1.8% among workers, household members and community residents, respectively.

Proportion of nonsusceptible S. aureus, MDRSA, and MRSA in S. aureus isolates. The proportion of *S. aureus* isolates ($n = 78$) that were nonsusceptible to at least one antimicrobial was higher in community members (96.0%) than workers (80.0%) or household members (72.2%) ($p = 0.09$) (Table 2). The proportion of MDRSA among all *S. aureus* isolates was higher in isolates from workers (37.1%) than household members (22.2%) or community residents (24.0%) ($p = 0.41$), and the proportion of phenotypic MRSA also was higher in workers (25.7%) than household members (16.7%) or community residents (16.0%) ($p = 0.67$). The proportion of *mecA*-positive MRSA was 14.3%, 11.1%, and

Table 1. Study population characteristics by participant category.

Category	Total [n = 336 (%)]	Worker [n = 162 (%)]	Household member [n = 63 (%)]	Community resident [n = 111 (%)]	χ^2 test statistic (df)	p-Value
Age (years)					48.13 (10)	<0.01
18–25	89 (26.5)	24 (14.8)	31 (49.2)	34 (30.6)		
26–35	66 (19.6)	32 (19.8)	10 (15.9)	24 (21.6)		
36–45	65 (19.3)	40 (24.7)	7 (11.1)	18 (16.2)		
46–55	62 (18.5)	43 (26.5)	6 (9.5)	13 (11.7)		
56–82	50 (14.8)	23 (14.2)	8 (12.7)	19 (17.1)		
Sex, female	196 (58.5)	88 (54.7)	41 (65.1)	67 (60.4)	2.26 (1)	0.32
Race/ethnicity					31.07 (6)	<0.01
African American	231 (68.8)	114 (70.4)	46 (73.0)	71 (64.0)		
Hispanic	52 (15.5)	30 (18.5)	13 (20.6)	9 (8.1)		
White non-Hispanic	26 (7.7)	5 (3.1)	1 (1.6)	20 (18.0)		
Native American	18 (5.4)	9 (5.6)	2 (3.2)	7 (6.3)		
Other	9 (2.7)	4 (2.5)	1 (1.6)	4 (3.6)		
Animal contact on home property	161 (47.9)	74 (45.7)	28 (44.4)	59 (53.2)	1.85 (2)	0.42
Medical facility visit in last 6 months	193 (58.0)	89 (54.9)	40 (64.5)	64 (58.7)	1.73 (2)	0.42
MRSA diagnosis in the last year	3 (0.9)	2 (1.2)	1 (1.6)	0 (0.0)	—[a]	0.43
Use of antimicrobials in last 6 months	80 (23.8)	37 (22.8)	17 (27.0)	26 (23.4)	0.44 (2)	0.82
Prevalence						
S. aureus	79 (23.5)	35 (21.6)	19 (30.2)	25 (22.5)	1.94 (2)	0.38
Nonsusceptible S. aureus	65 (19.4)	28 (17.3)	13 (21.0)	24 (21.6)	0.88 (2)	0.65
MRSA phenotype[b]	16 (4.8)	9 (5.6)	3 (4.8)	4 (3.6)	0.55 (2)	0.76
MRSA mecA[c]	9 (2.7)	5 (3.1)	2 (3.2)	2 (1.8)	—[a]	0.74
MDRSA[d]	23 (6.9)	13 (8.0)	4 (6.5)	6 (5.4)	0.73 (2)	0.70

[a]p-Value was calculated with Fisher's exact test. [b]Phenotypic MRSA defined as S. aureus resistant to cefoxitin. [c]MRSA identified by detection of the mecA gene, genotypic MRSA is a subset of that detected phenotypically. [d]MDRSA denotes S. aureus nonsusceptible to three or more of the antimicrobials used in this study or resistant to cefoxitin.

Table 2. Distribution of nonsusceptibility, multidrug-resistance, and MRSA among those positive for S. aureus.

Classification	Total [n = 78 (%)]	Worker [n = 35 (%)]	Household member [n = 18 (%)]	Community resident [n = 25 (%)]	p-Value[a]
Nonsusceptible S. aureus[b]	65 (83.3)	28 (80.0)	13 (72.2)	24 (96.0)	0.09
MRSA phenotype[c]	16 (20.5)	9 (25.7)	3 (16.7)	4 (16.0)	0.67
MRSA mecA[d]	9 (11.5)	5 (14.3)	2 (11.1)	2 (8.0)	0.90
MDRSA[e]	23 (29.5)	13 (37.1)	4 (22.2)	6 (24.0)	0.41

[a]p-Value calculated with Fisher's exact test. [b]S. aureus intermediate or resistant to any antimicrobial class. [c]Phenotypic MRSA defined as S. aureus resistant to cefoxitin. [d]MRSA identified by detection of mecA gene, genotypic MRSA is a subset of that detected phenotypically. [e]MDRSA denotes S. aureus nonsusceptible to three or more of the antimicrobials used in this study or resistant to cefoxitin.

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8% among workers, household members and community residents, respectively. The prevalence of MDRSA and MRSA in *S. aureus* isolates was similar between household members and community residents.

***Antimicrobial resistance profile of* S. aureus.** We also examined the distribution of susceptible, intermediate, and resistant isolates and found unequal proportions across participant groups (Fisher's exact test, $p < 0.01$). Proportions extracted from Figure 1 show that among participants carrying *S. aureus*, workers had the highest proportion of *S. aureus* resistant to at least one antimicrobial class (48.6%; 17/35), followed by household members (38.9%; 7/18) and community residents (20.0%; 5/25). The highest proportion of *S. aureus* showing intermediate resistance to at least one antimicrobial class was found in community members (76.0%; 19/25), followed by household members (33.3%; 6/18) and workers (31.4%; 11/35).

Detailed resistance profiles of these isolates (Figure 1) suggest that the numbers of different classes of antimicrobials to which *S. aureus* isolates were resistant varied among the participant groups. Workers carried *S. aureus* that were resistant to more antimicrobials compared with isolates carried by household members or community residents. Isolates from community residents were more likely to have intermediate resistance than isolates from workers or household members. The patterns of resistance to specific antimicrobials also varied among groups. Erythromycin nonsusceptibility (resistant or intermediate) was the most common phenotype observed in all groups. Workers and household members had the highest prevalence of erythromycin-resistant *S. aureus* (Figure 1). The most common pattern of multiple resistance in the entire study population was nonsusceptibility to erythromycin and ciprofloxacin (14.1%; 11/78), followed by nonsusceptibility to erythromycin, cefoxitin, and ciprofloxacin (9%; 7/78) and nonsusceptibility to erythromycin and cefoxitin (6.4%; 5/78).

Group differences in* S. aureus *antimicrobial resistance. Compared with isolates from community residents, isolates from workers and household members were on average resistant to 2.54 times (95% CI: 1.16, 5.56) and 1.69 times (95% CI: 0.64, 4.46) more antimicrobial classes, respectively, after adjusting for age, visiting a medical facility in the last 6 months, or using antimicrobials in the last 6 months (Table 3). Age, visiting a medical facility in the last 6 months, and taking antimicrobials in the last 6 months were not significantly associated with the number of antimicrobial classes to which the isolates were resistant and did not confound the associations with working in a hog-processing facility.

The prevalence of MDRSA carriage in workers was 1.96 times higher (95% CI: 0.71, 5.45) than in community residents after adjusting for other variables ($p = 0.20$) (Table 4). The prevalence of MDRSA in household members was comparable to community residents [prevalence ratio (PR) = 1.04; 95% CI: 0.25, 4.28].

MLST and* S. aureus *strains by group. We identified 19 unique sequence types (ST) from 68 *S. aureus* isolates (Figure 2). Sequence types for the 11 remaining isolates could not be determined. *S. aureus* isolates from workers demonstrated greatest sequence type diversity. ST1 and ST5 were found in all three participant groups. ST8 was common among *S. aureus* isolates from workers and household members (21% and 22%, respectively) but absent among isolates from community residents. ST72 was also observed only among isolates from workers ($n = 1$) and household members ($n = 3$). Notably, three isolates, all from workers, were identified as ST398, including two MDRSA isolates and one MRSA isolate. Among MRSA isolates, ST8 was the predominant sequence type (38%), followed by ST1 (19%).

Discussion

To our knowledge, this is the first published study in the United States to examine carriage of *S. aureus*, MDRSA, and MRSA in hog slaughter and processing plant workers and their communities. Although the prevalence of *S. aureus* and MRSA was similar among all three participant groups, *S. aureus* isolates from workers were resistant to a greater number of antimicrobial classes than isolates carried by household members or community residents. Workers also had a higher prevalence of MDRSA than community residents, although the difference was not statistically significant. The overall prevalence of *S. aureus* in our population was 23.5%, which is

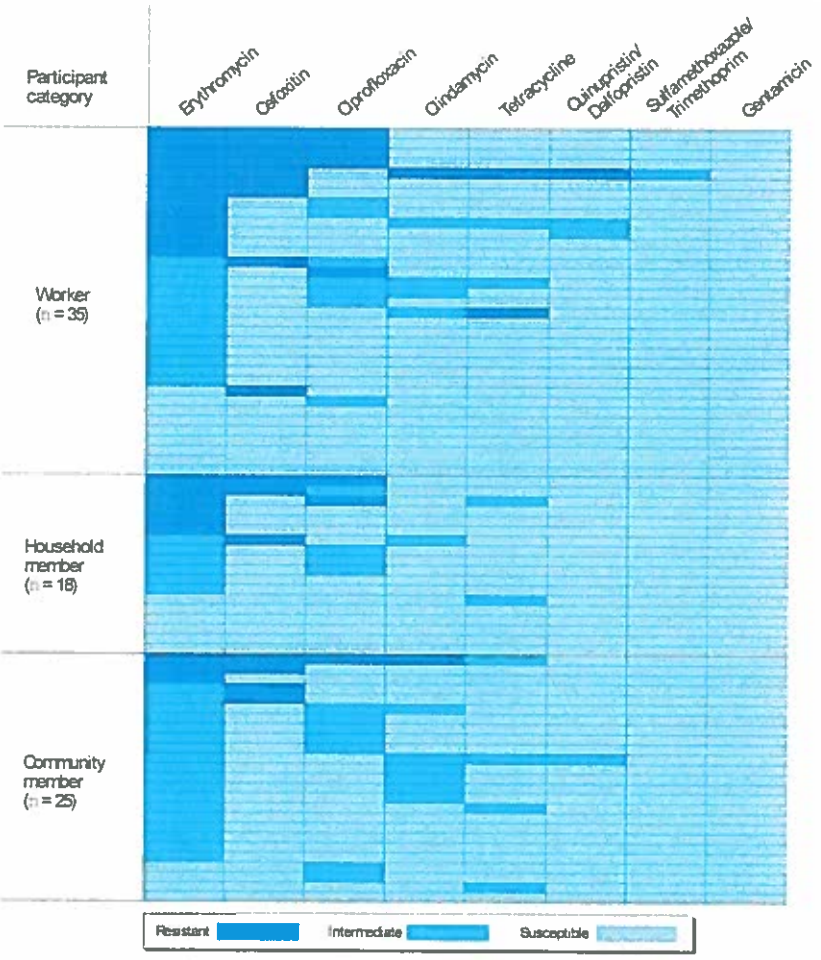

Figure 1. Heat map showing the pattern of antimicrobial resistance of the 78 isolates of S. aureus. Each row represents one isolate tested for susceptibility from a S. aureus–positive participant. Antimicrobial resistance was assessed by disk diffusion and cutoffs de ned by CLSI (2008) guidelines; resistance to cefoxitin was classi ed as either susceptible or resistant, based on CLSI (2008) guidelines.

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slightly lower than the estimated prevalence in U.S. adults (27.4% for people 20–59 years of age) based on NHANES data for 2003–2004 (Gorwitz et al. 2008). However, the prevalence of MRSA in our population [4.8% based on CLSI (2008) criteria, 2.7% *mecA* positive] was higher than the NHANES estimate of 1.1%. The prevalence of MRSA carriage in our study was also greater than estimates from two studies of young, healthy, adult military recruits that reported prevalences of MRSA carriage between 0.5% and 2% (Findlay et al. 2010; Zinderman et al. 2004).

PCR using previously reported primers (Poulsen et al. 2003) did not detect *mecA* in 7/16 phenotypically characterized MRSA isolates, consistent with the presence of variant *mecA* genes that are not detected by standard probes (García-Álvarez et al. 2011; Petersen et al. 2013). Therefore, we reported both phenotypic and genotypic MRSA as suggested by Fluit (2011). We did not conduct further PCR analyses to identify any *mecA* variants. We looked for ST398, a strain variant of the clonal complex (CC) 398 that has been associated with exposure to hogs and other livestock (Armand-Lefevre et al. 2005; Feingold et al. 2012; Smith and Pearson 2011). Three ST398 isolates were identified in workers using MLST, including one that was MRSA, and two that were susceptible to methicillin (cefoxitin) but classified as MDRSA on the basis of resistance to ≥ 3 other antimicrobial classes. Studies in European countries have showed that pigs are a source of MRSA CC398 infections in humans, with the predominant ST being ST398 (Lewis et al. 2008), and that MRSA CC398 is much more prevalent among persons exposed to hogs than their family members or non-exposed community residents (Cuny et al. 2009; Oppliger et al. 2012; VanCleef et al. 2010). Similar to our results, a Swiss study of antimicrobial-resistant *S. aureus* in pigs and pig farmers reported that 22% of all MRSA and methicillin-susceptible *S. aureus* CC398 strains were multidrug resistant (Oppliger et al. 2012).

We observed evidence of greater *S. aureus* genotype diversity in isolates from workers (11 MLST sequence types) than in isolates from household members or community residents (7 and 9 sequence types respectively). Oppliger et al. (2012) reported more *S. aureus* genotype diversity in isolates from non-farmers than pig farmers. We identified ST5 in all three participant groups, ST8 in workers and household members, and ST398 in workers only. Similarly, a French study

Table 3. Unadjusted and adjusted estimates of the association between exposures and the mean number of antimicrobials classes to which a S. aureus isolate was resistant.

Category	n	Unadjusted mean ratio (95% CI)	p-Value	Adjusted mean ratio (95% CI)	p-Value
Participant group					
Community resident	25	Referent	—	Referent	—
Household member	18	1.70 (0.70, 4.10)	0.24	1.69 (0.64, 4.46)	0.29
Worker	35	2.46 (1.17, 5.17)	0.17	2.54 (1.16, 5.55)	0.02
Age (years)					
18–25	29	Referent	—	Referent	—
26–35	17	1.93 (0.97, 3.87)	0.06	1.67 (0.80, 3.46)	0.17
36–45	12	1.13 (0.46, 2.77)	0.79	1.10 (0.43, 2.78)	0.85
46–55	11	1.05 (0.41, 2.72)	0.91	0.78 (0.28, 2.20)	0.64
56–82	8	1.45 (0.56, 3.74)	0.44	1.14 (0.43, 3.06)	0.79
Medical facility visit in last 6 months[a]	39	1.33 (0.75, 2.36)	0.33	1.37 (0.75, 2.48)	0.31
Use of antimicrobials in last 6 months[b]	19	0.85 (0.44, 1.66)	0.64	0.93 (0.47, 1.85)	0.83

[a]Reference group are those who did not visit a medical facility in last 6 months. [b]Reference group are those who did not take antimicrobials in last 6 months.

Table 4. Unadjusted and adjusted PRs estimating the association between exposures and carriage of multidrug-resistant S. aureus.

Category	n	Unadjusted PR (95% CI)	p-Value	Adjusted PR (95% CI)	p-Value
Participant group					
Community resident	111	Referent	—	Referent	—
Household member	62	1.19 (0.35, 4.07)	0.78	1.04 (0.25, 4.28)	0.96
Worker	162	1.48 (0.58, 3.79)	0.41	1.96 (0.71, 5.45)	0.20
Age (years)					
18–25	88	Referent		Referent	—
26–35	66	1.33 (0.45, 3.95)	0.60	0.97 (0.30, 3.15)	0.96
36–45	65	0.68 (0.18, 2.61)	0.57	0.54 (0.14, 2.17)	0.39
46–55	62	0.95 (0.28, 3.21)	0.93	0.55 (0.14, 2.22)	0.40
56–82	50	1.17 (0.35, 3.96)	0.80	1.07 (0.31, 3.74)	0.91
Medical facility visit in last 6 months[a]	193	0.96 (0.42, 2.22)	0.92	0.98 (0.41, 2.32)	0.96
Use of antimicrobials in last 6 months[b]	80	0.89 (0.34, 2.31)	0.80	1.07 (0.40, 2.86)	0.90

PR, prevalence ratio.
[a]Reference group are those who did not visit a medical facility in last 6 months. [b]Reference group are those who did not take antimicrobials in last 6 months.

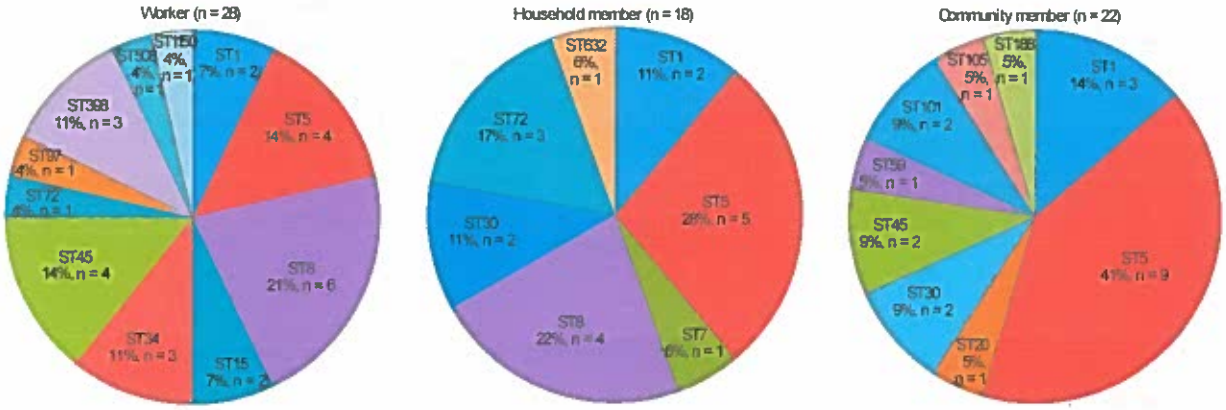

Figure 2. S. aureus sequence type diversity and distribution. Sequence types were based on seven housekeeping genes that were derived from whole genome sequences of each isolates.

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observed *S. aureus* ST5 in both pig farmers and non-farmers, and ST8 and ST398 in pig farmers only (Armand-Lefevre et al. 2005). ST1 was identified in isolates from all three groups in our study, and was the most common isolate identified in pork meat in a U.S. study (Waters et al. 2011). However, ST1 was not prevalent in pigs, pig farmers, or non-farmers in the Swiss study (Oppliger et al. 2012).

The most common *S. aureus* genotypes in hog slaughter and processing plant workers in our study were ST8 (belonging to CC8) and ST5 (belonging to CC5), with the predominant MRSA genotype being ST8 (4/9 isolates). In contrast, studies from other countries reported CC9 and CC398 as the predominant *S. aureus* and MRSA genotypes in pigs and pig farmers (Armand-Lefevre et al. 2005; Oppliger et al. 2012). ST8 and ST5 have been consistently reported to be the most common MRSA strains in isolates from pigs and pork in the United States (Molla et al. 2012; Pu et al. 2009; Waters et al. 2011). We did not identify ST9 (belonging to CC9) among *S. aureus* isolates, although this sequence type was previously found in pigs and pork in the United States (Molla et al. 2012; Waters et al. 2011).

Importantly, we found that, among participants carrying *S. aureus*, workers had the highest proportion of *S. aureus* resistant to at least one antimicrobial class. Moreover, workers had isolates resistant to more antimicrobial classes and also had a higher prevalence of carriage of MDRSA as compared with community residents. Multidrug resistance also was more pronounced in isolates from Swiss hog farmers than isolates from non-farmers (Oppliger et al. 2012).

Infections caused by multidrug resistant bacteria are associated with worse health outcomes and higher expenditures (Cardoso et al. 2012; Stone 2009); however, few studies have examined the prevalence of MDRSA in human populations in the United States. One previous North Carolina study reported a 16% prevalence of MDRSA carriage among industrial livestock operation workers compared with 9% among antibiotic-free livestock operation workers (Rinsky et al. 2013). The greater number of drugs to which isolates from workers in our study were resistant is also noteworthy and may be associated with the use of multiple antimicrobials in hog feeds (Silbergeld et al. 2008).

We found resistance to erythromycin was more prevalent than resistance to any other antimicrobial class, similar to Oppliger et al. (2012). However, patterns of resistance to other antimicrobials differed between the two studies, possibly reflecting differences in the use of antimicrobials as swine feed additives between the United States and Switzerland.

In the present study, we observed the prevalence of carriage of resistant strains of *S. aureus* to be greater in all studied groups than in the general U.S. population, but we did not observe differences between groups for some carriage outcomes. Although differences may have been obscured in part because of small sample sizes within groups, it is also possible that the non-worker groups in our study were exposed through environmental pathways from both farms and slaughter and processing operations. Studies by our group and others support this possibility. For example, *S. aureus* and MDRSA have been measured in air releases from intensive hog farms in the United States (Chapin et al. 2005; Gibbs et al. 2004, 2006), detected at distances of 150 m downwind from swine houses in Germany (Schulz et al. 2012), and found in hogs being transported in open trucks from farms to the slaughter house and in untreated swine house wastes and other releases (Burkholder et al. 2007). This explanation is also supported by other work by our group on clusters of MRSA infections among persons residing in areas of intensive hog production in the Netherlands and in northern North Carolina (Feingold et al. 2012).

The overall elevated rates of MDRSA and MRSA across participant groups, and the higher rate in the worker group, may be explained by the concentration of swine farms over the greater Tar Heel region and the common use of different antimicrobial formulations as growth promoters. The slaughterhouse plant in the present study served as a hub for collecting swine from these farms. As a result, workers at the Tar Heel plant were exposed to swine from different farms, and these animals may have carried strains of *S. aureus* with different patterns of antimicrobial resistance. In contrast, non-workers, depending on where they lived, may have been indirectly exposed to relatively few farms and a less diverse set of *S. aureus* strains.

Conclusions

Our results raise concerns about the exposure of hog slaughter and processing plant workers to antimicrobial-resistant *S. aureus*. *S. aureus* isolates from workers were, on average, resistant to more classes of antimicrobials than isolates from community residents. In addition, among *S. aureus*–positive participants, a greater proportion of workers carried strains of *S. aureus* resistant to at least one antimicrobial class. Further, the overall prevalence of MRSA carriage identified in our study population in 2011 was higher than the estimate for the general U.S. population based on NHANES data for 2003–2004 (Gorwitz et al. 2008).

The observation of a similar higher prevalence of MRSA among all groups in our study may be in part related to nonoccupational exposures in the region, which has the highest density of industrial hog farms and hogs in the United States (Wing et al. 2000). Further studies will be crucial for the identification of factors associated with nonoccupational exposures.

Our results suggest a need for surveillance of antimicrobial-resistant *S. aureus* in populations with direct or indirect exposure to livestock. Finally, our study adds to concerns about the use of antimicrobials for non-therapeutic purposes as part of food-animal production, a practice thought to contribute to selection for antimicrobial-resistant strains of *S. aureus* in the community, especially in the food-production system.

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High-Density Livestock Production and Molecularly Characterized MRSA Infections in Pennsylvania

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Background: European studies suggest that living near high-density livestock production increases the risk of sequence type (ST) 398 methicillin-resistant *Staphylococcus aureus* (MRSA) colonization. To our knowledge, no studies have evaluated associations between livestock production and human infection by other strain types.

Objectives: We evaluated associations between MRSA molecular subgroups and high-density livestock production.

Methods: We conducted a yearlong 2012 prospective study on a stratified random sample of patients with culture-confirmed MRSA infection; we oversampled patients from the Geisinger Health System with exposure to high-density livestock production in Pennsylvania. Isolates were characterized using *S. aureus* protein A (*spa*) typing and detection of Panton-Valentine leukocidin (PVL) and *scn* genes. We compared patients with one of two specific MRSA strains with patients with all other strains of MRSA isolates, using logistic regression that accounted for the sampling design, for two different exposure models: one based on the location of the animals (livestock model) and the other on crop field application of manure (crop field model).

Results: Of 196 MRSA isolates, we identified 30 *spa* types, 47 PVL-negative and 15 *scn*-negative isolates, and no ST398 MRSA. Compared with quartiles 1–3 combined, the highest quartiles of swine livestock and dairy/veal crop field exposures were positively associated with community-onset-PVL-negative MRSA (CO-PVL-negative MRSA vs. all other MRSA), with adjusted odds ratios of 4.24 (95% CI: 1.60, 11.25) and 4.88 (95% CI: 1.40, 17.00), respectively. The association with CO-PVL-negative MRSA infection increased across quartiles of dairy/veal livestock exposure (trend $p = 0.05$).

Conclusions: Our findings suggest that other MRSA strains, beyond ST398, may be involved in livestock-associated MRSA infection in the United States.

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Introduction

Over the past decade, the incidence of community-associated methicillin-resistant *Staphylococcus aureus* (*S. aureus*) (CA-MRSA) infection has increased in the United States (Dukic et al. 2013). These CA-MRSA infections cost third-party payers between $478 and $2,200 million annually (Lee et al. 2013). Beginning in the mid-2000s, European research suggested that a portion of the increased incidence of CA-MRSA might be attributable to high-density livestock production because studies had isolated the same MRSA strains from infected farmers and their livestock (Harrison et al. 2013; Hartmeyer et al. 2010). In Europe, multilocus sequence type (ST) 398 has been the most common colonizer of livestock, specifically swine, and swine farmers (Graveland et al. 2010; Lewis et al. 2008). This association has led many to refer to ST398 as livestock-associated MRSA (LA-MRSA) (Price et al. 2012). Importantly, pathways for community transmission have been identified, with MRSA isolated from the air and soil at least 150 m from swine facilities (Gibbs et al. 2006; Schulz et al. 2012) and from meat processing and consumption (Molla et al. 2012; Waters et al. 2011).

To our knowledge, no North American studies have evaluated residence in rural communities as a risk factor for MRSA infection of specific molecular types. Four studies of colonization in farmers have disparate findings. The first reported ST398 as the only type colonizing swine and farmers (Smith et al. 2009); the second found mainly ST398, but also ST5 (Khanna et al. 2008); and two more recent studies identified ST5 [t002 by *S. aureus* protein A (*spa*) typing (Monecke et al. 2011)] as the primary colonizer of swine and of veterinary students visiting farms (Frana et al. 2013; Molla et al. 2012). In the United States, ST5 has been considered to be a health care–associated MRSA clone, but it has begun to appear in the community in persons without health care risk factors (Klevens et al. 2006). Nearly all MRSA isolates associated with livestock colonization lack the genes encoding Panton-Valentine leukocidin (PVL) (Smith et al. 2009; Sunde et al. 2011). Finally, recent studies have reported that *scn*, the gene encoding staphylococcal complement inhibitor (SCIN), is often absent in MRSA strains that colonize livestock (McCarthy et al. 2011; Sung et al. 2008; Verkaik et al. 2011).

In a previous study in Pennsylvania using electronic health records from 2005 through 2010 from a large health care system, we reported associations between CA-MRSA infection and residential proximity to high-density livestock operations and the crop fields to which manure was applied (Casey et al. 2013b). Due to the retrospective study design, we were unable to obtain MRSA isolates from patients. The objectives of the present study were to *a*) prospectively collect MRSA isolates from patients residing in communities with and without high-density livestock production, *b*) characterize these isolates by *spa* typing and polymerase chain reaction (PCR) for the presence of *lukF-lukS* genes (encoding PVL) and for the *scn* gene, and *c*) assess associations of high-density livestock production with the molecular subgroups.

Methods

Setting, study design, and participants. The study area was a 38-county region of central and northeast Pennsylvania with 3.8 million inhabitants in which Geisinger Health System provides primary care services from 41 community practice clinics (Figure 1).

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The primary care population is representative of the region's population (Casey et al. 2013b). We compared patients infected with two specific MRSA strains to patients infected with all other strains as described below. Institutional review boards at the Geisinger Health System and the Johns Hopkins Bloomberg School of Public Health approved the study and waived informed consent.

Patients with MRSA infection identified by culture between 1 January 2012 and 31 December 2012, who had a Geisinger primary care provider, were eligible for inclusion. The cases were stratified as community-onset or hospital-onset and as residing in an area of high-density livestock production or not. Infections were classified as community-onset (CO) infections if the patient had a positive culture collected in the outpatient setting or ≤ 2 days after hospital admission. Infections were classified as hospital-onset (HO) if the patient had a positive culture collected > 2 days after hospital admission (David and Daum 2010). Onset date was defined as the date the culture was ordered. Patients living in a ZIP code with a high-density livestock operation or a crop field to which manure from such an operation was applied were defined as residing in an area of high-density livestock production, as described in detail below. Using these case definitions, we completed a random stratified sample (a sample was evaluated because of budgetary limitations) to select cases into four *a priori* categories (Table 1). We over-selected patients who resided in areas of high-density livestock production to improve the power to detect associations.

Patient data collection. MRSA isolates (one per patient) collected in clinical practice settings were sent to a central laboratory, grown on conventional blood agar plates, and stored at 4°C. A research assistant selected appropriate isolates and obtained samples for transport using sterile swab applicators (BBL Cultureswabs; Becton Dickinson, Franklin Lakes, NJ). A total of 203 unique isolates collected from sites of infection were sent unrefrigerated to New York University Langone Medical Center for genotypic testing, where isolates were subcultured onto agar plates and incubated overnight at 37°C. DNA was then extracted by mechanical lysis. We obtained information on patient demographics and inpatient, outpatient, and emergency department encounters, procedures, medication orders, and laboratory data from the electronic health records. Antimicrobial resistance testing on clindamycin, erythromycin, gentamicin, rifampin, tetracycline, trimethoprim–sulfamethoxazole, and vancomycin was also available from the electronic health records. Multidrug resistance was reported as resistance to three or more unique antimicrobials.

Genotyping. DNA sequence analysis of the protein A gene variable repeat region (*spa* typing) was completed using the primers TIGR-F (5′-GCCAAAGCGCTAACCTTTTA-3′) and TIGR-R (5′-TCCAGCTAATAACGCT GCAC-3′) (Shopsin et al. 1999). Spa types were assigned a StaphType (e.g., t008, t002) using the Ridom SpaServer database (http://www.spaserver.ridom.de). We subsequently mapped *spa* types to clonal complex (CC) categories (CC5 or CC5-like, CC8 or CC8-like, or other) using the Ridom SpaServer *spa* to multilocus sequence type (MLST) database (http://spa.ridom.de/mlst.shtml). We also checked for the presence of PVL genes using *S. aureus* ATCC 49775 (ATCC, Manassas, VA) as a reference strain and primers as previously described (Lina et al. 1999). The presence of *scn* was determined by an additional PCR (Sung et al. 2008).

Earlier literature from northern Europe suggested that ST398 would be a cause of human infection in those exposed to high-density livestock production (Hartmeyer et al. 2010; Wulf et al. 2012); however, we did not identify any ST398 infections. Therefore, before beginning statistical analysis, we identified two other strains of interest. Although most CA-MRSA contains PVL genes (David and Daum 2010), most MRSA (both ST5 and ST398) isolated from humans and animals with exposure to high-density livestock production in North America has been PVL-negative (Frana et al. 2013; Price et al. 2012; Tattevin et al. 2012). Therefore, we selected community-onset PVL-negative (CO-PVL-negative) MRSA isolates as a unique group with potential ties to high-density livestock production. We created a second molecular subgroup based on recent evidence that only

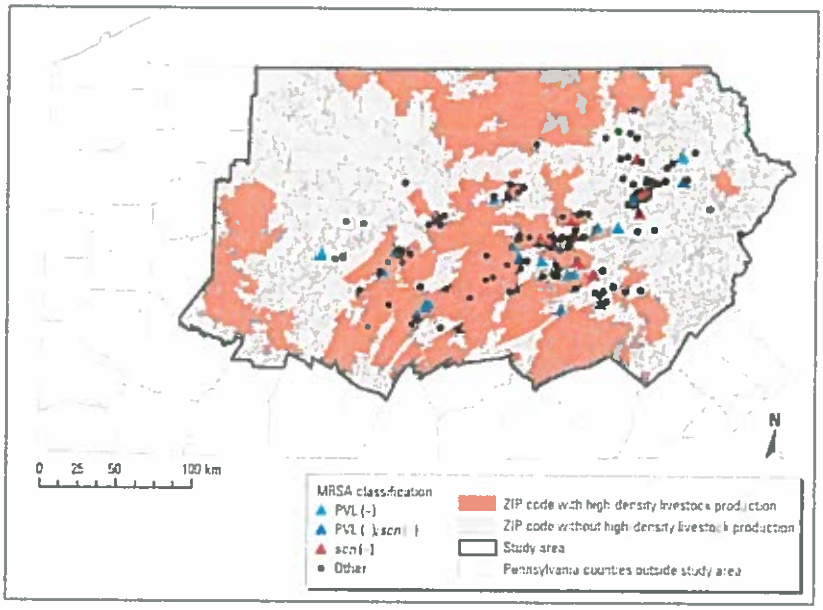

Figure 1. High density livestock production and MRSA infection, Geisinger Health Care System, Pennsylvania.

Table 1. Patients identified and included in the present analysis according to MRSA subtype and exposure in their residential ZIP code.

Group	High-density livestock production	No high-density livestock production	Total
CO-MRSA			
Patients included [*n* (%)]	70 (42.2)	96 (57.8)	166
Total patients [*n* (%)]	321 (32.5)	667 (67.5)	988
Sample weight[a]	4.59	6.95	
HO-MRSA			
Patients included [*n* (%)]	11 (36.7)	19 (63.3)	30
Total patients [*n* (%)]	54 (22.5)	186 (77.5)	240
Sample weight[a]	4.91	9.79	
Total patients included (*n*)	81	115	196
Total patients identified (*n*)	375	853	1,128

Abbreviations: CO, community-onset; HO, hospital-onset.
[a]Sample weight was calculated as the total number of patients identified in each stratum divided by the number of patients sampled from that stratum for the present analysis.

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about 25% of animal *S. aureus* isolates carry the *scn* gene, whereas human isolates carry it about 90% of the time (Sung et al. 2008; Verkaik et al. 2011). To complete the analysis, we created two case groups—CO-PVL-negative MRSA and *scn*-negative MRSA—and compared these groups to patients with all other MRSA types.

Geospatial estimates of high-density livestock exposure. Pennsylvania Act 38 of 2005 (2005) requires nutrient management plans (NMPs) to regulate concentrated animal operations, operations where livestock density exceeds two animal equivalent units (AEUs; 1,000 pounds of animal weight) per acre and where the total number of AEUs exceeds eight. NMPs detail appropriate manure handling, storage, and land application to crop fields, both on-site where the animals are raised and off-site. NMPs also contain data on operation location and acreage and livestock type. In addition, the Pennsylvania Department of Environmental Protection requires NMPs from the largest operations called concentrated animal feeding operations (> 1,000 AEUs, or 301–1,000 AEUs and a concentrated animal operation, or per federal regulation) (U.S. Environmental Protection Agency 2012). For our analysis, we defined a high-density livestock operation as *a*) > 2 AEUs per acre and > 8 AEUs total, or *b*) > 300 AEUs total.

We used ArcGIS (version 10.0; Esri, Redlands, CA) to geocode livestock operations, treated crop fields, and patients at their home address. Although patients were sampled using presence of high-density livestock production in their ZIP code, this criterion was not used to generate exposure metrics. We created two exposure metrics for livestock operations (swine or dairy/veal):

$$\text{Exposure for patient } j = \Sigma_{i=1}^{n}(a_i/d_{ij}^2), \quad [1]$$

where n is the number of operations, a_i is the AEUs of livestock at operation i, and d_{ij}^2 is the squared distance (in meters) between operation i and patient j. In addition, we created two metrics for exposure to treated crop fields (swine or dairy/veal manure applications) during the season of infection:

$$\text{Exposure for patient } j = \Sigma_{k=1}^{n}(c_k/d_{kj}^2), \quad [2]$$

where n is the number of treated crop fields, c_k is the concentration of manure (gallons per square meter) applied to field k during the season of diagnosis, and d_{kj}^2 is the squared distance (in meters) between field centroid k and patient j (Casey et al. 2013b). We modeled the exposure variables as quartiles to allow for nonlinear associations and for ease of interpretation.

Statistical methods. A multivariable logistic regression model was used to estimate associations between exposures and outcomes (i.e., CO-PVL-negative MRSA or *scn*-negative MRSA vs. all other MRSA strains combined). By study design, we oversampled cases living in ZIP codes with high-density livestock production. To account for this sampling design while obtaining unbiased regression estimates and robust standard errors, each participant was assigned a sample weight equal to the total number of MRSA patients identified in a stratum/total number included in the present analysis (Table 1), a measure of the number of patients represented by each sampled individual (Vittinghoff et al. 2005). We used the *p*-value from Fisher's exact test to compare molecular profiles of the two subgroups of interest to all other MRSA isolates (Table 2).

Models were constructed with attention to the small sample size. Our primary models compared the highest quartile of exposure to livestock or treated crop fields to all other quartiles combined. In addition, we modeled quartiles of exposure as an ordinal variable (0, 1, 2, 3) and used the *p*-value of the resulting coefficient as a test of linear trend. For CO-PVL-negative MRSA, we also estimated associations with individual quartiles of exposure relative to the lowest quartile, but numbers of observations were too small to run comparable models for *scn*-negative MRSA. Similarly, adjustment for confounders selected based on *a priori* information (Casey et al. 2013a, 2013b) was limited to models of CO-PVL-negative MRSA. Specifically, we adjusted for sex, age (continuous), ever-smoking status, season of infection [winter (December–February) vs. all other seasons combined], physician order for an antibiotic in the 365 to 14 days preceding diagnosis, and ever-receiving Medical Assistance as health insurance [as a surrogate for low individual socioeconomic status (Bratu et al. 2006; Casey et al. 2013b)]. We were unable to adjust models for race/ethnicity and to isolate sources because data were off-support (Oakes 2006). We did not adjust for location of onset because location was part of the CO-PVL-negative MRSA definition. Statistical analyses were performed using Stata 11.2 (StataCorp, College Station, TX) using the svy commands for weighted regression and R version 3.0.0 (R Foundation for Statistical Computing, Vienna, Austria).

Results

Study population characteristics. From 1 January to 31 December 2012 we collected data on 203 MRSA infections (from a pool of 1,128 patients with MRSA infection) from patients in 20 counties in Pennsylvania. The analysis included 196 isolates (Figure 1) after exclusion of isolates lacking the *mecA* gene (n = 4) and patients who could not be geocoded or resided outside the study area (n = 3). We identified 30 unique Ridom *spa* types, 47 PVL-negative isolates and

Table 2. Onset location, Ridom spa types, and PVL presence by MRSA subgroup [n (%)].

Characteristic	CO-PVL-negative[a] (n = 23)	*scn*-negative[a] (n = 15)	All other MRSA (n = 162)
CO-MRSA	23 (100)[b]	12 (80.0)	135 (83.3)
CC5 or CC5-like			
t002	9 (39.1)[b]	1 (6.7)	17 (10.5)
t010	2 (8.7)[b]	0	0
t045	0	1 (6.7)	1 (0.6)
t062	1 (4.3)	0	0
t088	3 (13.0)[b]	1 (6.7)	0
t105	1 (4.3)	1 (6.7)	2 (1.2)
t306	1 (4.3)	0	0
t6614	1 (4.3)	1 (6.7)	0
Other[c]	0	0	3 (1.8)
CC8 or CC8-like			
t008	0[b]	7 (46.7)	115 (71.0)
t024	0	1 (6.7)	6 (3.7)
t068	0	0	2 (1.2)
t121	0	1 (6.7)	2 (1.2)
t622	0	0	3 (1.9)
Other[d]	0	0	7 (4.3)
Other CC			
t125	1 (4.3)	1 (6.7)	0
t948	1 (4.3)	0	0
t9964	1 (4.3)	0	0
t11970	1 (4.3)	0	0
Other[e]	0	0	3 (1.9)
Novel[f]	1 (4.3)	0	1 (0.6)
PVL-positive	0[b]	9 (60.0)[b]	140 (86.4)

Percentages do not add to 100 due to rounding.
[a]Four patients were in both the CO-PVL-negative group and the scn-negative group. [b]p-Value < 0.05 comparing two subgroups of interest to all other MRSA using Fisher's exact test. [c]One each of t437, t539, and t85. [d]One each of t064, t206, t211, t304, t681, t692, t1610. [e]One each of t216, t316, t11971. [f]Novel spa type.

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15 *scn*-negative isolates, and no ST398 MRSA (Table 2). Four isolates were both CO-PVL-negative and *scn*-negative. Patients with CO-PVL-negative MRSA (n = 23) as well as patients with *scn*-negative MRSA (n = 15) were older than patients in the all other MRSA group (n = 162) (Table 3). Patients with the two MRSA strains of interest were less likely to reside in cities than were patients with all other MRSA strains (Table 3). Patients in the third and fourth quartiles of swine livestock exposure were more likely than those in the first and second quartiles to be diagnosed in the autumn (Table 3). Approximately 95% of patients with MRSA onset in the winter fell into the first or second quartile of swine and dairy/veal crop field exposure (data not shown).

Molecular testing. We identified 30 *spa* types, but 2 predominated: t008 [n = 122 (62.2%)] and t002 [n = 27 (13.8%)] (Table 2). Nearly all t008, n = 116 (95.1%), was community-onset, whereas the majority of t002, n = 17 (63.0%), was hospital-onset. Isolates lacking *scn* (n = 15) were distributed across multiple *spa* types, and 80% (n = 12) were community-onset, CO-PVL-negative isolates were mostly *spa* types associated with CC5.

Antimicrobial susceptibility. CO-PVL-negative strains were more often resistant to antibiotics commonly used to treat MRSA infection (i.e., clindamycin, tetracycline, and trimethoprim–sulfamethoxazole) than all other CO-PVL-positive MRSA strains. The 30 hospital-onset (HO)-MRSA isolates were resistant to more antibiotics compared with CO-MRSA: clindamycin (83.3% vs. 12.7%), tetracycline (6.7% vs. 3.6%), trimethoprim–sulfamethoxazole (3.3% vs. 1.2%), and multidrug (83.3% vs. 14.5%). Resistance patterns did not appear to be associated with agriculture exposure variables, but tetracycline resistance in a small number of isolates (n = 4) was associated with infection by CO-PVL-negative MRSA (p = 0.02).

Associations with livestock and crop field manure exposure. High-density livestock production was not associated with *scn*-negative MRSA infection in unadjusted analysis (Table 4). Swine livestock exposure was associated with CO-PVL-negative MRSA in unadjusted and adjusted analysis (Table 4), which appeared driven by the association in the fourth quartile of exposure (Figure 2). There was a positive but nonsignificant association with the dichotomized dairy/veal livestock exposure variable [odds ratio (OR) = 2.42; 95% CI: 0.85, 6.88]. There was a trend (p = 0.05) of increasing odds of CO-PVL-negative MRSA across quartiles of dairy/veal livestock exposure; however, all ORs were increasingly imprecise with higher exposure for individual versus lowest quartile exposures (Figure 2). Those in the highest quartile of swine crop field exposure had an OR of 2.38 (95% CI: 0.78, 7.28) of being a CO-PVL-negative MRSA case compared with those in quartiles 1–3 (Table 4). Dichotomous dairy/veal crop field exposure was associated with CO-PVL-negative MRSA in adjusted analyses (OR = 4.88; 95% CI: 1.40, 17.00) (Table 4). Neither crop field

Table 3. Patient demographic and clinical characteristics of MRSA subgroups by swine livestock exposure quartile[a] [data are n (%) unless otherwise indicated].

Characteristic	CO-PVL-negative (n = 23)[b]	*scn*-negative (n = 15)[b]	All other MRSA (n = 162)	Swine (quartile) 1	2	3	4
Sex, male	15 (65.2)	11 (73.3)	85 (52.5)	28 (26.2)	25 (23.4)	24 (22.4)	30 (28.0)
Age at infection or visit [median (interquartile range)] (years)	54.2 (32.3–75.2)	52.8 (14.6–75.1)	32.8 (14.4–55.2)	46.0 (17.3–62.4)	33.6 (22.5–54.7)	31.1 (9.8–51.7)	37.5 (13.6–59.1)
Race/ethnicity[c]							
Non-Hispanic white	22 (95.7)	15 (100)	155 (95.7)	44 (23.4)	49 (26.1)	48 (25.5)	47 (25.0)
Non-Hispanic black	1 (4.4)	0	6 (3.7)	5 (71.4)	0	0	2 (28.6)
Other	0	0	1 (0.6)	0	0	1 (100)	0
Never-smoker	16 (69.6)	10 (66.7)	139 (85.8)	39 (23.9)	43 (26.4)	40 (24.5)	41 (25.2)
Season of onset							
Winter	7 (30.4)	3 (20.0)	27 (16.7)	12 (34.3)	7 (20.0)	7 (20.0)	9 (25.7)
Spring	5 (21.7)	4 (26.7)	37 (22.8)	16 (34.8)	13 (28.3)	9 (19.6)	8 (17.4)
Summer	7 (30.4)	5 (33.3)	39 (24.1)	10 (20.4)	16 (32.7)	12 (24.5)	11 (22.5)
Autumn	4 (17.4)	3 (20.0)	59 (36.4)	11 (16.7)	13 (19.7)	21 (31.8)	21 (31.8)
Antibiotic prescription in previous year	5 (21.7)	6 (40.0)	65 (40.1)	21 (27.6)	20 (26.3)	15 (19.7)	20 (26.3)
Source							
Skin/soft tissue	19 (82.6)	11 (73.3)	141 (87.0)	36 (25.9)	39 (28.1)	28 (20.1)	36 (25.9)
Respiratory	0	2 (13.3)	15 (9.3)	6 (35.3)	4 (23.5)	4 (23.5)	3 (17.7)
Bone	2 (8.7)	1 (6.7)	2 (1.2)	1 (25.0)	0	2 (50.0)	1 (25.0)
Other	2 (8.7)	1 (6.7)	4 (2.5)	0	3 (42.9)	2 (28.6)	2 (28.6)
Antibiotic resistance[d]							
Clindamycin	12 (52.2)	2 (13.3)	32 (19.8)	10 (21.7)	11 (23.9)	13 (28.3)	12 (26.1)
Erythromycin	18 (78.3)	12 (80.0)	149 (92.0)	43 (24.4)	46 (26.1)	46 (26.1)	41 (23.3)
Tetracycline	4 (17.4)	1 (6.7)	4 (2.5)	2 (25.0)	2 (25.0)	2 (25.0)	2 (25.0)
TMP-SMZ	1 (4.4)	1 (6.7)	2 (1.2)	2 (66.7)	1 (33.3)	0	0
Multidrug[e]	14 (60.9)	3 (20.0)	33 (20.4)	12 (24.5)	11 (22.5)	14 (28.6)	12 (24.5)
Community type							
City	1 (4.4)	0	23 (14.2)	11 (45.8)	3 (12.5)	9 (37.5)	1 (4.2)
Borough	11 (47.8)	5 (33.3)	44 (27.2)	15 (25.9)	15 (25.9)	8 (13.8)	20 (34.5)
Township	11 (47.8)	10 (66.7)	95 (58.6)	23 (20.2)	31 (27.2)	32 (28.1)	28 (24.6)
Medical Assistance							
Never received	15 (65.2)	10 (66.7)	127 (78.4)	35 (23.3)	37 (24.7)	41 (27.3)	37 (24.7)
Location of onset							
Community	27 (100)	15 (83.3)	135 (83.3)	41 (24.7)	43 (25.9)	40 (24.1)	42 (25.3)
Hospital	0	3 (16.7)	27 (16.7)	8 (26.7)	6 (20.0)	9 (30.0)	7 (23.3)
No. of patients with high-density livestock production in their residential ZIP code	9 (39.1)	7 (46.7)	67 (41.4)	1 (1.2)	17 (21.0)	25 (30.9)	38 (46.9)

Abbreviations: previous year, 365 to 14 days before infection; TMP-SMZ, trimethoprim–sulfamethoxazole. [a]Quartile 1: swine livestock exposure < 6.20 AEU/km^2; quartile 2: 6.20–16.00 AEU/km^2; quartile 3: 16.01–33.40 AEU/km^2; quartile 4: > 33.41 AEU/km^2. [b]Four patients were in both the CO-PVL-negative group and the scn-negative group. [c]Race/ethnicity was missing for two members of the all other MRSA isolates comparison group. [d]Resistance to gentamicin was observed in one CO-PVL-negative isolate, and intermediate resistance to rifampin was observed in one all other MRSA isolate. [e]Resistance to three or more unique antimicrobials.

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variable evidenced a statistically significant trend across quartiles (Figure 2). Associations strengthened slightly as we added sex, age, ever-smoking, antibiotic order, and Medical Assistance to the models. Season of onset was a strong confounder in the crop field exposure models [e.g., the unadjusted OR of 0.79 (95% CI: 0.20, 3.09) increased to 2.38 (95% CI: 0.78, 7.28) (Table 4) for the swine crop field model, primarily due to the inclusion of season as a variable].

Discussion

This analysis compared patients infected by two specific MRSA strains to patients infected by all other MRSA strains and found a number of associations with high-density livestock production. The livestock model incorporated AEUs at the farming operation and distance to the patient residence; whereas the crop field model incorporated manure volume, crop field area, and distance to the patient residence. Although adjusted estimates were imprecise because of small sample numbers, each exposure variable was associated with increased odds of CO-PVL-negative MRSA infection, and three of four were statistically significant. Specifically, there were increased odds comparing the fourth quartiles to the other three quartiles of both swine livestock exposure and dairy/veal crop field exposure. There was also a significant trend of increasing odds across the four quartiles for dairy/veal livestock exposure. For the fourth exposure variable, swine crop field, the OR in the fourth quartile versus the other three was higher, but not statistically significant. Unexpectedly, we did not identify any patients with MRSA infection due to ST398, the MRSA subtype that previously has been associated with livestock operations, mainly based on studies of colonization in Europe. This raises two issues. First, to understand risk factors for MRSA infection, we need to study MRSA infection rather than colonization. Second, although ST398 may be prevalent among swine and swine farmers in the United States, other strains found on farms may actually be more important for infection.

When we did not identify any infections due to ST398, we evaluated associations of livestock production with two other MRSA strains compared with all other MRSA strains. To our knowledge, only one U.S. study has reported PVL-positive MSRA isolated from swine (Osadebe et al. 2013). Associations with CO-PVL-negative MRSA were of interest because many highly successful human epidemic MRSA clones, like CC5, do not contain PVL genes and have recently been isolated from swine and swine farmers in the United States (Frana et al. 2013; Molla et al. 2012; Osadebe et al. 2013). We observed eight tetracycline-resistant isolates, four of which were CO-PVL-negative MRSA. This resistance could plausibly be a marker of high-density livestock production as tetracycline is the antibiotic most commonly sold for use in U.S. farm animals, and isolates resistant to tetracycline have been observed in workers at industrial livestock operations (Food and Drug Administration 2010; Rinsky et al. 2013). In addition, only 6.7% of HO-MRSA was resistant to tetracycline, suggesting that the association of CO-PVL-negative MRSA is not likely attributable to the health care system. Likewise, we selected *scn*-negative MRSA strains because we expected MRSA associated with livestock production to lack *scn* (McCarthy et al. 2011; Sung et al. 2008; Verkaik et al. 2011). Previous work showing selection against *scn* in animal hosts dealt primarily with ST398 (McCarthy et al. 2011), a strain of MRSA already adapted to animals (Price et al. 2012). Because the *scn* gene produces a protein that hinders phagocytosis of *S. aureus* by human neutrophils (Sung et al. 2008), this work might not translate directly to human-adapted strains of MRSA (e.g., ST5 or ST8), especially in the study of infection rather than colonization.

A few U.S. studies have molecularly characterized MRSA isolated from agricultural workers (Frana et al. 2013; Molla et al. 2012; Osadebe et al. 2013; Smith et al. 2009, 2013). Because those studies only described MRSA carriage in persons with direct contact with swine, they may have low utility regarding inference about MRSA infection in the community. Two studies reported transient carriage (< 24 hours) after short-term exposure to pigs and veal calves (Frana et al. 2013; van Cleef et al. 2011). Even if carriage persists after exposure, and the risk of infection increases, infection is not assured (Davis et al. 2004).

Table 4. Unadjusted and adjusted[a] associations of dichotomous exposures with CO-PVL-negative MRSA and scn-negative MRSA compared with all other MRSA (n/N).

	CO-PVL-negative[b]			*scn*-negative[b]	
Exposure	All other MRSA (*n*/*M*)	Unadjusted OR (95% CI)	Adjusted OR[c] (95% CI)	All other MRSA (*n*/*M*)	Unadjusted OR (95% CI)
Livestock					
Swine (quartile)					
1, 2, 3	12/124	1.0	1.0	12/125	1.0
4[d]	11/37	3.55 (1.41, 8.94)	4.24 (1.60, 11.25)	3/37	0.79 (0.20, 3.09)
Dairy/veal (quartile)					
1, 2, 3	15/122	1.0	1.0	13/122	1.0
4[e]	8/40	1.57 (0.61, 4.05)	2.42 (0.85, 6.88)	2/40	0.47 (0.10, 2.24)
Treated crop field					
Swine (quartile)					
1, 2, 3	15/121	1.0	1.0	14/121	1.0
4[f]	8/41	1.55 (0.59, 4.05)	2.38 (0.78, 7.28)	1/41	0.18 (0.02, 1.43)
Dairy/veal (quartile)					
1, 2, 3	14/123	1.0	1.0	13/123	1.0
4[g]	9/39	2.28 (0.89, 5.83)	4.88 (1.40, 17.00)	2/39	0.46 (0.10, 2.20)

[a]Adjusted estimates are not reported for the scn-negative group due to sample size limitations. [b]Four patients were in both the CO-PVL-negative group and the scn-negative group. [c]Adjusted for sex, age, ever-smoking status, antibiotic order in the 365 to 14 days before infection, season, and receipt of Medical Assistance. [d]Quartile 4: ≥ 33.41 AEU/km². [e]Quartile 4: ≥ 49.30 AEU/km². [f]Quartile 4: ≥ 43,310 gallons/m²/km². [g]Quartile 4: ≥ 118,393 gallons/m²/km².

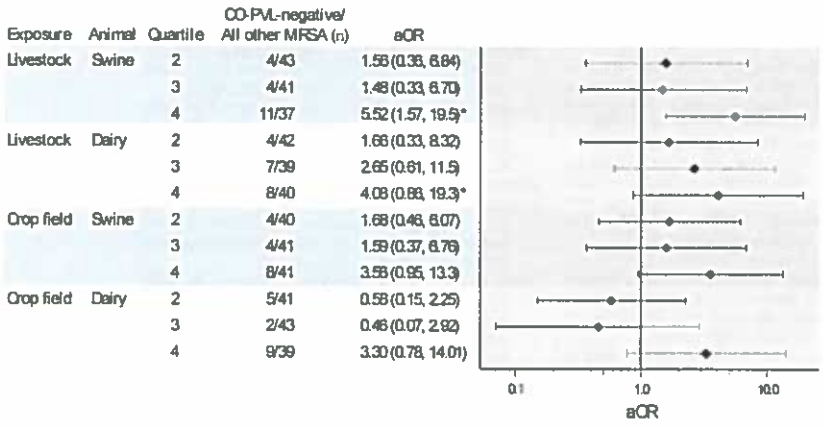

Figure 2. Association of swine and dairy/veal seasonal crop field quartiles and livestock quartiles with CO-PVL-negative MRSA status from adjusted models. Adjusted for sex, age, ever-smoking status, antibiotic order in the 365 to 14 days before infection, season, and receipt of Medical Assistance.
*p-Value for linear trend ≤ 0.05 (quartiles included as a single variable with values 1, 2, 3, and 4).

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The body of literature on MRSA carriage is also relevant to the absence of ST398 among our MRSA isolates. Although there is ample evidence that those in contact with livestock have increased prevalence of ST398 MRSA colonization (Graveland et al. 2010; Smith et al. 2009; Voss et al. 2005), data suggest that ST398 MRSA infection is rare (Golding et al. 2010; Salmenlinna et al. 2010; Wulf et al. 2012). Strains of MRSA adapted primarily to animals (e.g., ST398) may have a diminished ability to infect humans (Graveland et al. 2011; Price et al. 2012). A recent Italian study reported a much greater proportion of ST398 among MRSA-colonized patients compared with those with a MRSA infection where ST8 was most prevalent (Monaco et al. 2013).

Confounding by occupation or socioeconomic status may have impacted our associations. We could not obtain patient occupation from the electronic health records and, therefore, cannot exclude the possibility that some CO-PVL-MRSA cases were occupational versus community acquired. We adjusted for Medical Assistance, a surrogate for low socioeconomic status that was associated with MRSA infection in our previous study (Casey et al. 2013b), but we acknowledge that there may be residual confounding due to socioeconomic status. Since the CO-PVL-negative MRSA group had several characteristics of health care–associated MRSA [(HA-MRSA), e.g., older age, antibiotic resistance, lack of PVL genes, many *spa* type t002] the association with high-density livestock production could have arisen if HA-MRSA was more common in rural areas. However, in a previous study conducted in this region, HA-MRSA was not more common in rural areas (Casey et al. 2013b). Also, HA-MRSA in the present analysis defined by common epidemiologic criteria (Morrison et al. 2006) was not associated with high-density livestock production (data not shown). We adjusted models for season of onset because, as expected, MRSA patients with onset in the winter had low exposure to treated crop fields (manure application is restricted in the winter).

The novel observations in this study require replication. We completed analysis on a limited number of patients with a MRSA infection and, although we incorporated several aspects of operations and crop fields into our individual-level exposure estimates, we did not collect environmental samples. Finally, we could not calculate incidence rates because we included only patients with MRSA infection.

Conclusions

To our knowledge, no previous studies in the United States have evaluated associations between patients infected with specific MRSA strains and high-density livestock production. We identified associations of CO-PVL-negative MRSA with swine and dairy/veal livestock operations and application of dairy/veal manure to crop fields. Our findings were based on small numbers of observations and indirect estimates of exposure, but if confirmed, have important implications for the role of livestock operations in the MRSA epidemic, the different roles of colonization and infection studies, and the identification of other MRSA strains that may be arising from high-density livestock production. To help estimate the public health burden that high-density livestock production may place on the U.S. health care system, future studies should use MRSA infection, along with colonization, as their outcomes of interest. Our study also indicates the need to look beyond MRSA ST398 when investigating MRSA infection associated with high-density livestock production in the United States.

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Air Pollution and Odor in Communities Near Industrial Swine Operations

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Background: Odors can affect health and quality of life. Industrialized animal agriculture creates odorant compounds that are components of a mixture of agents that could trigger symptoms reported by neighbors of livestock operations.

Objective: We quantified swine odor episodes reported by neighbors and the relationships of these episodes with environmental measurements.

Methods: Between September 2003 and September 2005, 101 nonsmoking volunteers living within 1.5 mi of industrial swine operations in 16 neighborhoods in eastern North Carolina completed twice-daily odor diaries for approximately 2 weeks. Meteorological conditions, hydrogen sulfide, and particulate matter ≤ 10 μm in aerodynamic diameter (PM_{10}) were monitored in each neighborhood. We used mixed models to partition odor variance within and between people and between neighborhoods, and to quantify relationships between environmental factors and odor.

Results: Participants reported 1,655 episodes of swine odor. In nine neighborhoods, odor was reported on more than half of study-days. Odor ratings were related to temperature, PM_{10}, and semivolatile PM_{10} in standard but not mixed models. In mixed models, odor increased 0.15 ± 0.05 units (mean ± SE) for a 1-ppb increase in H_2S, and 0.45 ± 0.14 units for a 10-μg/m^3 increase in PM_{10} at wind speeds >6.75 miles per hour. The odds of reporting a change in daily activities due to odor increased 62% for each unit increase in average odor during the prior 12 hr (t-value = 7.17).

Conclusions: This study indicates that malodor from swine operations is commonly present in these communities and that the odors reported by neighbors are related to objective environmental measurements and interruption of activities of daily life.

Key words: agriculture, air pollution, community-based participatory research, environmental justice, epidemiology, quality of life, rural health. Environ Health Perspect 116:1362–1368 (2008). doi:10.1289/ehp.11250 available via http://dx.doi.org/ [Online 5 June 2008]

There is a long history of medical interest in the health impacts of environmental malodor, from Hippocrates to William Farr, England's first Registrar General. In recent decades, scientific consideration of the health consequences of malodors has increased in the context of residential exposures to malodors from municipal solid waste landfills; wastewater treatment; land application of treated sewage sludge; industrialized animal operations; and the production, storage, and transport of industrial chemicals (Schiffman et al. 2000). Environmental malodors may prompt reports of annoyance, worry, and physical symptoms (Shusterman 2001). The extent to which malodor is an aesthetic issue versus a threat to health is a subject of scientific investigation and litigation that has important implications for environmental regulation, public health, and environmental justice (Thu 1998).

Odorant compounds can affect human health via several mechanisms (Schiffman et al. 2000; Shusterman 1992). First, at concentrations high enough to stimulate the trigeminal nerve, odorant chemicals may produce irritation of the eyes, nose, and throat, or other toxicologic effects. In this case, the toxicologic properties of the odorous molecules, rather than odor, produce symptoms. Second, via innate aversion, conditioning, or stress responses, odorant compounds can induce symptoms such as nausea, vomiting, headaches, stress, negative mood, and a stinging sensation at concentrations higher than the olfactory nerve threshold but below the trigeminal nerve threshold (Schiffman 1998; Schiffman et al. 2000; Shusterman 1992, 2001; Shusterman et al. 1991). Third, symptoms occurring in response to odorant mixtures may be due to a nonodorant component such as endotoxin, which can induce inflammation and airflow obstruction (Kline et al. 1999).

Odors may be quantified in natural settings or by laboratory analysis of ambient air samples using trained odor panels, scentometers, olfactometers, or electronic noses (Schiffman et al. 2001, 2005); however, transient and unpredictable odors are difficult to quantify. Although spontaneous reports of malodor may be quantified (e.g., Aitken and Okun 1992; Drew et al. 2007), this approach mixes variation in odor with variation in people's propensities to report odors and the limited availability of public agencies or researchers to track reports.

Research on malodors from concentrated animal feeding operations (CAFOs) and the consequences of these malodors for the health and quality of life of nearby neighbors has increased with expansion of industrial animal agriculture. Recent studies report that CAFO neighbors experience elevated levels of gastrointestinal and respiratory tract symptoms (Thu et al. 1997; Wing and Wolf 2000), wheezing and asthma (Merchant et al. 2005; Mirabelli et al. 2006; Radon et al. 2007), and decreased secretion of salivary IgA during episodes of high odor (Avery et al. 2004). Research on malodor is of interest in the context of broader impacts of industrial livestock production on energy use, diet, air and water pollution, and occupational health and safety (Donham et al. 2007; Thu 2002).

The purpose of this study was to quantify the reports of hog odors made by neighbors of swine CAFOs. To address a common limitation of research into connections between odor and health based on self-report without objective measures, we measured hydrogen

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This paper has not been subjected to the U.S. EPA's required peer and policy review, and therefore does not necessarily reflect the views of the agency and no official endorsement should be inferred. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

In exchange for a report and testimony, a law firm representing plaintiffs in a civil suit about impacts of an industrial swine operation on its neighbors contributed $2,000 to the University of North Carolina in support of S.W.'s research. K.T. has served as a consultant and provided testimony in civil suits regarding impacts of industrial swine operations on neighbors, and has received funding from the Iowa Pork Producers Association and the National Pork Producers Council. S.S.S. has received funding from the National Pork Board, the North Carolina Pork Council, and the Smithfield Agreement between Smithfield Foods and the State of North Carolina. The remaining authors declare they have no competing financial interests.

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We used mixed logistic regression for analyses of activity limitation as the dependent variable. Average hourly outdoor odor since the previous diary entry was the independent variable. Models were fitted using the SAS GLIMMIX procedure. Random intercepts and fixed effects of average odor ratings of 1 to <2, 2 to <3, 3 to <5, and ≥ 5 compared with no odor were estimated as predictors of activity limitation due to odor, coded as a 0/1 variable. A model was also fit with average hourly odor as a continuous variable.

SEs of regression coefficients are presented as measures of precision in order to reduce the probabilistic interpretations implied by the use of confidence intervals. For the same reason, we assessed contributions of predictors to the fit of models by t-tests instead of p-values because this is not a randomized study (Greenland 1990).

Results

Neighborhood and participant characteristics. A total of 102 volunteers from 16 neighborhoods enrolled in the study. One person who had difficulty with the study protocol was excluded from analyses. Analyses here include 84 people who collected data for 2 weeks, 15 (from three neighborhoods) who chose to continue an additional 4–7 days, and 2 who stopped before 2 weeks. Sixty-six women and 35 men participated. Age ranged from 19 to 89 years, with a mean age of 53. Eighty-four participants identified themselves as black, 15 as white, one as black/Native American, and one as Latino.

Characteristics of study neighborhoods, labeled A–P, are given in Table 1. Two neighborhoods had one swine CAFO within 2 mi of the monitoring trailer, and six neighborhoods had ≥ 10 within 2 mi. Approximately two-thirds of participants lived in neighborhoods within 2 mi of ≥ 5 swine CAFOs. In nine neighborhoods, participants reported outdoor swine odor on more than half the study days. Mean temperature on study days ranged from 47°F in neighborhood A to 82°F in neighborhood K; no neighborhoods participated during January. Mean H_2S was 0.004 ppb in neighborhood E, where 99.8% of readings were below the detection limit (2 ppb). Neighborhoods O and C had the highest mean values, 1.02 and 1.48 ppb, respectively, and the highest values recorded in neighborhood O were at the upper limit of detection, 90 ppb. Average PM_{10} varied from 10.8 μg/m^3 in neighborhood A to 28.7 μg/m^3 in neighborhoods C and E, whereas semivolatile PM_{10} was highest (9.2 μg/m^3) in neighborhood O and lowest in H (–3.2 μg/m^3), indicating the high degree of measurement error when using the microbalance to characterize semivolatile particle levels over short time periods.

Frequency, magnitude, and duration of odor episodes. We calculated the average daily odor that participants reported following the twice-daily preselected 10-min periods of sitting outdoors, as well as the average hourly outdoor odor reported each day. Study participants collected data on 1,495 days, although twice-daily odor was missing for 39 of these days. Results for the 1,456 days with twice-daily odor information are reported here (Table 2). The average twice-daily odor was zero for 563 days (38.7%), and > 5 on 51 days (3.5%). Average hourly outdoor odor was zero for 591 days (40.6%) and > 5 on 33 days (2.3%). Average twice-daily odor was zero on fewer days than average hourly odor. This is possible because participants could report nonzero odor during twice-daily times sitting outdoors when there was no odor at other times during the hour.

Reported hourly outdoor odor was highest in the mornings and evenings and lowest in the middle of the day and night (Figure 1). Morning odor was highest around 0300 hours (mean = 1.7) when 12.2% of ratings were ≥ 5. Mean hourly odor was 2.1 at 2000 hours, when 19.2% of odor ratings were five or greater.

Based on hourly outdoor odor ratings, participants reported 1,655 odor episodes (Table 3). The duration of an episode is the number of consecutive hours that swine odor was reported to be above zero. The majority of episodes (62.1%) lasted 1 hr, whereas 9 episodes (0.5%) lasted ≥ 9 hr. Average odor was < 2 for about 39% and > 5 for about 16% of odor episodes lasting 1 or 2 hr. Average strength was ≥ 5 for > 21% of odor episodes of ≥ 3 hr.

Hog odor was reported inside homes on 185 of 1,456 person-days of follow-up (12.5%). Five hundred episodes of indoor hourly odor were reported, of which 233 (46.6%) lasted 1 hr, 179 (35.8%) lasted 2–3 hr, and 88 (17.6%) lasted ≥ 4 hr. Three of the 1-hr indoor odor episodes, rated 3, 6 and 8, were reported in the middle of time periods when consistent sleep was indicated.

Butanol odor sensitivity threshold was estimated for 98 participants, of whom 39 had a threshold of 10 or 20 ppm (Table 4). Most odor ratings were provided by people with butanol detection thresholds between 10 and 160 ppm. Average reported odor declined with sensitivity from 20 to 160 ppm. Among the 12 participants with odor thresholds of ≥ 320 there was not a clear relationship between odor sensitivity and average odor.

Environmental correlates of odor. Analyses of environmental correlates were based on the

Table 2. Daily averages of twice-daily and hourly outdoor odor ratings (scale of 0–8).

Mean odor rating	Twice-daily odor [no.(%)]	Hourly outdoor odor [no. (%)]
0	563 (38.7)	591 (40.6)
> 0 to < 2	541 (37.2)	581 (39.9)
> 2 to < 5	301 (20.7)	251 (17.2)
≥ 5	51 (3.5)	33 (2.3)
Total	1,456 (100.0)	1,456 (100.0)

Table 1. Characteristics of neighborhoods and CAFOs within 2 mi of the monitoring platform.

Site	Swine CAFOs (no.)	Participants (no.)	Mean 10-min odor	Days with any odor outdoors (%)	Days with any odor indoors (%)	Mean temp (F)	Mean H_2S (ppb)	H_2S values < 2 ppb (%)	Highest H_2S (ppb)[a]	Mean PM_{10} (μg/m^3)	Mean semivolatile PM_{10} (μg/m^3)
A	1	7	0.4	26	2	47	0.01	99.7	4	10.8	1.1
B	1	6	0.7	48	10	50	0.09	97.0	9	13.6	1.8
C	3	5	1.4	70	14	60	1.48	77.1	28	28.7	2.7
D	3	6	0.8	68	9	59	0.41	90.7	20	13.7	1.4
E	4	7	0.5	20	15	77	> 0.00	99.8	2	28.7	5.9
F	4	4	2.7	95	46	77	0.15	94.2	10	28.4	3.9
G	5	4	0.6	41	2	51	0.07	96.7	3	17.5	5.0
H	9	6	1.0	45	9	63	0.02	98.9	3	16.8	–3.2
I	9	9	2.9	88	23	80	0.40	90.9	20	27.0	7.5
J	9	4	1.9	63	15	79	0.40	91.2	52	21.7	3.5
K	10	8	1.3	73	12	82	0.28	93.3	21	22.8	8.6
L	12	7	0.8	43	3	71	0.05	97.6	4	23.0	4.6
M	12	10	2.1	73	11	75	0.05	98.6	27	17.1	1.6
N	15	5	0.9	49	13	59	0.01	99.5	4	27.3	4.6
O	15	5	1.8	68	26	77	1.02	91.1	90	18.7	9.2
P	16	8	1.2	66	10	59	0.08	97.3	9	19.1	6.5

temp, temperature.
[a]Based on 15-min average values.

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personal space. There was an association between activity change and average outdoor odor intensity during the 12 hr prior to a diary record, with odor grouped into several levels (Table 7). Participants noted changes in activity due to odor from 1.4% of occasions when average odor was < 1.0 up to 16.2% when average odor was ≥ 5.0. Estimates from logistic mixed models with random intercepts and a fixed slope for odor show a similar relationship; all model coefficients are substantially larger than their SEs, and t-values are large. A separate model was estimated for odor as a continuous variable; the log odds ratio of activity change for a one-unit increase in odor is 0.48 ± 0.07, a 62% increase in the odds of activity change per odor unit (t = 7.17).

Discussion

In the present study 101 participants from 16 neighborhoods in eastern North Carolina reported on the strength of hog odor inside and outside their homes for approximately 2 weeks while temperature, humidity, wind speed, H_2S, and PM_{10} were monitored nearby. One to 16 swine CAFOs were located within 2 mi of the monitoring platform in each neighborhood. Odor was reported outside on more than half the study days in 9 neighborhoods. Odor ratings made during 10-min periods of sitting outside twice a day were associated with weather conditions, H_2S, and PM_{10}. One-third of participants reported ceasing or changing their activities due to malodor, and the intensity of odors reported between diary entries was strongly associated with these reports. This study indicates that malodor from swine operations is commonly present in these communities and that the odors reported by neighbors are related to objective environmental measurements.

Neighborhoods were included in the study if at least several members were interested in participating in a 2-week study that required a 3-hr training session and a twice-daily routine of reporting and measurement. Neither the neighborhoods nor participants are a representative or systematic sample of the region. We relied on local knowledge to select neighborhoods where hog odor had been reported to community organizers and where individuals might be interested in participating. However, there are > 2,000 swine CAFOs in the region, and we had no way to identify those CAFOs with higher releases of odorant chemicals. Although it is unlikely that neighborhoods with the highest exposures were included in this study, neighborhoods with no odor problems, if they exist, would not have been included either. Pollution levels and odor strength in this study may also have been affected by actions taken by operators of swine CAFOs near the study sites; participants in several neighborhoods reported cessation or relocation of hog waste sprayers, as well as reduced odor, during their period of study participation.

Other analyses indicated that the completeness and consistency of data in this study were high (Schinasi 2007). Participants reported twice-daily odor ratings in 94% of 2,949 total journal entries and at least one such rating on 97% of 1,495 study days. On the 1,456 study days with at least one twice-daily odor rating, the mean and median percentages of hours of the day for which hourly odor ratings were provided were 96% and 100%, respectively. On 95% of study days, participants reported information on whether hog odor had altered their daily activities.

We evaluated the hypothetical possibility that, due to their access to the H_2S monitor, odor ratings of 12 study participants who were asked to check for malfunctions with the environmental monitoring equipment could have been influenced by the value on the display screen; in this case the relationship between H_2S and odor might be overestimated. We refit the random-intercept, random-slope model for H_2S and odor excluding these 12 participants; the β coefficient and its SE rounded to the same values reported in Table 6.

Although the structured reporting of odor by neighbors of swine CAFOs is a strength of our study, the frequency, duration, and intensity of reported hog odor episodes must be interpreted in the context of participants' daily activity patterns. Participants reported being indoors at home 30.0%, outdoors at home 17.1%, away from home 25.5%, and sleeping 27.4% of hours in the study. The large proportion of time spent indoors and away from home limits information on outdoor odor episodes. The duration of outdoor odor episodes is also truncated by going indoors or away from home to avoid odor; this may contribute to the shorter duration of reported outdoor hourly odor episodes (62.1% lasted 1 hr) compared with indoor hourly odor (46.6% lasted 1 hr).

With the exception of PM_{10} in higher wind conditions, temperature, PM_{10}, and semivolatile PM_{10} were correlated with hog odor ratings only if the within-person, between-person, and between-neighborhood structure of the data was ignored. This might reflect the lack of seasonal variation of these variables within neighborhoods sampled for only about 2 weeks, which is a limitation of the study design. H_2S, in contrast, was strongly related to odor in mixed models. Unlike the weather variables, H_2S levels varied markedly within neighborhoods. In a recent chamber experiment, naive volunteers exposed to swine CAFO air with a 24 ppb concentration of H_2S reported an average odor of 5.29 on a 0–8 scale (Schiffman et al. 2005). The predicted odor at 24 ppb in the present study, based on the linear regression function from Table 4 [odor = 1.25 + 0.17 × H_2S (ppb)] produces a similar value of 5.33.

In theory, a stronger relationship between odor ratings and the concentration of odorant compounds should have been observed among people with a better sense of smell. We considered butanol detection threshold as a modifier of the H_2S effect because, unlike PM_{10}, it was strongly associated with odor even without taking into account the modifying effect of wind speed. The observation that this association was restricted to people with detection thresholds < 320 ppm suggests that this simple threshold test distinguishes a subgroup of participants (87.8%) who are more responsive to H_2S.

The microbalance produced many negative values for semivolatile PM_{10}, indicating large measurement error relative to the semivolatile

Table 6. Mixed-model coefficients for environmental predictors of odor.

	Effect	SE	t-Value
Wind speed[a,b]			
Low	0.18	0.07	2.62
Medium (intercept)	1.23	0.20	6.03
High	0.38	0.13	2.91
Relative humidity ≥ 50%	0.29	0.11	2.59
H_2S (ppb)[c]	0.15	0.05	3.10
H_2S × wind speed[d]			
Low	0.28	0.11	2.49
Medium	−0.09	0.10	−0.83
High	0.77	0.44	1.75
PM_{10} (10 μg/m³) × wind speed[e]			
Low	−0.01	0.05	−0.23
Medium	0.00	0.02	0.25
High	0.45	0.14	3.14

[a]Random-intercept, fixed-slope model. [b]Low, ≤ 0.57 mph; 0.57 < medium ≤ 6.75; high, > 6.75. [c]Random intercepts, random slopes. [d]Random intercept, random slope for H_2S, random intecept, fixed slope for wind. [e]Random intercept, fixed slope for wind and PM_{10}.

Table 7. Reports of change in activities due to odor in relation to average odor during the previous 12 hr.

12-hr average	No. of changes in activity reports	Percentage of times with change in activity	Rate ratio	Log_e odds ratio[a]	SE	t-Value
Odor < 1	22	1.4	1.0	Referent	—	—
1 ≤ odor < 2	23	5.1	3.6	1.32	0.38	3.46
2 ≤ odor < 3	19	7.1	5.0	1.56	0.40	3.93
3 ≤ odor < 5	30	11.0	7.7	2.12	0.39	5.46
Odor ≥ 5	24	16.2	11.3	2.78	0.43	6.39

[a]From mixed model with random intercepts and fixed slope for odor terms.

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Land Application of Treated Sewage Sludge: Community Health and Environmental Justice

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Background: In the United States, most of the treated sewage sludge (biosolids) is applied to farmland as a soil amendment. Critics suggest that rules regulating sewage sludge treatment and land application may be insufficient to protect public health and the environment. Neighbors of land application sites report illness following land application events.

Objectives: We used qualitative research methods to evaluate health and quality of life near land application sites.

Methods: We conducted in-depth interviews with neighbors of land application sites and used qualitative analytic software and team-based methods to analyze interview transcripts and identify themes.

Results: Thirty-four people in North Carolina, South Carolina, and Virginia responded to interviews. Key themes were health impacts, environmental impacts, and environmental justice. Over half of the respondents attributed physical symptoms to application events. Most noted offensive sludge odors that interfere with daily activities and opportunities to socialize with family and friends. Several questioned the fairness of disposing of urban waste in rural neighborhoods. Although a few respondents were satisfied with the responsiveness of public officials regarding sludge, many reported a lack of public notification about land application in their neighborhoods, as well as difficulty reporting concerns to public officials and influencing decisions about how the practice is conducted where they live.

Conclusions: Community members are key witnesses of land application events and their potential impacts on health, quality of life, and the environment. Meaningful involvement of community members in decision making about land application of sewage sludge will strengthen environmental health protections.

Key words: biosolids, environmental health, environmental justice, land application, qualitative research, sewage sludge. *Environ Health Perspect* 121:537–542 (2013). http://dx.doi.org/10.1289/ehp.1205470 [Online 11 March 2013]

In the United States, municipal wastewater must be treated before it is returned to the environment. Sewage sludge is the solid by-product of wastewater treatment. Most of the sludge created by municipal wastewater treatment plants in the United States undergoes biological, chemical, or thermal treatment and is then applied to farmland as a soil amendment [National Research Council (NRC) 2002]. Treated sewage sludge, also called biosolids, contains nutrients useful as fertilizers as well as heavy metals, toxicants, and pathogens. U.S. Environmental Protection Agency (EPA) regulations require periodic monitoring of certain heavy metals and indicator bacteria in treated sludge, but there is no routine monitoring of other toxicants (NRC 2002; U.S. EPA 1994). Most treated sludge is labeled Class B, which has less stringent requirements for pathogen reduction than Class A sludge; the two classes are the same with respect to other contaminants (NRC 2002). Treated sludge is usually applied to land as a liquid spray or solid cake, creating aerosols and dust particles that can drift downwind from the application sites (Baertsch et al. 2007; Paez-Rubio et al. 2007).

Some scientists suggest the rules regulating sludge treatment and land application are based on outdated science and may be insufficient to protect public health and the environment (Gattie and Lewis 2004; Harrison and McBride 2008; Harrison et al. 1999, 2006; Lewis and Gattie 2002; Lewis et al. 2002; Mathney 2011; Snyder 2008). Monitoring land application, enforcing regulatory rules, and systematic tracking and investigation of public concerns are often limited by staffing shortages and budget constraints at federal, state, and local levels (Harrison and Eaton 2001; Lowman et al. 2011; U.S. EPA 2000, 2002). The U.S. EPA's Inspector General (U.S. EPA 2000) found that,

> while EPA promotes land application, EPA cannot assure the public that current land application practices are protective of human health and the environment.

Some residents living near land application sites associate physical symptoms such as mucous membrane irritation, respiratory and gastrointestinal distress, headaches, and skin rashes with land application of sewage sludge (Harrison and Oakes 2002; Lewis et al. 2002; Lowman et al. 2011; Shields 2002). Residents also report foul odors and interference with their quality of life and beneficial use of their property (Lowman et al. 2011; Shields 2002). Although in 2002 the NRC's Committee on Toxicants and Pathogens in Biosolids Applied to Land recommended studying human exposure and illness, little research into the experiences of persons living near such sites has been conducted since then (NRC 2002).

This article reports the results of analyses of qualitative interviews conducted with neighbors of sites where sewage sludge is applied to land. Qualitative research is of increasing interest in environmental health science, and has been promoted as a useful tool that can complement traditional exposure assessment and epidemiologic studies (Brown 2003; Moffatt and Pless-Mulloli 2003; Scammell 2010). Little quantitative research has been conducted on the impacts of the land application of treated sewage sludge on neighbors' health because of a lack of systems for surveillance of reported illness (Keil et al. 2011; Lowman et al. 2011), the episodic nature of most applications, and low population density in rural areas. We use qualitative methods to provide detailed information about people's perceptions of health and quality of life, including temporal sequences of events that may be difficult to ascertain in traditional cross-sectional epidemiologic research. Furthermore, we use qualitative research to understand local and individual factors that may modify a person's experience with the land application of sewage sludge and to place these experiences into a broader context of environmental injustice.

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they notice sludge odor for periods lasting from 2 days to 6 months after application.

Over half (18/34) of the interview respondents associated acute physical symptoms that lasted a short period of time with sludge application events near their home (Table 1). The most commonly reported symptoms were eye, nose, and throat irritations and gastrointestinal symptoms (nausea, vomiting, diarrhea). Other symptoms reported by more than one respondent include cough, difficulty breathing, sinus congestion or drainage, and skin infections or sores.

One respondent described recurring physical reactions coincident with sludge applications near her home:

> All I know is [the sludge] will make your eyes burn. It will make your throat burn. And then you'll start coughing, and after that, you can't breathe. And that's when I go to the doctors.

A farmer and long-time resident described the nauseating effects of sludge odor:

> The stench—it would actually make you sick. It takes a lot to bother me, but it certainly got to me. I'd get nauseated after being out for about an hour in the morning.

Other physical symptoms or conditions that were mentioned by no more than one respondent include pneumonia, swelling of brain arteries, increased seizures, temporary blindness, swollen tongue, closed throat, lung infection, and migraine.

A few respondents expressed concern that they or their family members have chronic health problems, such as asthma or cancer, that make them more sensitive to harmful constituents in sludge. The parents of a child with chronic respiratory problems said they keep him indoors as long as sludge odors from a neighboring field are present—up to 2 or 3 months—to protect him from possible airborne pollutants.

Mental well-being. Over half of the respondents (18/34) said sludge application in their neighborhoods stirred unsettling emotions, including anger, frustration, misery, fear, worry, anxiety, insecurity, and helplessness. Respondents most commonly expressed anger related to not being informed about sludge application in their neighborhood, reckless sludge truck drivers, regulators who seem unconcerned with violations of land application rules, public officials who do not respond to reported concerns, and health impacts.

A woman who reported that she and other family members get sick after nearby sludge applications described the emotional impact of sludge this way:

> I'm bitter and frustrated and angry because [sludge] is affecting my family .... And it's going to alter the rest of their lives because of something that's been laid down next to them that we knew nothing about, and had no control over.

Malodor from sludge seemed to affect some respondents' mental states. As one interviewee said,

> I'm outside cutting grass or working in the garden and constantly smelling that [sludge] .... Your attitude changes by disturbances in your environment.

A war veteran with posttraumatic stress disorder reported experiencing flashbacks from sludge odor reminiscent of the smell of burning waste in a warzone:

> [Sludge] is not just a nuisance; it's a medical problem for me .... I am not able to get myself to a place where I can begin to heal if they're constantly driving me backwards ... every time I've got to walk out of my house and smell the freaking warzone.

Most respondents (26/34) shared ways that sludge odor and other related nuisances interfere with their enjoyment of home, property, and the outdoors. One long-time rural resident who joined her husband in the country after they married volunteered this common sentiment about the impact of sludge odor on her home life:

> I don't want to come home because when we come home, we're locked in the house. My husband says, "This is not the same. It's just not the same. We can't really enjoy where we live."

Social well-being. Some respondents (8/34) said sludge odors disrupt their opportunities to socialize with family and friends. Several lamented they are unable to spend time walking, playing, eating, or sitting outside as a family when sludge odor is present. One father said,

> We have a gazebo outside. We sit outside. At least, that was our conversation in planning it. Familyness. And [sludge] took that away.

A few respondents said they refuse visits from extended family members because of the intensity of the sludge odor and concerns about its health impacts. A mother and grandmother said,

> My daughter wants to come up with the grandkids, with the family—I won't let her come when they're sludging. She got so hurt one year. "Mommy, we're coming for a week." I said, "No, you can't."

Others said sludge odors interfere with social gatherings. One respondent whose family has lived in his neighborhood for generations recalled,

> They first put [sludge] out right before the Fourth of July .... We had to put our plans to the side on doing something on the outside. We usually have cookouts, but you can't cook out in nothing like that.

A total of 22 respondents named specific activities they are unable to do because of malodor from sludge during and for up to several months after a sludge application event (Table 2). The most frequently mentioned activity limitations were letting children play outdoors, opening house and car windows, and hosting relatives or outdoor social gatherings. Others include line-drying laundry, walking freely around the neighborhood, gardening or working outside, sitting outside as a family, and staying home. A few respondents described ways of coping with the odor so they could continue their usual activities. One woman said she wears a mask to do barn chores when sludge odor is strong. Another said she wears a mask to leave the house when the odor is present.

Environmental impacts. Over half of the interview respondents (18/34) reported observing land application activities of environmental concern to them. The most commonly reported concerns include sludge spillage on public roadways and private property, grazing cattle on land-applied pasture soon after application, the absence of signage at land application sites, and sludge runoff into surface waters. Table 3 lists these and other observations of concern to respondents, as well as the number of respondents who reported them. In some cases, self-informed respondents said that the land application activities they observed were violations of state standards and that they attempted to report them to officials. In other cases, respondents had no knowledge of their state's land application standards.

About one-third of the respondents (12/34) said they noticed changes in the natural environment since sludge application began

Table 1. Acute (short duration) physical symptoms respondents attributed to sludge exposure (n = 18/34 respondents).

Acute symptom	No. of respondents reporting symptom
Eye, nose, throat irritation	8
Nausea, vomiting, diarrhea	8
Cough	5
Difficulty breathing	4
Sinus congestion, drainage	4
Skin infection, irritation, sore	2

Table 2. Activities respondents said they are unable to do because of malodor from sludge during and for up to several months after a sludge application event (n = 22/34 respondents).

Activity	No. of respondents reporting activity limitation
Let children play outdoors	8
Open house/car windows	8
Host relatives or outdoor social gatherings	6
Line-dry laundry	5
Walk freely around the neighborhood	5
Garden or work outside	4
Sit outside as a family	3
Stay home	3

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frustration was expressed in other interviews. For example, a respondent from Virginia said the Dillon Rule, a judicial doctrine that limits local government authority in Virginia, North Carolina, and other states (Clay 1989), prevents her local government from establishing rules and regulations governing land application where she lives. She felt that it was unfair to favor one land owner who wants to use sludge when the majority of the community is opposed to it. She added,

> The industry has all the control. Because they can pull up application, or they can lay it down. And they don't care. As long as they've got permission to do it, they're going to do it.

In spite of perceived barriers to influencing land application decisions, over half of the interviewees (19/34) described changes they would like the industry to make to improve public notification and enhance public and environmental protections. First, several respondents suggested public officials should directly notify residents within 1 mile of sludge fields before the first and subsequent land application events. A few said residents should be given the opportunity before land application events to inform public officials of household members with health conditions, such as a respiratory illness or weakened immune system, so that an injection method of land application can be used to better safeguard their health, or so application at the site can be suspended.

Some respondents who reported poorly visible signs near sludge fields or who reported seeing no signs at all suggested that land appliers post large visible signs 2 weeks before application and for the duration of the event. Respondents said this would allow them to prepare for the event and take necessary safety precautions for their family and animals. Also related to public notifications, some respondents said they would like to receive the results of sludge testing from the wastewater treatment plants that apply waste near their homes in order to monitor concentrations of harmful constituents and possible concerns.

Respondents concerned about well water contamination said the city should provide water to residents in land application areas or offer free periodic testing of their private well water to evaluate its safety. A few respondents said application in a critical watershed and land application before forecasted rain events should be prohibited. If the latter should occur, respondents said the sludge should be tilled under immediately following application to prevent runoff. Some respondents also felt that land application should not occur under windy conditions because of the increased likelihood of exposing neighbors to migrating pollutants. Generally speaking, respondents who were aware of land application rules and who reported violations said that better enforcement of existing rules is needed to protect human and environmental health.

Respondents who felt there were conflicts of interest in land application governance and practice that undermine human health and the environment said these should be minimized by contracting with independent scientists to perform and report soil and sludge batch testing; funding independent, formal research about health and environmental impacts of sludge application; prohibiting state and local health departments and the U.S. EPA from promoting land application; and making government employees responsible for telling residents the truth about land application.

Finally, a few respondents said they would like the land application industry to improve and maintain roads damaged by the frequent travel of heavy sludge trucks.

Overall, eight respondents said they would like land application to stop, either indefinitely or until independent research can "prove it's safe" for human health and the environment.

Discussion

We used qualitative research methods to enhance understanding of the impacts of land-applied sewage sludge on the health and quality of life of nearby populations. Respondents reported symptoms consistent with findings from earlier studies that report neighbors of land application sites experience physical reactions to land-applied sludge (Gattie and Lewis 2004; Lewis et al. 2002). Confined animal feeding operations (CAFOs) also apply liquid wastes and sludge to farmland. CAFO neighbors describe health impacts similar to those reported by neighbors of land-applied sewage sludge (Bullers 2005; Horton et al. 2009; Radon et al. 2007; Schiffman 1998; Schiffman et al. 2000; Schinasi et al. 2011; Tajik et al. 2008; Thu 2002; Thu et al. 1997; Wing and Wolf 2000; Wing et al. 2008). The overlap of hazardous agents in CAFO waste and treated sewage sludge, including odorant compounds, endotoxins, and other allergens and irritants, suggests that similar community health impacts are plausible (Lewis et al. 2002).

Respondents also reported adverse impacts on their mental and social well-being and on the surrounding natural environment. Some said they observed sludge spillage on public roadways and private property, grazing cattle on land-applied pasture soon after application, and sludge runoff into surface waters. These and other land application activities that respondents said they witnessed are violations of land application standards in one or more of the three states represented in this study (Harrison and Eaton 2001; North Carolina Department of Environment and Natural Resources 2006; South Carolina Department of Health and Environmental Control 2009; Virginia Department of Environmental Quality 2011), highlighting the need for stricter enforcement of standards.

Respondents also described environmental injustices related to land application of sewage sludge, including barriers to participating in decisions about how the practice is conducted in their neighborhood. Land application of sewage sludge is part of a larger context of environmental injustice that characterizes relationships between urban areas that create wastes and nearby rural areas that receive the wastes. In addition to sewage sludge, urban wastes disposed in rural and semirural communities include municipal solid wastes, construction and demolition debris, and industrial wastes (Norton et al. 2007). Jones (2011) describes the urban–rural dimension of environmental injustice this way:

> For the majority of Americans who live in metropolitan areas, rural dumping becomes a logical choice: undeveloped land is inexpensive and available, fewer residents will be harmed should containment measures fail, and, most importantly, nuisances and dangers are removed from their own neighborhoods.

This report does not include everything respondents said about living near sludge application sites; rather it represents the dominant themes that we identified in the open-ended interviews. There were few positive remarks about sludge and the response of industry and government officials to residents' concerns, possibly because of our method of recruiting participants. We asked community contacts to help us identify people who could provide information on the subject of living near sludge application sites. Although we did not ask for referrals to people who had problems with sludge, people with negative opinions of the practice may share local social networks, which could lead to their perspectives being overrepresented. Alternatively, some rural residents who have been negatively affected by land application of sludge may be unwilling to speak out or participate in research because they fear retribution from influential land owners or government officials who benefit from sludge application and control rental property, access to resources, or jobs. In addition, we are unable to report the numbers of respondents who had similar or opposing views or experiences for all interview topics because we obtained the information through open-ended interviews that did not probe the participants to respond to a list of standardized questions. Our study was not designed to quantify the prevalence or incidence of reported symptoms, health impacts and other concerns in populations near land application sites.

Our study does demonstrate that people of diverse backgrounds who live in three different states raised health and environmental concerns about land application. Similarities

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Factory Farming's Effect on Rural Communities

Though only a few studies have examined the effects of factory farms on the people who live near them, a wealth of data has been gathered on the health hazards to which these facilities expose their employees. Viewed together, these two bodies of research indicate that the industry poses serious threats to the well-being of rural communities.

- Studies have discovered an increase in respiratory, neurobehavioral, and mental illnesses among the residents of communities next to factory farms. In a major study, residents in the vicinity of a large pig farm were found to have "higher reporting of headaches, runny noses, sore throats, excessive coughing, diarrhea, and burning eyes." A separate study determined that pregnant women and children are especially susceptible to factory farm emissions.
- Waste from factory farms poses a serious risk for nearby residents. Manure and urine are generally stored in open-air pits known as lagoons. When the lagoons are full, large amounts of waste are applied to nearby land, compromising soil and water quality. Lagoons are also prone to spills, which can contaminate a community's water.
- Manure lagoons are known to release a number of air pollutants, including methane, a major greenhouse gas, and hydrogen sulfide, which the National Institute for Occupational Safety cites as a leading cause of death in the workplace. In fact, 25 percent of workers at pig factory farms report respiratory problems, including asthma, bronchitis, and organic dust toxic syndrome.
- Evidence suggests that living near a factory farm compromises residents' overall quality of life. Residents in towns near these farms are often forced to keep their windows closed and remain indoors due to foul odors. In a study of one town in the vicinity of a major factory farm, a third of the residents reported that their daily activities were affected by the presence of the operation. Proximity to a factory farm can also substantially decrease property values.
- A 2003 survey of rural Iowans indicated that the construction of pig factory farm in their area was less desirable to them than that of a prison, a solid waste landfill, a slaughter plant, or a sewage treatment plant.

Communications Foundation

Food Program

Waste Management

photo from Socially Responsible Agricultural Project

On this page:

Mountains of Manure
Animal Waste, the Environment, and Human Health
Regulation and Technology in Managing Waste
Comparing Animal and Human Waste Production
Did You Know?
What You Can Do

Where there are animals, there is animal waste, and as the growth of industrial farming concentrates thousands of animals on increasingly fewer farms, it produces massive amounts of animal waste on relatively small plots of land. When too much waste is produced in one place, there's no safe, cost-effective way to either use it productively or dispose of it. While government regulation and better waste management practices can make a difference and should be encouraged for existing farms, the problem of livestock waste will never end so long as we rely on concentrated industrial farms to produce our food.

Mountains of Manure

The USDA estimates that more than 335 million tons of "dry matter" waste (the portion of waste remaining after water is removed) is produced annually on farms in the United States, representing almost a third of the total municipal and industrial waste produced every year.[1] What's more, animal feeding operations annually produce about 100 times more manure than the amount of human sewage sludge processed in US municipal wastewater plants.[2] One dairy farm with 2,500 cows produces as much waste as a city with around 411,000 residents.[3] Unlike human waste, however, in most cases the law does not require that livestock waste be treated.

At farms where animals are allowed to graze on pasture, much - if not all - of their manure is excreted directly onto the land, serving as a fertilizer and recycling nutrients back into the soil. On industrial livestock farms, however, animals drop their manure in the houses where they live. From there, the manure must be cleaned out, transported, and stored, each step of which can negatively affect the environment. Simply cleaning out livestock houses can waste vast amounts of water—a dairy operation that utilizes an automatic "flushing" system can use up to 150 gallons of water per cow per day.[4]

Manure is usually stored for many months, often in giant outdoor pits known as lagoons.[5] As it decomposes, the manure emits harmful gases such as ammonia and hydrogen sulfide.[6] Meanwhile, these lagoons can leak or rupture, polluting the surrounding soil and water systems. One study conducted by North Carolina State University in 1995 estimated that as many as 55% of the manure lagoons on hog farms in that state were leaking.[7] Even without leaks, manure lagoons are so fragile that major storms often result in overflows. Perhaps most famously, in 1999, the

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majority of North Carolina's manure lagoons spilled over into waterways during Hurricane Floyd, leading to widespread water contamination. What made matters even worse was that North Carolina, like most states, requires no treatment of animal waste.[8]

Since manure is produced on factory farms in excess of what can safely be absorbed by the farm's soil, it is often shipped to neighboring farms for use as fertilizer. Unfortunately, manure is quite heavy, so transporting it both consumes large amounts of fuel (needed to power the trucks that haul it) while at the same time contributing to air pollution (due to emissions from the trucks that haul it).[9]

Once the manure arrives at its destination, it is sprayed onto farm fields as fertilizer. Under the current system of animal production, however, there is always more manure available than can possibly be absorbed by the soil as fertilizer. In fact, studies show that between 1982 and 1997, as industrial agriculture grew, the US experienced a 64 percent increase in the amount of manure that could not be absorbed by our soils.[10] This practice is not only harmful to the soil, but can also result in contamination of human drinking water and lead to serious public health problems.

Animal Waste, the Environment, and Human Health

People often believe that animal manure is harmless, but in truth it can be quite hazardous. Factory livestock facilities pollute the air and release over 400 separate gasses, mostly due to the large amounts of manure they produce.[11] The principal gases released are hydrogen sulfide, methane, ammonia, and carbon dioxide.[12] Gasses can be dangerous air pollutants that threaten both the environment and human health. Nitric oxides are also released in large quantities from farms through manure application, and are among the leading causes of acid rain.[13]

The risks of lagoon leakage, overflows, and illegal discharge of waste also pose a direct threat to the quality of soil and water systems. A report for the U.S. Geological Survey documented over one thousand spills and dumps of animal waste in the ten Midwestern states it surveyed over the course of three years.[14] Manure from leaky lagoons or saturated farm fields has also been known to enter public water sources and infect humans.[15] For example, a study of waterborne disease outbreaks from 1986 to 1998 conducted by the Centers for Disease Control demonstrated that in every case where the pathogen could be identified, it most likely originated in livestock.[16]

Among the many nutrients usually present in high concentrations in animal waste are phosphorous and nitrogen, which are beneficial to the soils when the manure is added in small concentrations. However, the volume of manure usually found in lagoons and storage systems, and subsequent very high concentrations of nutrients, can cause a range of ecological problems like fish kills or a loss in biodiversity[17] when released into the environment and can affect human health when leached into drinking water. Nitrogen in manure is tied up in its organic state until, through decomposition, it is converted to a soluble form (ammonium nitrate). When ammonium nitrate is mixed with water, nitrates can leach into groundwater systems and threaten the water quality.[18] According to the Environmental Protection Agency (EPA), drinking water with nitrate concentrations above ten parts per million (ppm),[19] can cause developmental deficiencies in infants and death in severe cases due to oxygen deprivation. Nitrates introduced into the body through affected water significantly reduce the blood's oxygen carrying capacity,[20] and deprive the body of oxygen. High nitrate concentrations are also believed to have caused spontaneous abortions and possibly cancer.[21]

The storage of animal waste under industrial livestock facilities and in manure tanks also poses a direct health risk to both animals and humans. Since animal waste is often stored directly beneath the barns in which the livestock live, livestock commonly die from poor ventilation that allows for the buildup of toxic gases inside confinement facilities.[22] What's more, manure pits have been known to claim the lives of farm workers, and between 1992 and 1997 at least twelve workers died due to asphyxiation by manure gases and drowning while trapped in manure lagoons.[23] The gases in livestock facilities can also pose other risks to workers; for example, methane is highly flammable, and if not vented properly from manure tanks it can cause explosions.[24]

Regulation and Technology in Managing Waste

Until recently, there has been very little regulation of animal waste. Federal law changed in 2002 to require virtually all confined animal feeding operations (CAFOs[G]) to apply for National Pollutant Discharge Elimination System (NPDES) permits for their waste discharge. In 2005, the rule was revised requiring only CAFOs that discharge waste (i.e. into streams, rivers, or lakes) to apply for a NPDES permit.[25] However, these new regulations make it clear that Federal law prohibits any CAFO from discharging waste, even accidentally, without a permit and will face fines if this is violated. Additionally, CAFOs applying for this permit are now required to submit a nutrient management plan (NMP) with the permit application that is open for public review.[26] This new regulation makes nutrient management a Federal regulation (no longer leaving it up to the states to enforce) and requires a plan of action for the management of waste to ensure that no waste is discharged from the CAFO site. The Environmental Protection Agency has the right to prosecute those who discharge animal waste illegally under the Clean Water Act,[27] although these cases are brought infrequently.

Apart from regulation, there are some other innovations that may help control the potential problems associated with animal waste. Researchers have discovered that adding sodium carbonate—a mineral commonly found in laundry detergents—to manure can dramatically decrease the amount of the harmful bacterium E. Coli O157:H7 present.[F] There are also feed additives for cattle—including one derived from a type of seaweed which is already widely used in human foods and cosmetics—that can significantly reduce the amount of this dangerous strain of E. Coli in cattle manure.[F]

Another proven and simple way to reduce the presence of E. Coli in cattle manure is the method of sending them out to graze on pasture, and taking them off of industrial feed made of corn and other grains.

While feed additives are a creative way to address some problems, ultimately they do nothing to address the fact that too much waste is being

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produced in areas that are too concentrated. Eliminating E. Coli bacteria does nothing to address the problems of harmful gases or the detriment high concentrations of manure (and therefore nitrogen and phosphorous) have on the environment and human health. While methane digesters can partially reduce the discharge of harmful gasses, they can't eliminate the solid waste which still must be stored and discharged, nor do they protect against leaks or overflows that can contaminate water supplies.

Comparing Animal and Human Waste Production

In order to compare the impact of different types of animals, livestock statistics are often cited in terms of "animal units." One animal unit equals 1,000 lbs. of the live weight of an animal, (for example, four 1,250-pound cows equal 5 "animal units" of cattle, while 125 eight-pound chickens make up 1 "animal unit" of chicken).

By this measure, one animal unit of broiler (meat) chickens produces an average of 14.97 tons of manure each year, fattened cattle 10.59 tons per year and dairy cows 15.24 tons per year.[F] In comparison, one "animal unit" of humans produces a mere 5.48 tons of waste per year.[F]

Did You Know?

- Dairy cows in confined feeding operations throughout the US produce more than two billion pounds of manure nitrogen per year.[F]
- The most recent available Census of Agriculture data shows that there were almost 95.5 million cows and calves in the United States in 2002.[F] There were also about 60.4 million hogs and pigs, each producing waste every day.[F]

What You Can Do

It's clear that the best way to deal with industrial agriculture's mountains of manure is to de-concentrate the animals and likewise de-concentrate their waste. Sustainable, pasture-based systems allow for the animals to distribute their waste in amounts that the soil can absorb, without using large quantities of water for washing or fuel to power trucks for transportation and spraying. By shopping at small, local sustainable farms and supporting pasture-based methods of waste management, we can all encourage change and promote healthier and more environmentally-friendly farming.

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Relative exposure to swine animal feeding operations and childhood asthma prevalence in an agricultural cohort.

Authors
Pavilonis-BT; Sanderson-WT; Merchan-JA

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Abstract
Large swine animal feeding operations (AFOs) have become the model of livestock production throughout the United States. Epidemiological studies have consistently shown an increase in adverse respiratory symptoms among workers at AFOs. However, the impact on communities surrounding these facilities is still being investigated. We evaluated the association between relative environmental exposure to AFOs and the prevalence of prescribed medication for wheeze and/or childhood asthma in rural Iowa. Demographic and health information on 565 children aged 0-17 was obtained from a previous population-based cohort study while data on the AFOs were collected from publically available tax records. We created a metric of each child's relative environmental exposure to swine CAFOs which incorporated the size of the AFO as well as distance and wind direction. We determined the association between self-reported prescription medication for wheeze and/or self-reported physician diagnosed asthma and relative exposure while controlling for recognized risk factors using correlated logistic regression. The prevalence of childhood asthma in the cohort was 11.0% while 22.7% of children had been previously prescribed medication for wheeze or had a lifetime asthma diagnosis. Children with a larger relative environmental exposure to AFOs had a significantly increased odds of both outcomes (OR=1.51, p=0.014 asthma; OR=1.38, p=0.023 asthma or medication for wheeze). When stratified into exposure quartiles a linear trend was observed with asthma or medication for wheeze as the dependent variable but not with asthma alone. This study is the first to investigate children's cumulative relative exposure to smaller AFOs and adds to the growing volume of literature supporting a link between proximity to swine AFOs and adverse respiratory health.

Keywords
Animals; Livestock; Livestock-industry; Epidemiology; Respiration; Respiratory-system-disorders; Pulmonary-system; Pulmonary-system-disorders; Pulmonary-function; Pulmonary-disorders; Workers; Work-environment; Environmental-exposure; Exposure-levels; Risk-factors; Demographic-characteristics; Humans; Children; Statistical-analysis; Agriculture; Adolescents; Author Keywords: CAFOs; Childhood asthma; Rural air quality

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Research Relevant to Health Effects of Swine Operations

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The association between proximity to animal-feeding operations and community health: a protocol for updating a systematic review.

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Abstract

BACKGROUND:

Livestock and poultry operations that feed large numbers of animals are common. Facility capacity varies, but it is not uncommon for facilities to house 1,000 swine with multiple barns at a single site, feedlots to house 50,000 cattle, and poultry houses to house 250,000 hens. There is primary research that suggests livestock facilities that confine animals indoors for feeding can represent a health hazard for surrounding communities. In this protocol, we describe a review about the association between proximity to animal-feeding operations (AFOs) and the health of individuals in nearby communities. A systematic review of the topic was published by some members of our group in 2010. The purpose of this review is to update that review.

METHODS/DESIGN:

The populations of interest are people living in communities near livestock production facilities. Outcomes of interest are any health outcome measured in humans such as respiratory disease, gastrointestinal disease, and mental health. Measures of antibiotic resistance in people from the communities compared to measures of resistance found in animals and the environment on animal-feeding operations will also be summarized. The exposure of interest will be exposure to livestock production using a variety of metrics such as distance from facilities, endotoxin levels, and measures of odor. Electronic searches will be conducted using MEDLINE and MEDLINE In-Process (via OvidSP), CAB Abstracts (via Web of Knowledge), and Science Citation Index (via Web of Knowledge). No language or date restriction will be applied. We will access the risk of bias using a pilot version of a tool developed by the Methods Groups of the Cochrane Collaboration for non-randomized interventions.We propose to conduct a meta-analysis for each health metric (e.g., combining all respiratory disease outcomes, combining all gastrointestinal outcomes). A planned subgroup analysis will be based on the domains of the risk of bias.

DISCUSSION:

This systematic review will provide synthesis of current evidence reporting the association between living near an animal-feeding operation and human health.

SYSTEMATIC REVIEW REGISTRATION: PROSPERO CRD42014010521. PMID: 25200608 Free PMC Article

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Environ Sci Technol. 2014 Sep 16;48(18):10804-12. doi: 10.1021/es502725f. Epub 2014 Sep 2.

Nitrate variability in groundwater of North Carolina using monitoring and private well data models.

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Abstract

Nitrate (NO3-) is a widespread contaminant of groundwater and surface water across the United States that has deleterious effects to human and ecological health. This study develops a model for predicting point-level groundwater NO3- at a state scale for monitoring wells and private wells of North Carolina. A land use regression (LUR) model selection procedure is developed for determining nonlinear model explanatory variables when they are known to be correlated. Bayesian Maximum Entropy (BME) is used to integrate the LUR model to create a LUR-BME model of spatial/temporal varying groundwater NO3- concentrations. LUR-BME results in a leave-one-out cross-validation r2 of 0.74 and 0.33 for monitoring and private wells, effectively predicting within spatial covariance ranges. Results show significant differences in the spatial distribution of groundwater NO3- contamination in monitoring versus private wells; high NO3- concentrations in the southeastern plains of North Carolina; and wastewater treatment residuals and swine confined animal feeding operations as local sources of NO3- in monitoring wells. Results are of interest to agencies that regulate drinking water sources or monitor health outcomes from ingestion of drinking water. Lastly, LUR-BME model estimates can be integrated into surface water models for more accurate management of nonpoint sources of nitrogen.

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Int Immunopharmacol. 2014 Nov;23(1):356-63. doi: 10.1016/j.intimp.2014.07.014. Epub 2014 Jul 31.

Influence of farming exposure on the development of asthma and asthma-like symptoms.

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Abstract

Based upon age and type of farming exposures, a wide range of studies demonstrate either protective or deleterious effects of the farming environment on asthma. In this review, we highlight key studies supporting the concept that farming exposure protects children from asthma and atopy based on studies performed largely in European pediatric cohorts. Various types of farming in certain regions appear to have a greater effect on asthma protection, as does the consumption of unpasteurized milk. In the United State, where concentrated animal feeding operations (CAFOs) are more common, asthma is increased in children exposed especially to swine CAFOs; whereas, rates of atopy and allergy are lower in these children. We also review studies evaluating the role of farming exposures both as a child and/or as an adult on asthma seen in adults. The importance of microbes in farming environments and the contribution of various components of the innate immune system including toll-like receptors to the underlying mechanisms of asthma related to farming exposures are also reviewed.

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Microbial ecology, bacterial pathogens, and antibiotic resistant genes in swine manure wastewater as influenced by three swine management systems.

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Abstract

The environmental influence of farm management in concentrated animal feeding operations (CAFO) can yield vast changes to the microbial biota and ecological structure of both the pig and waste manure lagoon wastewater. While some of these changes may not be negative, it is possible that CAFOs can enrich antibiotic resistant bacteria or pathogens based on farm type, thereby influencing the impact imparted by the land application of its respective wastewater. The purpose of this study was to measure the microbial constituents of swine-sow, -nursery, and -finisher farm manure lagoon wastewater and determine the changes induced by farm management. A total of 37 farms were visited in the Mid-South USA and analyzed for the genes 16S rRNA, spaQ (Salmonella spp.), Camp-16S (Campylobacter spp.), tetA, tetB, ermF, ermA, mecA, and intI using quantitative PCR. Additionally, 16S rRNA sequence libraries were created. Overall, it appeared that finisher farms were significantly different from nursery and sow farms in nearly all genes measured and in 16S rRNA clone libraries. Nearly all antibiotic resistance genes were detected in all farms. Interestingly, the mecA resistance gene (e.g. methicillin resistant

Staphylococcus aureus) was below detection limits on most farms, and decreased as the pigs aged. Finisher farms generally had fewer antibiotic resistance genes, which corroborated previous phenotypic data; additionally, finisher farms produced a less diverse 16S rRNA sequence library. Comparisons of Camp-16S and spaQ GU (genomic unit) values to previous culture data demonstrated ratios from 10 to 10,000:1 depending on farm type, indicating viable but not cultivatable bacteria were dominant. The current study indicated that swine farm management schemes positively and negatively affect microbial and antibiotic resistant populations in CAFO wastewater which has future "downstream" implications from both an environmental and public health perspective.

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KEYWORDS:

Antibiotic resistance; Campylobacter; Confined animal feeding operation (CAFO); Lagoon wastewater; Salmonella; Swine

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Clinically relevant multidrug resistant Salmonella enterica in swine and meat handlers at the abattoir.

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Abstract

The presence of multidrug resistant (MDR) Salmonella serotypes in slaughtered swine, carcasses, meat and meat handlers is scarcely evaluated. Recently we demonstrated that diverse Salmonella serotypes are frequently present in swine, pork meat and carcasses, and meat handlers at Portuguese abattoirs. Here we have characterized their antibiotic resistance phenotypes and genotypes, helping elucidate the flow of MDR Salmonella in the food chain. Testing 60 Salmonella isolates from different serotypes, the highest frequencies of resistance were observed for tetracycline (T) [70% (n=42/60), tet(A)/tet(B)/tet(G)], streptomycin (S) [63% (n=38/60), aadA2/strA/strB], sulfamethoxazole (Sul) [62% (n=37/60), sul1/sul2/sul3] and ampicillin (A) [57% (n=34/60), blaPSE-1/blaTEM]. Thirty-seven percent (n=22/60) carried class 1 integrons and multidrug resistance was frequently observed (63% n=38/60), including those serotypes common to human infections [S. Typhimurium 78% n=25/32; S. 4,[5],12:i:- 67% n=2/3; S. Rissen 75% (n=3/4); S. London 67% n=2/3; S. Derby 55%; n=6/11)]. The emergent S. 4,[5],12:i:- isolates were mostly characterized by ASSuT phenotype [blaTEM/strA-strB/sul2/tet(B)], typical of the European clone, while for the first time the ST phenotype [strA-strB-tet(A)-tet(B)] was also observed. Moreover, we report a first finding of a MDR phenotype in S. London [ANSSuT; blaTEM-strA-strB-sul2-tet(A)]. Our findings suggest that the abattoir environment and the slaughter operations seem not only to harbor MDR serotypes that originated in the pig reservoir, but also propagate them through cross-contamination processes, involving meat handlers. The present study suggests a probable relationship between swine and human salmonellosis throughout the food chain, which is of interest for epidemiological, animal health and public health purposes.

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KEYWORDS:

Antibiotic resistance; Meat; S. Typhimurium monophasic variant; Salmonella; Swine

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High-density livestock operations, crop field application of manure, and risk of community-associated methicillin-resistant Staphylococcus aureus infection in Pennsylvania.

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Abstract

IMPORTANCE:

Nearly 80% of antibiotics in the United States are sold for use in livestock feeds. The manure produced by these animals contains antibiotic-resistant bacteria, resistance genes, and antibiotics and is subsequently applied to crop fields, where it may put community members at risk for antibiotic-resistant infections.

OBJECTIVE:

To assess the association between individual exposure to swine and dairy/veal industrial agriculture and risk of methicillin-resistant Staphylococcus aureus (MRSA) infection.

DESIGN, SETTING, AND PARTICIPANTS:

A population-based, nested case-control study of primary care patients from a single health care system in Pennsylvania from 2005 to 2010. Incident MRSA cases were identified using electronic health records, classified as community-associated MRSA or health care-associated MRSA, and frequency matched to randomly selected controls and patients with skin and soft-tissue infection. Nutrient management plans were used to create 2 exposure variables: seasonal crop field manure application and number of livestock animals at the operation. In a substudy, we collected 200 isolates from patients stratified by location of diagnosis and proximity to livestock operations.

MAIN OUTCOMES AND MEASURES:

Community-associated MRSA, health care-associated MRSA, and skin and soft-tissue infection status (with no history of MRSA) compared with controls.

RESULTS:

From a total population of 446,480 patients, 1539 community-associated MRSA, 1335 health care-associated MRSA, 2895 skin and soft-tissue infection cases, and 2914 controls were included. After adjustment for MRSA risk factors, the highest quartile of swine crop field exposure was significantly associated with community-associated MRSA, health care-associated MRSA, and skin and soft-tissue infection case status (adjusted odds ratios, 1.38 [95% CI, 1.13-1.69], 1.30 [95% CI, 1.05-1.61], and 1.37 [95% CI, 1.18-1.60], respectively); and there was a trend of increasing odds across quartiles for each outcome ($P \leq .01$ for trend in all comparisons). There were similar but weaker associations of swine operations with community-associated MRSA and skin and soft-tissue infection. Molecular testing of 200 isolates identified 31 unique spa types, none of which corresponded to CC398 (clonal complex 398), but some have been previously found in swine.

CONCLUSIONS AND RELEVANCE:

Proximity to swine manure application to crop fields and livestock operations each was associated with MRSA and skin and soft-tissue infection. These findings contribute to the growing concern about the potential public health impacts of high-density livestock production.

Comment in

- Identifying livestock-associated methicillin-resistant staphylococcus aureus in the United States--reply. [JAMA Intern Med. 2014]
- Identifying livestock-associated methicillin-resistant Staphylococcus aureus in the United States. [JAMA Intern Med. 2014]
- Methicillin-resistant Staphylococcus aureus: where is it coming from and where is it going? [JAMA Intern Med. 2013]

PMID:24043228 [PubMed - indexed for MEDLINE] PMCID:PMC4372690 Free PMC Article

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- Abstract

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J Toxicol Environ Health B Crit Rev. 2012;15(8):524-41. doi: 10.1080/10937404.2012.744288.

Respiratory health effects of large animal farming environments.

May S[1], Romberger DJ, Poole JA.

Author information

- [1]Pulmonary, Critical Care, Sleep & Allergy Division, [2]Department of Internal Medicine, University of Nebraska Medical Center, Omaha, NE 68198, USA.

Abstract

With increases in large animal-feeding operations to meet consumer demand, adverse upper and lower respiratory health effects in exposed agriculture workers are a concern. The aim of this study was to review large animal confinement feeding operational exposures associated with respiratory disease with a focus on recent advances in the knowledge of causative factors and cellular and immunological mechanisms. A PubMed search was conducted with the keywords airway, farm, swine, dairy, horse, cattle inflammation, organic dust, endotoxin, and peptidoglycan, among items were published between 1980 and now. Articles were selected based on their relevance to environmental exposure and reference to airway diseases. Airway diseases included rhinitis, sinusitis, mucus membrane inflammation syndrome, asthma, chronic bronchitis, chronic obstructive pulmonary disease, hypersensitivity pneumonitis, and organic dust toxic syndrome. There is lower prevalence of immunoglobulin (Ig) E-mediated asthma and atopy in farmers and their children, but organic dust worsens existing asthma. Multiple etiologic factors are linked to disease, including allergens, organic dusts, endotoxins, peptidoglycans, and gases. Large animal confinement feeding operations contain a wide diversity of microbes with increasing focus on gram-positive bacteria and archaebacteria as opposed to gram-negative bacteria in mediating disease. Toll-like receptors (TLR) and nucleotide oligomerization domain (NOD)-like innate immune pathways respond to these exposures. Finally, a chronic inflammatory adaptation, tolerance-like response in chronically exposed workers occurs. Large animal confinement farming exposures produce a wide spectrum of upper and lower respiratory tract diseases due to the complex diversity of organic dust, particulates, microbial cell wall components, and gases and resultant activation of various innate immune receptor signaling pathways.

COPD

PMID: 23199220 [PubMed - indexed for MEDLINE] PMCID:PMC4001716 Free PMC Article

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Environ Health Perspect. 2013 Jan;121(1):92-6. doi: 10.1289/ehp.1205109. Epub 2012 Oct 28.

Air pollution from industrial swine operations and blood pressure of neighboring residents.

Wing S[1], Horton RA, Rose KM.

Author information

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Abstract

BACKGROUND:

Industrial swine operations emit odorant chemicals including ammonia, hydrogen sulfide (H2S), and volatile organic compounds. Malodor and pollutant concentrations have been associated with self-reported stress and altered mood in prior studies.

OBJECTIVES:

We conducted a repeated-measures study of air pollution, stress, and blood pressure in neighbors of swine operations.

METHODS:

For approximately 2 weeks, 101 nonsmoking adult volunteers living near industrial swine operations in 16 neighborhoods in eastern North Carolina sat outdoors for 10 min twice daily at preselected times. Afterward, they reported levels of hog odor on a 9-point scale and measured their blood pressure twice using an automated oscillometric device. During the same 2- to 3-week period, we measured ambient levels of H2S and PM10 at a central location in each neighborhood. Associations between systolic and diastolic blood pressure (SBP and DBP, respectively) and pollutant measures were estimated using fixed-effects (conditional) linear regression with adjustment for time of day.

RESULTS:

PM10 showed little association with blood pressure. DBP [β (SE)] increased 0.23 (0.08) mmHg per unit of reported hog odor during the 10 min outdoors and 0.12 (0.08) mmHg per 1-ppb increase of H2S concentration in the same hour. SBP increased 0.10 (0.12) mmHg per odor unit and 0.29 (0.12) mmHg per 1-ppb increase of H2S in the same hour. Reported stress was strongly associated with BP; adjustment for stress reduced the odor-DBP association, but the H2S-SBP association changed little.

CONCLUSIONS:

Like noise and other repetitive environmental stressors, malodors may be associated with acute blood pressure increases that could contribute to development of chronic hypertension.

PMID:23111006[PubMed - indexed for MEDLINE] PMCID:PMC3553433 Free PMC Article

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J Environ Public Health. 2012;2012:565690. doi: 10.1155/2012/565690. Epub 2012 Feb 9.

Human impairment from living near confined animal (hog) feeding operations.

Kilburn KH[1].

Author information

- [1]Keck School of Medicine, University of Southern California, Los Angeles, CA 90033, USA. khkilburn@sbcglobal.net

Abstract

PROBLEM:

To determine whether neighbors around manure lagoons and massive hog confinement buildings who complained of offensive odors and symptoms had impaired brain and lung functions.

METHOD:

We compared near hog manure neighbors of lagoons to people living beyond 3 kilometers in Ohio and to unexposed people controls in a nearby state for neurophysiological, cognitive, recall and memory functions, and pulmonary performance.

RESULTS:

The 25 exposed subjects averaged 4.3 neurobehavioral abnormalities, significantly different from 2.5 for local controls and 2.3 for Tennessee controls. Exposed subjects mean forced vital capacity and expiratory volume in 1 sec were reduced significantly compared to local and regional controls.

CONCLUSIONS:

Near neighbors of hog enclosures and manure lagoon gases had impaired neurobehavioral functions and pulmonary functions and these effects extended to nearby people thought to be controls. Hydrogen sulfide must be abated because people living near lagoons cannot avoid rotten egg gas.

PMID:22496706[PubMed - indexed for MEDLINE] PMCID:PMC3306954 Free PMC Article

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J Food Prot. 2012 Mar;75(3):428-36. doi: 10.4315/0362-028X.JFP-11-363.

Salmonella prevalence and antimicrobial susceptibility from the National Animal Health Monitoring System Swine 2000 and 2006 studies.

Haley CA[1], Dargatz DA, Bush EJ, Erdman MM, Fedorka-Cray PJ.

Author information

contaminants can spread and cause a public nuisance--up to a 1-km radius around the farm. To mitigate these effects, the Quebec Government adopted regulations that set minimum buffer distances to be observed by any expansion of an existing or new pig farm. The objectives of this study were (i) to assess the efficiency of the current buffer distance prescriptions in Quebec in mitigating effects of air pollution from swine units and (ii) to identify potential areas for establishing pig farm operations that will not be offensive to people. The air dispersion American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) with receptors distributed at 1.6 km around each source was used first, followed by a spatial geographic information system (GIS) model. Results from the dispersion model showed that the highest hourly concentration with a 99.5% compliance frequency for a single farm was 3078.1 microg/m3 and exceeded the NH3 odor criterion hourly standard set by the Quebec Government at 183.4 microg/m3. Thus, for public safety, densely populated areas like housing developments must be located >1300 m from a pig farm. This distance is in the range of setback distances (723 to 1447 m) obtained by using abacuses defined in the L'Erable Regional County Municipality. That is why we can say the current rules established by the Quebec Government, if rigorously applied, can prevent odor nuisance, due to NH3 emission, from swine farms. In the spatial model, buffer zones were established around houses, roads, waterways, and drinking water intakes. By combining layers of information in the ArcGIS Model Builder, potential areas in which pig farms can be installed, without public odor nuisance, were identified.

PMID:21284294[PubMed - indexed for MEDLINE]

Epidemiology. 2011 Mar;22(2):208-15. doi: 10.1097/EDE.0b013e3182093c8b.

Air pollution, lung function, and physical symptoms in communities near concentrated Swine feeding operations.

Schinasi L[1], Horton RA, Guidry VT, Wing S, Marshall SW, Morland KB.

Author information

- [1]Department of Epidemiology, University of North Carolina at Chapel Hill, Chapel Hill, NC 27599–7435,USA. steve_wing@unc.edu

Abstract

BACKGROUND:

Concentrated animal feeding operations emit air pollutants that may affect health. We examined associations of reported hog odor and of monitored air pollutants with physical symptoms and lung function in people living within 1.5 miles of hog operations.

METHODS:

Between September 2003 and September 2005, we measured hydrogen sulfide (H2S), endotoxin, and particulate matter (PM10, PM2.5, and PM2.5-10) for approximately 2-week periods in each of 16 eastern North Carolina communities. During the same time periods, 101 adults sat outside their homes twice a day for 10 minutes, reported hog odor and physical symptoms, and measured their lung function. Conditional fixed-effects logistic and linear regression models were used to derive estimates of associations.

RESULTS:

The log odds (±1 standard error) of acute eye irritation following 10 minutes outdoors increased by 0.53 (±0.06) for every unit increase in odor, by 0.15 (±0.06) per 1 ppb of H2S, and by 0.36 (±0.11) per 10 µg/m of PM10. Odor and H2S were also associated with irritation and respiratory symptoms in the previous 12 hours. The log odds of difficulty breathing increased by 0.50 (±0.15) per unit of odor. A 10 µg/m increase in mean 12-hour PM2.5 was associated with increased log odds of wheezing (0.84 ± 0.29) and declines in forced expiratory volume in 1 second (-0.04 ± 0.02 L). A 10 EU/mg increase in endotoxin was associated with increased log odds of sore throat (0.10 ± 0.05), chest tightness (0.09 ± 0.04), and nausea (0.10 ± 0.05).

CONCLUSIONS:

Pollutants measured near hog operations are related to acute physical symptoms in a longitudinal study using analyses that preclude confounding by time-invariant characteristics of individuals.

Comment in

- Advancing industrial livestock production: health effects research and sustainability. [Epidemiology. 2011]

PMID:21228696[PubMed - indexed for MEDLINE]

Environ Sci Technol. 2010 May 1;44(9):3442-8. doi: 10.1021/es9026024.

Endotoxin levels at Swine farms using different waste treatment and management technologies.

Ko G[1], Simmons Iii OD, Likirdopulos CA, Worley-Davis L, Williams CM, Sobsey MD.

Author information

- [1]Department of Environmental Health and Institute of Health and Environment, Department of Biological Sciences and Institute of Microbiology, Seoul National University, Seoul, Korea. gko@snu.ac.jr

Abstract

Concentrated animal feeding operations (CAFOs) are a major source of airborne endotoxins, which are air pollutants that can cause adverse health effects to both on-site farmers and neighbors. Release of airborne endotoxins to the environment can be reduced using proper waste treatment and management technologies. In this study, the levels of endotoxins released from two swine CAFOs using conventional lagoon-sprayfield technology were compared to those of 15 farms using various alternative waste management technologies in North Carolina. Over a 2-year period, 236 endotoxin samples were collected from the 17 farm units and analyzed using the Limulus amebocyte lysate (LAL) test. Concentrations of airborne endotoxins near barn exhaust fans were significantly higher than at the upwind boundary of the farm and at other farm sites. For most of the study sites, mean concentrations of endotoxins at the downwind boundary of the farm were higher than those at the upwind boundary of the farm, indicating the release of endotoxins from swine CAFOs to the neighboring environment. Endotoxin levels were significantly associated with concentrations of airborne bacteria but not fungi. Environmental factors, such

as temperature, relative humidity, and wind velocity, affected the levels of airborne endotoxins at the farms. Based on the ratios of airborne endotoxins in downwind and upwind samples from the farm units, at least five different alternative waste management technologies significantly reduced the release of endotoxins from swine CAFOs. These results suggest that swine CAFOs are important sources of airborne endotoxins, the levels of which can be reduced by applying more robust and effective waste management technologies.

PMID:20356077[PubMed - indexed for MEDLINE]

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Am J Public Health. 2009 Nov;99 Suppl 3:S610-5. doi: 10.2105/AJPH.2008.148924.

Malodor as a trigger of stress and negative mood in neighbors of industrial hog operations.

Horton RA[1], Wing S, Marshall SW, Brownley KA.

Author information

- [1]Department of Epidemiology, University of North Carolina at Chapel Hill, CB# 7435, Chapel Hill, NC 27599-7435, USA. ravery@email.unc.edu

Abstract

OBJECTIVES:

We evaluated malodor and air pollutants near industrial hog operations as environmental stressors and negative mood triggers.

METHODS:

We collected data from 101 nonsmoking adults in 16 neighborhoods within 1.5 miles of at least 1 industrial hog operation in eastern North Carolina. Participants rated malodor intensity, stress, and mood for 2 weeks while air pollutants were monitored.

RESULTS:

Reported malodor was associated with stress and 4 mood states; odds ratios (ORs) for a 1-unit change on the 0-to-8 odor scale ranged from 1.31 (95% confidence interval [CI] = 1.16, 1.50) to 1.81 (95% CI = 1.63, 2.00). ORs for stress and feeling nervous or anxious were 1.18 (95% CI = 1.08, 1.30) and 1.12

(95% CI = 1.03, 1.22), respectively, for a 1 ppb change in hydrogen sulfide and 1.06 (95% CI = 1.00, 1.11) and 1.10 (95% CI = 1.03, 1.17), respectively, for a 1 microg/m(3) change in semivolatile particulate matter less than 10 microm in aerodynamic diameter (PM(10)).

CONCLUSIONS:

Hog odor, hydrogen sulfide, and semivolatile PM(10) are related to stress and negative mood in disproportionately low-income communities near industrial hog operations in eastern North Carolina. Malodor should be considered in studies of health impacts of environmental injustice.

PMID:19890165[PubMed - indexed for MEDLINE] PMCID:PMC2774199 Free PMC Article

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Risk Anal. 2009 Dec;29(12):1664-71. doi: 10.1111/j.1539-6924.2009.01303.x. Epub 2009 Oct 29.

Why reduced-form regression models of health effects versus exposures should not replace QRA: livestock production and infant mortality as an example.

Cox LA Jr[1].

Author information

- [1]University of Colorado, Denver, CO 80218, USA. tcoxdenver@aol.com

Abstract

Do pollution emissions from livestock operations increase infant mortality rate (IMR)? A recent regression analysis of changes in IMR against changes in aggregate "animal units" (a weighted sum of cattle, pig, and poultry numbers) over time, for counties throughout the United States, suggested the provocative conclusion that they do: "[A] doubling of production leads to a 7.4% increase in infant mortality." Yet, we find that regressing IMR changes against changes in specific components of "animal units" (cattle, pigs, and broilers) at the state level reveals statistically significant negative associations between changes in livestock production (especially, cattle production) and changes in IMR. We conclude that statistical associations between livestock variables and IMR variables are very sensitive to modeling choices (e.g., selection of explanatory variables, and use of specific animal types vs. aggregate "animal units). Such associations, whether positive or negative, do not warrant causal interpretation. We suggest that standard methods of quantitative risk assessment (QRA), including emissions release (source) models, fate and transport modeling, exposure assessment, and dose-response modeling, really are important-and indeed, perhaps, essential-for drawing valid causal inferences about health effects of exposures to guide sound, well-informed public health risk management policy. Reduced-form regression models, which skip most or all of these steps, can only quantify statistical associations (which may be due to model specification, variable selection, residual confounding, or other noncausal factors). Sound risk management requires the extra work needed to identify and model valid causal relations.

Comment in

- Comment on "Why reduced-form regression models of health effects versus exposures should not replace QRA: livestock production and infant mortality as an example," by Louis Anthony (Tony) Cox, Jr., Risk Analysis 2009, Vol. 29, No. 12. [Risk Anal. 2010]

binary regression models, adjusting for potential confounders, including age, race, socioeconomic status, smoking, school exposures, and household exposures.

RESULTS:

The prevalence of wheezing during the past year was slightly higher at schools that were estimated to be exposed to airborne effluent from confined swine feeding operations. For students who reported allergies, the prevalence of wheezing within the past year was 5% higher at schools that were located within 3 miles of an operation relative to those beyond 3 miles and 24% higher at schools in which livestock odor was noticeable indoors twice per month or more relative to those with no odor.

CONCLUSIONS:

Estimated exposure to airborne pollution from confined swine feeding operations is associated with adolescents' wheezing symptoms.

PMID:16818539[PubMed - indexed for MEDLINE] PMCID:PMC4517575 Free PMC Article

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J Agromedicine. 2005;10(4):55-64.

Health effects from breathing air near CAFOs for feeder cattle or hogs.

Von Essen SG[1], Auvermann BW.

Author information

- [1]Department of Internal Medicine, Pulmonary and Critical Care Medicine Section, Box 985300, Omaha, NE 68198-5300, USA. svonesse@unmc.edu

Abstract

There is concern that livestock operations for fattening cattle and raising hogs known as concentrated animal feeding operations (CAFOs) release substances into the air that have negative effects on the health of persons living nearby. These substances include dust containing endotoxin and other microbial products as well as ammonia, hydrogen sulfide and a variety of volatile organic compounds. Odors from these farms are considered offensive by some neighbors. A variety of medical complaints are reported to be more common in those people who live near CAFOs for raising hogs than in people without this exposure. Respiratory health effects, including symptoms of pulmonary disease and lung function test result abnormalities, have been described in workers employed in CAFOs where hogs are raised. Health effects after inhalation exposure of neighbors to substances released into the ambient air from these farms is less well characterized. It must be noted that CAFO workers may differ from neighbors in terms of their exposures and general health status. The presence of dust and other substances from cattle feedlots also causes some neighbors to voice concerns about the impact on their health but this exposure has been studied less extensively than exposure to substances released from CAFOs where hogs are raised. Further research needs to be done to look for measurable health effects attributable to living near all CAFOs in order to better understand the impact of these farms.

PMID:16702123[PubMed - indexed for MEDLINE]

J Agromedicine. 2006;11(3-4):15-24. doi: 10.1300/J096v11n03_03.

Assessment of air quality at neighbor residences in the vicinity of swine production facilities.

Donham KJ[1], Lee JA, Thu K, Reynolds SJ.

Author information

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Abstract

Air sampling was completed on the front lawn of 35 homes neighboring swine farms in three different regions in the Upper Midwest of the United States. One region was dominated by large scale, swine confined animal feeding operations (CAFO's) noted as swine confinement area (SCA). The second area was dominated by smaller scale operations utilizing hoop structure facilities (HA). The third area was basically devoid of livestock, dominated by row-crop production, and served as the control area (CA). The time weighted average concentrations of hydrogen sulfide (8.42 ppb) was higher (p = 0.047) in SCA area than the control (3.48 ppb). However, carbon dioxide (449.6 ppm), ammonia (12.78 ppb) and PM10 (42.25 microg/m3) were higher in the hoop structure area than the other areas. Swine population density, distance between the homes and swine facilities, and wind direction had an interactive effect on the average levels of ammonia (p = 0.04). The contaminant levels at the homes were relatively low compared to typical concentrations inside animal buildings. However, exceedences of federal recommended limits for hydrogen sulfide in outdoor air were observed in the swine CAFO area. Concentration of hydrogen sulfide exceeded the recommended limits of the ATSDR (30 ppb) for chronic exposure at two of the 12 homes in the CAFO area (17%). Average hydrogen sulfide concentration exceeded the EPA recommended community standards (0.7 ppb) in all three areas assessed (SCA, HA, and CA). As chronic exposure to hydrogen sulfide may be present in areas of production agriculture, a potential health risk may be present. Further studies to provide additional information regarding exposures to hydrogen sulfide in rural environments are warranted.

PMID:19274894[PubMed - indexed for MEDLINE]

Arch Environ Health. 2004 Feb;59(2):101-8.

Odor from industrial hog farming operations and mucosal immune function in neighbors.

Avery RC[1], Wing S, Marshall SW, Schiffman SS.

Author information

- [1]Department of Epidemiology, School of Public Health, University of North Carolina Chapel Hill, North Carolina 27599-7435, USA. ravery@email.unc.edu

Abstract

The authors evaluated whether exposure to malodor from industrial hog farming operations has a psychophysiologically mediated immunosuppressive effect on secretory immunoglobulin A (sIgA) in neighbors. Fifteen adults living within 2.4 km (1.5 mi) of at least one hog farming operation rated odor intensity on a 9-point scale and provided saliva samples twice daily for two weeks. The authors used hierarchical regression to model the association between reported odor and sIgA; study participants were their own controls. The natural log of sIgA concentration and secretion rate declined, on average, 0.058 (0.032) and 0.116 (0.103), respectively, for each incremental 1-unit increase in reported odor from 4 to 9, adjusted for time of day, suggesting reduced levels of sIgA in response to moderate or high odor. Findings support the hypothesized immunosuppressive effect of malodor on mucosal immunity and provide preliminary data useful in understanding health effects related to malodor from industrial hog farming operations.

PMID:16075904[PubMed - indexed for MEDLINE]

Environ Health Perspect. 2005 Feb;113(2):137-42.

Airborne multidrug-resistant bacteria isolated from a concentrated swine feeding operation.

Chapin A[1], Rule A, Gibson K, Buckley T, Schwab K.

Author information

- [1]Johns Hopkins Bloomberg School of Public Health, Department of Environmental Health Sciences, Baltimore, Maryland 21205-2103, USA.

Abstract

The use of nontherapeutic levels of antibiotics in swine production can select for antibiotic resistance in commensal and pathogenic bacteria in swine. As a result, retail pork products, as well as surface and groundwaters contaminated with swine waste, have been shown to be sources of human exposure to antibiotic-resistant bacteria. However, it is unclear whether the air within swine operations also serves as a source of exposure to antibiotic-resistant bacterial pathogens. To investigate this issue, we sampled the air within a concentrated swine feeding operation with an all-glass impinger. Samples were analyzed using a method for the isolation of Enterococcus. A total of 137 presumptive Enterococcus isolates were identified to species level using standard biochemical tests and analyzed for resistance to erythromycin, clindamycin, virginiamycin, tetracycline, and vancomycin using the agar dilution method. Thirty-four percent of the isolates were confirmed as Enterococcus, 32% were identified as coagulase-negative staphylococci, and 33% were identified as viridans group streptococci. Regardless of bacterial species, 98% of the isolates expressed high-level resistance to at least two antibiotics commonly used in swine production. None of the isolates were resistant to vancomycin, an antibiotic that has never been approved for use in livestock in the United States. In conclusion, high-level multidrug-resistant Enterococcus, coagulase-negative staphylococci, and viridans group streptococci were detected in the air of a concentrated swine feeding operation. These findings suggest that the inhalation of air from these facilities may serve as an exposure pathway for the transfer of multidrug-resistant bacterial pathogens from swine to humans.

PMID:15687049[PubMed - indexed for MEDLINE] PMCID:PMC1277855
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Residential Proximity to Large Numbers of Swine in Feeding Operations Is Associated with Increased Risk of Methicillin-Resistant *Staphylococcus aureus* Colonization at Time of Hospital Admission in Rural Iowa Veterans

Margaret Carrel PhD, Marin L. Schweizer PhD, Mary Vaughan Sarrazin PhD, Tara C. Smith PhD and Eli N. Perencevich MD MS

Infection Control and Hospital Epidemiology
Vol. 35, No. 2 (February 2014), pp. 190-192

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Page Count: 4

None

CONCISE COMMUNICATION

Residential Proximity to Large Numbers of Swine in Feeding Operations Is Associated with Increased Risk of Methicillin-Resistant *Staphylococcus aureus* Colonization at Time of Hospital Admission in Rural Iowa Veterans

Margaret Carrel, PhD;[1] Marin L. Schweizer, PhD;[2,3] Mary Vaughan Sarrazin, PhD;[2,3] Tara C. Smith, PhD;[4] Eli N. Perencevich, MD, MS[2,3]

Among 1,036 patients, residential proximity within 1 mile of large swine facilities was associated with nearly double the risk of methicillin-resistant *Staphylococcus aureus* (MRSA) colonization at admission (relative risk, 1.8786 [95% confidence interval, 1.0928–3.2289]; $P = .0239$) and, after controlling for multiple admissions and age, was associated with nearly triple the odds of MRSA colonization (odds ratio, 2.76 [95% confidence interval, 1.2728–5.9875]; $P = .0101$).

Infect Control Hosp Epidemiol 2014;35(2):190-192

Methicillin-resistant *Staphylococcus aureus* (MRSA) has been found to colonize both livestock and livestock workers and to transiently colonize visitors to livestock facilities.[1-3] MRSA-colonized livestock can act as reservoirs for the bacterium and transmit MRSA to humans.[4] Thus, there exists potential for the introduction of MRSA into hospitals from livestock via individuals who have close proximity to colonized animals. Livestock density in Dutch administrative areas was a risk factor for livestock-associated MRSA colonization in individuals not engaged in livestock production.[5] Furthermore, residential proximity to farms that used swine manure was found to be associated with MRSA infection in Pennsylvania.[6]

Colonization with MRSA at time of hospital admission is known to increase the risk of MRSA infection and is associated with the introduction of MRSA into healthcare settings.[7] In 2006, the Veterans Administration (VA) implemented a set of procedures, including mandatory admission nares screening, designed to halt the transfer of MRSA into and within hospitals.[8]

There are typically 19 million pigs being raised in Iowa, housed primarily in 7,000 concentrated animal feeding operations (CAFOs). Given these conditions, we examined whether residential proximity to swine CAFOs was associated with increased risk of MRSA-positive nares screening results at the time of admission to the Iowa City Veterans Affairs Health Care System (IC-VAHCS) in rural veterans.

METHODS

Between December 1, 2009, and December 31, 2011, 2,996 patients with an Iowa home address were admitted to the IC-VAHCS. For each patient, the nasal MRSA status at admission, age, and sex were recorded. VA methodology for nares screening and assessment of MRSA colonization status have been described elsewhere.[8]

Patient addresses were geocoded, and then household locations were categorized on the basis of the urban designations of the census. Any veterans whose address could not be geocoded or who lived in urban areas were excluded from further analysis. Data on swine CAFO populations within

TABLE 1. Frequency Table and Relative Risk (RR) Estimates for Methicillin-Resistant *Staphylococcus aureus* (MRSA) Colonization Status by Household Proximity to Swine

	No. (%) of patients, by MRSA nares screen result				
Swine AU within 1 mile	Positive	Negative	Total	Unadjusted RR (95% CI)	*P*[a]
Any vs none				1.4627 (0.909–2.238)	.1239
Any	21 (9.21)	207 (90.79)	228		
None	98 (6.46)	1,420 (93.54)	1,518		
High vs low				1.8786 (1.093–3.229)	.0239
High (>1,000)	13 (12.15)	94 (87.85)	107		
Low (<1,000)	106 (6.47)	1,533 (93.53)	1,639		

NOTE. Animal units (AUs) are a measure developed by the Iowa Department of Natural Resources to make comparisons between concentrated animal feeding operations raising different species. One fully grown cow equals 1 AU, a mature swine (>55 pounds) equals 0.4 AU, and immature swine are smaller fractions of an AU.

[a] By χ^2 test.

http://www.jstor.org/stable/10.1086/674860?seq=1#page_scan_tab_contents

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Intensive Livestock Operations threaten the health and well-being of rural communities.

The health risks accompanying ILOs include respiratory, physical, and emotional illnesses that affect both old and young. Extensive research has examined the extent to which ILOs contaminate air, water, and soil, and the consequences this can have for rural people. The results demonstrate that the very presence of ILOs in rural communities is making people sick.

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Human Health

From farm to fork industrial livestock production impacts our well being. Farm workers are exposed to noise, harmful emissions, particulate matter and other hazards. Rural neighbours are exposed to polluted air, water, and soil, suffer decreased quality of life, and often experience stress stemming from community conflict. Consumers are often exposed to meat contaminated with pathogens such as e coli and salmonella, and the public at large is facing serious public health issues including flu pandemics and antibiotic resistance linked to the industrialization and globalization of livestock production.

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Community Health

Intensive Livestock Operations threaten the health and well-being of rural communities.

The health risks accompanying ILOs include respiratory, physical, and emotional illnesses that affect both old and young. Extensive research has examined the extent to which ILOs contaminate air, water, and soil, and the consequences this can have for rural people. The results demonstrate that the very presence of ILOs in rural communities is making people sick.

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Antibiotic resistance

In order to prevent disease outbreaks caused by unsanitary, confined conditions, factory farms routinely use antibiotics as an ingredient in feed. The systemic overuse of antibiotics in agriculture is encouraging the development of antibiotic resistant bacteria or "superbugs" such as Methicillin-Resistant Staphylococcus Aureus (MRSA) that threaten the efficacy of antibiotics used to treat humans. The World Health Organization (WHO) calls for an end to the use of antibiotics in livestock that compromise human medical care. Nevertheless, the use of antibiotics in livestock production in Canada continues. The Canadian Food Inspection Agency's Summary of Feed Drug Clearances lists the drugs approved for use in Canadian livestock.

The Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS) 2004 retail meat surveillance report found that in the case of Salmonella, 63 percent of all isolates (strains of bacteria) in samples taken from chickens in Ontario and Québec were resistant to one or more antimicrobials. Ceftiofur resistance was detected in 45 percent and 40 percent of chicken isolates from Ontario and Québec, respectively. For Campylobacter isolates from chicken, 53 percent from Ontario and 81 percent from Québec were resistant to one or more antimicrobials. For Enterococcus isolates from chicken, 98 percent from Ontario and 94 percent from Québec were resistant to one or more antimicrobials.

Read our fact sheet, Antibiotic Resistance Factories for more information.

In 2007 Beyond Factory Farming asked the Federal Government what is done to monitor the health and environmental impacts of antibiotic use in livestock agriculture. Read our questions and the government departments' responses to the Petition- *Environmental contamination of ecosystems from antibiotic use in livestock production*, we submitted to the Sustainable Development Commissioner.

In April 2009 the Canadian Medical Association Journal published an article critical of the federal government's decision to continue allowing unlimited and undocumented importation of antibiotics for use in intensive livestock production.

Methicillin-Resistant Staphylococcus Aureus (MRSA)
A deadly strain of Methicillin-Resistant-Staphylococcus bacteria that is antibiotic-resistant. In one year it led to over 100,000 infections and 19,000 deaths in the U.S.

A recent study demonstrated that there is MRSA in intensive hog operations. The following is an excerpt from Our Decrepit Food Factories by food and agriculture journalist Michael Pollan:

This month, the Centers for Disease Control and Prevention published a study showing that a strain of "MRSA from an animal reservoir has recently entered the human population and is now responsible for more than 20 percent of all MRSA in the Netherlands." Is this strictly a European problem? Evidently not. According to a study in Veterinary Microbiology, MRSA was found on 45 percent of the 20 pig farms sampled in Ontario, and in 20 percent of the pig farmers. (People can harbor the bacteria without being infected by it.) Thanks to NAFTA, pigs move freely between Canada and the United States. So MRSA may be present on American pig farms; we just haven't looked yet.

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FACT SHEET:

Antibiotic Resistance Factories

Antibiotics are one of the most powerful tools in modern medicine. Prior to the discovery of antibiotics many people died from infections and diseases caused by bacteria, or lived with chronic conditions and disabilities that are now curable. The medical benefits of antibiotics have been so fully accepted that we tend to take them for granted. **However, if antibiotics are used irresponsibly, the pathogens they kill will evolve resistance, making the drugs useless.** The worst-case scenario is a return to the 19th century, where people frequently suffered and died as a result of infected wounds and diseases such as pneumonia.

Antibiotics used as Growth Promoters in Canada

Antibiotics (also known as antimicrobials) are used in agriculture as well as in medicine. Some are used to treat sick animals, but **the vast majority of livestock antibiotics are used in factory farms as a feed additive to promote growth and prevent disease**[1]. Animals living in the crowded stressful conditions of industrial livestock operations grow faster if given low doses of antibiotics, but in less crowded conditions antibiotics do not affect growth rate. This indicates that feeding antibiotics is to compensate for unhealthy living conditions of the barns. As much as 90% of the antibiotics used in livestock production in Canada are used as growth promoters[2].

Factory farm conditions are ideal for creating antibiotic resistant bacteria. When low levels of antibiotics are used routinely, susceptible germs die off quickly, leaving those resistant to the drug to reproduce and multiply. Different kinds of bacteria can trade genes, so resistance conferred in the factory farm environment can be passed on to other bacteria in soil and water that is in contact with manure. Antibiotic resistant organisms are also found on meat that has been contaminated with fecal material. People who eat contaminated meat get sick with food poisoning, and create an opportunity for antibiotic resistant pathogens to pass resistance on to other bacteria in the person's system.

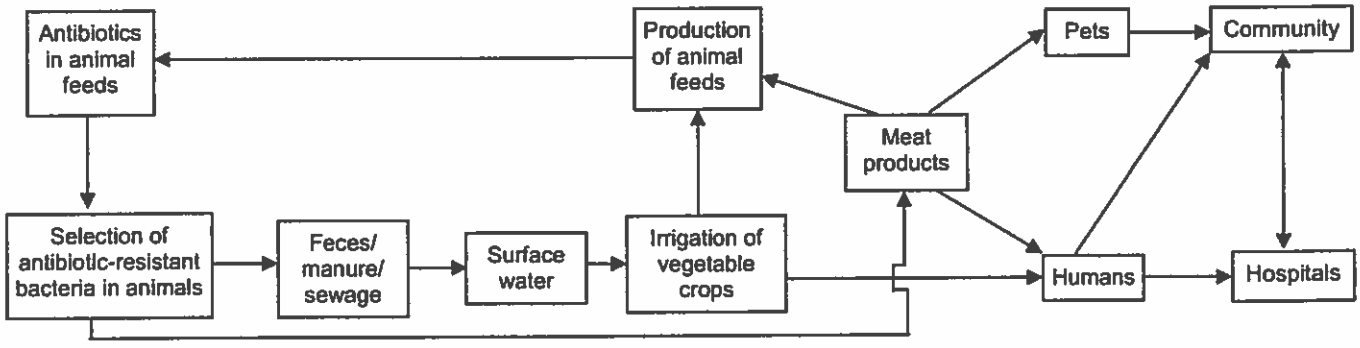
Antibiotic Resistance a Public Health Issue

When people become infected with antibiotic resistant pathogens it is much more difficult to treat their illness. In October 2006 antibiotic resistant *Clostridium difficile*, a sometimes fatal intestinal disease, was found in people who had not been in the hospital[3]. *C. difficile* was thought to be acquired only in hospitals, where antibiotic use is rife. But increasingly *C. difficile* disease in being found in people who haven't been hospitalized. So how did they contract the bug? Contaminated food is suspected. An Ontario Veterinary College study shows that the same strain of *C. difficile* that has caused severe hospital outbreaks has been found in the feces of dairy calves in Ontario.

Links between "human" and "animal" antibiotics

The rise of antibiotic resistance due to excessive use of antibiotics in livestock production is a serious public health problem recognized by the World Health Organization (WHO). In 1997 WHO recommended that antibiotics in livestock production be strictly regulated by governments, that the use of antibiotics as growth promotants be replaced with alternatives, and that **the use of any antimicrobial for growth promotion be terminated if it is also used in human medicine** or is known to select for cross-resistance to medical antimicrobial drugs.

The Canadian government's own advisory committee stated that "Even resistance in animal bacteria that are harmless to humans is important to public health because these bacteria are a pool of resistance genes available to be transferred from animal bacteria to human pathogens[4]."



The agricultural use of antibiotics in animal feed can result in the selection and transmission of antibiotic-resistant bacteria.These bacteria move through the environment by a variety of routes, and their presence ultimately has consequences for human health. - *Canadian Medical Association Journal*, Nov. 1998, p.1130

It is not enough to stop feeding livestock antibiotics used for human medicine. Feeding animals drugs not used in humans can increase resistance to drugs important in human medicine if the antibiotic resistance traits are genetically linked. The linkage of two or more resistance genes on DNA strands bacteria normally trade with each other is an increasing concern. Understanding this process makes it less justifiable to seperate antibiotics into "animal" and "human" use categories when considering antimicrobial resistance issues.[5]

Canadian response inadequate

Canada has not eliminated antibiotic use in livestock production. In 2002 the federal goverment finally started a surveillance program, the Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS)[6].

The CIPARS 2004 surveillance showed that

- Generic *E. coli* samples showed resistance to one or more antimicrobials in 80% of swine, 78% of chicken, and 31% of cattle isolates.
- For *Salmonella*, 63% of all chicken isolates were resistant to one or more antimicrobials.
- For *Campylobacter* isolates from chicken, 53% from Ontario and 81% from Québec were resistant to one or more antimicrobials.
- For *Enterococcus* isolates from chicken, 98% from Ontario and 94% from Québec were resistant to one or more antimicrobials.

Clearly the use of antibiotics in livestock is creating antibiotic resistance and contaminating Canadian factory farmed meat.

In January 2007 Canada'sVeterinary Drugs Directorate asked livestock producers and veterinarians to check how effective antibiotics are as growth promoters, and to stop using them if they are not providing an economic return[7]. This baby step in the right direction is far less than what is required. The European Union banned the use of subtherapeutic antibiotics as of January 1, 2006. In 1999 Denmark banned them, and significantly reduced levels of antibiotic resistance while demonstrating that antibiotics can be eliminated without losing production capacity[8].

Resisting antibiotic resistance

Canadian consumers can avoid meat contaminated by antibiotic resistant bacteria by seeking out certified organic meat. Organic certification does not permit the use of antibiotics. Organic farmers may use antibiotics to treat sick animals, but the animal cannot be sold as certified organic.

Consumer demand for certified organic meat, and meat purchased directly from local farmers where it is possible to verify antibiotic use is helpful. However **effective monitoring and surveillance and strict regulations combined with the capacity and will to enforce them are required to deal with the public health issue that affects all Canadians** whether or not they purchase or eat meat. The alternative is to lose antibiotics as a medical tool. BFF

- Fact Sheet author Cathy Holtslander works for the Beyond Factory Farming Coalition.

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[7] http://www.hc-sc.gc.ca/dhp-mps/vet/antimicrob/agp_hc_vdd_e.html

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Organizations working on antibiotic resistance and factory farming issues:

Keep Antibiotics Working
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MRSA prevalent in Canadian pig farms and pig farmers

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A new study published in Veterinary Microbiology found methicillin-resistant Staphylococcus aureus (MRSA) prevalent in Canadian pig farms and pig farmers, pointing to animal agriculture as a source of the deadly bacteria.

The Veterinary Microbiology study (Khanna et al. 2007) is the first to show that North American pig farms and farmers commonly carry MRSA. The study looked for MRSA in 285 pigs in 20 Ontario farms. It found MRSA at 45% of farms (9/20) and in nearly one in four pigs (71/285). One in five pig farmers studied (5/25) also were found to carry MRSA, a much higher rate than in the general North American population. The strains of MRSA bacteria found in Ontario pigs and pig farmers included a strain common to human MRSA infections in Canada.

An estimated nine million Canadian hogs will be imported into the United States this year.

A study published last month in the Journal of the American Medical Association (JAMA) (Klevens et al. 2007) estimated almost 100,000 MRSA infections in 2005, and nearly 19,000 deaths in the United States. In comparison, HIV/AIDS killed 17,000 people that year.

Until recently, conventional wisdom had MRSA pegged as an opportunistic infection occurring mainly in hospitals. The JAMA study found that even healthy people are developing MRSA infections. The Veterinary Microbiology study points to pig farms as a possible source of these resistant infections, as have earlier European studies.

Members of the Keep Antibiotics Working coalition (KAW), including medical, agriculture, and environmental experts, are calling for Congress to compel the U.S. Food and Drug Administration (FDA) to study whether the use of human antibiotics in animal agriculture is contributing to the reported surge in MRSA infections and deaths in the United States.

"Identifying and controlling community sources of MRSA is a public health priority of the first order," said Richard Wood, Executive Director of Food Animal Concerns Trust and Steering Committee Chair of Keep Antibiotics Working. "Are livestock farmers and farms in the United States also sources? We don't know for sure, because the U.S. government is not systematically testing U.S. livestock for MRSA."

"Last summer, when we raised the MRSA issue, the FDA told us that it had no plans to sample U.S. livestock to see if they carry MRSA," said David Wallinga, MD, Director of the Institute for Agriculture and Trade Policy's Food and Health Program. "Given the latest science that hog farms may generate MRSA, we need Congress to give FDA and other relevant agencies the necessary funding and a sense of urgency. Sampling needs to be done as soon as possible."

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U.S. veterinarians are documented as carriers of MRSA. A 2005 survey of attendees at an international veterinary convention in Baltimore, MD, who were tested for MRSA found that of the 27 who tested positive, 23 were from the United States.

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In Europe, MRSA has been shown to be transmitted from pigs to farmers, their families, veterinarians, and hospital staff treating farm-infected patients. The same pig strain that was detected in Canada has been associated in Europe with serious human illness including skin, wound, breast, and heart infections, as well as pneumonia.

The heavy use of antibiotics in industrialized livestock operations can select for resistant bacteria, such as MRSA. A study in Europe documented that pig farms routinely using antibiotics were more likely to have MRSA than farms with limited antibiotics use.

Proposed federal legislation, The Preservation of Antibiotics for Medical Treatment Act, sponsored by Senate Health Committee Chairman Edward Kennedy (D-MA) and Senators Olympia Snowe (R-ME), Susan Collins (R-ME), Sherrod Brown (D-OH) and Jack Reed (D-RI) in the Senate (S. 549) and Rep. Louise Slaughter (D-NY), the only microbiologist in Congress, and 34 other House members in the U.S. House of Representatives (H.R. 962), would phase out the use of antibiotics that are important in human medicine as animal feed additives within two years. The American Medical Association, the Infectious Diseases Society of America, and the American Academy of Pediatrics are among the more than 350 advocacy groups nationwide that have endorsed this bill.

Source:
http://www.keepantibioticsworking.com

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Chapter 9. Relevant Laws, Regulations and Decisions

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9.1 Introduction

Air emissions and odor from Concentrated Animal Feeding Operations (CAFOs) has become the subject of discussion and government action in a number of states. Sometimes the news media, environmental disasters or the large number of constituent contacts, push legislative changes or administrative action on how CAFOs are sited and managed. Occasionally a new scientific study on the topic changes the tone of the debate.

This chapter documents action taken to regulate and manage CAFO air emissions and odor in jurisdictions outside Iowa. It gives examples of the kind of control various levels of government have imposed on the management of these facilities in an attempt to balance economic advantage with public health and welfare.

9.2 Distinguishing the Consequences of Air Emissions: Nuisance or Health Effects

Air emissions from animal waste storage systems, buildings and land application of animal waste contain a number of gasses and particles that include hydrogen sulfide, ammonia, methane, particulate matter and bioaerosols. Hydrogen sulfide is an example of a substance that is both a direct toxic health risk and odorous. Furthermore, this odorous substance, as well as other odorous substances, may also cause adverse health symptoms, from an indirect toxic mechanism via interactions with the central and peripheral nervous system. [See Chapter 6]

Odorous compounds also decrease the quality of life of neighbors. Hydrogen sulfide, for instance, causes corrosion of metals and damage to plants. When a state or local government acts to reduce air emissions, it might describe this as intervening to protect public health or to enhance the quality of life or the government may say nothing about what motivates its action.

The Minnesota Pollution Control Agency (MPCA) places limits on hydrogen sulfide emissions at CAFOs. Minnesota is similar to other states that have recently intervened to reduce air emissions from a type of activity that was formerly thought to be only a local issue.

> In the past, the Minnesota Pollution Control Agency (MPCA) has viewed odors as a natural result of animal production that could best be addressed through good land use planning, with the primary responsibility for land use planning at the local level of government (see Minn.R. 7020.0100).[1]

Just as states have struggled to determine whether state or local regulation is appropriate, they have not found it simple to distinguish the rationale for regulation. It is not simple to say which air emission is a health issue and which a nuisance. Rather there is a continuum from life threatening acute health effects, through acute effects that are not life threatening, to chronic effects that appear after longer exposure, to annoyance smell. Odor or a constituent part of the air emission can have a range of effects. Consider this example. Two Minnesota agencies, the MPCA and the Minnesota Department of Health (MDH) have established values to limit the various adverse effects from hydrogen sulfide emissions from CAFOs. The MDH explains why both agencies have acted.

> The MPCA standard for hydrogen sulfide will protect against symptoms of headache, nausea, and maintain a quality of life for Minnesotans. The MDH acute Health Risk Value (HRV) will protect against respiratory effects by ensuring that hydrogen sulfide is included in

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hazard indexes calculations where hydrogen sulfide is one of many chemicals emitted to air potentially having respiratory impacts.[2]

9.3 Minnesota GEIS on Animal Agriculture

The state of Minnesota has recently brought the scientific and public policy community together to advise state government on how to proceed on several CAFO issues. This extensive process resulted in a Generic Environmental Impact Statement (GEIS) for animal agriculture that was presented at a public hearing on December 10, 2001. Because the technical work papers for the GEIS date from the first half of 2001, this chapter relied heavily on three GEIS Technical Work Papers -- Air Quality and Odor, Role of Government, and Human Health. One finding of the GEIS Technical Work Papers is that air quality has not been the driving force behind government action.

> Existing laws and programs have mostly emerged out of a long-standing concern over surface water impacts, which, while valid, have meant that air, groundwater and other emerging issues are not adequately factored into government decision-making.[3]

Government's slow involvement with air emissions and odor is substantiated by data presented in 1998 survey on Animal Confinement Policy designed by a National Task Force of 15 Extension Specialists representing all regions of the nation. For only 13 of 48 states did those surveyed answer yes to the following question: Are odor standards imposed as a matter of state government policy or court decisions in your state?[4] More than twice as many states regulate discharge to surface water. However, some states like Missouri, which recorded an answer of 'no' to the preceding question, now have odor standards.

9.3.1 Iowa

We will discuss Iowa CAFOs at length below. However it is informative to see the view of our state from our neighbor to the north. The Minnesota GEIS Technical Work Paper on Air Quality and Odor Impacts investigated regulatory programs in a number of states including Iowa. According to the researchers,

> {d}espite having an estimated 3,000 large animal feeding operations that have the capacity for more than 1,000 animal units and receiving many odor complaints from neighbors, the State of Iowa has essentially no program in place for addressing odors or air emissions from animal agriculture facilities.[5]

This strong language points to the inadequacy of present Iowa rules and regulations. However, two members of this research team, one from the University of Iowa and one from Iowa State University were part of a study group which put the following language into Iowa Administrative Rules of the former Air Quality Commission in 1977 when an odorous substance standard was defined as:

> The emission of an odorous substance from an odorous substance source shall constitute a violation of these rules if the emission is of such frequency, duration, quality, and intensity to be harmful or injurious to human health and welfare, or as to unreasonably interfere with the comfortable use and enjoyment of life and property or so as to constitute a nuisance as defined in sections 657.1 and 657.2 of the Code.

The former paragraph was part of the state Administrative Code for only a short time. The rule was rescinded in 1984 when the term "odorous substances" was also deleted from the Administrative Rules.*[6]

While the Minnesota GEIS was our starting point to seek out governmental action on air and odor, we also talked to government officials and staff of non-governmental organizations in pork producing states. We have omitted setback requirements, one type of policy that nearly every state has adopted to reduce the effects of air emissions and odor from CAFOs. We will look at regulations for three constituents of air emissions, hydrogen sulfide, ammonia and odor. We will look at local government activities and we will look at the results of action in the courts. In each category, rather than an exhaustive look we will choose a few jurisdictions to serve as exemplars for the kind of government intervention to control CAFO air emissions.

9.4 Hydrogen Sulfide Standards

The Agency for Toxic Substances and Disease Registry (ATSDR) of the US Department of Health and Human Services, lists 24 states with regulations or guidelines for hydrogen sulfide. In this section we will look at three states with regulations especially relevant to CAFOs.[7]

9.4.1 Minnesota

Minnesota is interesting because it addresses air quality issues from animal agriculture in several ways. First, the MPCA maintains a two-component Ambient Air Quality Standard for hydrogen sulfide. 50 parts per billion (ppb) is not to be exceed for ½ hour twice per year and 30 ppb is the ½ hour average not to be exceed more than 2 times in any 5 consecutive days.[8] These are emitter property line standards for animal feeding operations over 1000 animal units in size.

Second, subsequent to establishing these standards, another Minnesota agency, the MDH, proposed a draft acute Inhalation Health Risk Value (HRV) for hydrogen sulfide of 60 ppb as a 1-hour average and a draft subchronic (3-month average) HRV of 7 ppb.[9] These standards are evaluated at the receptor rather than the emitter's property line. The MDH plans to adopt both HRVs without public hearing in the very near future. In addition, the state addresses air quality issues from CAFOs by requiring each facility with a capacity of 1000 animal units to include an Air Emission Plan in its water quality permit.

The many different air emission limits in a single state for only one constituent makes clear the difficulty in describing laws, regulations and decisions relating to CAFO air emissions and odor. Many authors do not make a distinction between air emissions and odor or between health effects and nuisance. In this chapter we will deal with both odor and air emissions and will try to record accurately which a particular law, regulation or decision is being referred to.

9.4.2 Nebraska

The Nebraska Department of Environmental Quality (NDEQ) implemented an ambient air quality health-based standard of 100 ppb for total reduced sulfur (TRS) in September 1997 (Revised January 1999). The impetus for this action was industrial emissions in Dakota City, Nebraska and not

* Rule 400--4.5 was published as an adopted and filed rule on 6/16/77. On 6/22/83 the rule was transferred to WAWM as rule 900--23.5. An amendment published 9/12/84 changed the catchwords from "Odorous substances" to "Anaerobic lagoons"; rescinded subrules 23.5(1) and 23.5(2) and renumbered subrules 23.5(3) and 23.5(4) as 23.5(1) and 23.5(2), respectively. Rule 23.5 is still in the Iowa Administrative Code.

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CAFOs. However, since the revision in 1999, the standard applies to CAFOs. NDEQ prepared an extensive background research paper that focused on low-level exposure to hydrogen sulfide and TRS through inhalation.[10]

> Total Reduced Sulfur (TRS) consists of the total sulfur from the following compounds: hydrogen sulfide (H2S), methyl mercaptan (CH3SH), dimethyl sulfide ((CH3)2S), and dimethyl disulfide (CH3SSCH3) (87). These TRS compounds occur naturally in the environment. H2S makes up the greatest proportion of TRS.[11]

As part of their research paper, NDEQ surveyed the 49 other states and found 27 states that had standards for H2S or TRS. These states based standards on a variety of issues including, odor or nuisance, welfare effects, and health effects. Standards varied considerably to as low as 0.7 ppb for a yearly average (New York) and 5 ppb averaged over 24 hours (Pennsylvania). Many of the standards were based on nuisance including Minnesota's 30 ppb and 50 ppb standards. The lowest standard that was reported to be health based was a 10 ppb 8-hour 10 ppb standard (Illinois).[12]

The authors of the background research paper recommended Nebraska's present health standard of 100 ppb, averaged over 30 minutes. The authors also recommended a much lower 30-day standard of 10 ppb or 5 ppb (depending on average humidity level in the air) to protect against other effects of sulfur compounds. While the state adopted the 100 ppb health-based standard, it has not yet adopted the lower, welfare standard for TRS.

9.4.3 California

The California Ambient Air Quality Standard (CAAQS) for hydrogen sulfide of 30 ppb for one hour was adopted in 1969 and reviewed but not changed in 1980 and 1984. A year 2000 review states the purpose of the standard was to decrease odor annoyance from industry rather than CAFOs. However, the review notes that significant adverse health effects might occur at levels of exposure below the CAAQS.[13] More recently, the California Office of Environmental Health Hazard has adopted a chronic reference inhalation standard of H2S at 8 ppb.

The three states give three motivations for a sulfurous emission standard. Nebraska has a health-based standard of 100 ppb, averaged over 30 minutes at the receptor. Minnesota's health standards vary from an acute 60 ppb 30-minute standard to a sub-chronic 7 ppb, 3-month standard measured at the receptor or nearer the source of the emission. The state also has two nuisance-based property line standards of 50 ppb and 30 ppb averaged over 30-minutes. California's much older 30 ppb for one hour standard is based on nuisance but the state is looking into whether significant adverse health effects might occur at similar levels. The California Office of Environmental Health Hazard has adopted a chronic reference inhalation standard of hydrogen sulfide of 8 ppb.[14] Standards for the three states as well as for federal agencies and the World Health Organization are contained in Table 1.

9.5 Ammonia Measurements

The ATSDR has published a toxicological profile for ammonia, which contains a list of regulations and advisories from various states. The list of acceptable ambient air concentration levels for Ammonia based on 1988 information, contains standards in place in 11 states.[15] (See Appendix and Table 2.) The ammonia standards for the three following jurisdictions are contained in Table 2 at the end of the chapter.

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9.5.1 Minnesota

Besides establishing a Health Risk Value (HRV) for hydrogen sulfide, the Minnesota Department of Health has filed a draft HRV for ammonia as well. This HRV, like the other, will receive final approval in the next few months. Both HRVs are scientifically measured standards that protect the public from adverse health effects. The point of measurement would often be at the receptor but it is possible that the agency will take measurements at the property line as well. A brochure prepared for the public explains that being below the HRV does not necessarily take care of odor problems.

> However, keeping emissions at or below the HRV does not necessarily eliminate odors from the agricultural animal operation and may not eliminate health effects from odors.[16]

9.5.2 Netherlands

While The Netherlands is very different from any US state, it is similar in terms of livestock production.[17] [18] The numbers of livestock animals in The Netherlands are 14 million hogs, 108 million chickens, 4.2 million cattle and 1.4 million sheep. On four times as much land mass Iowa has 15 million hogs, 37.8 million chickens, 3.7 million cattle and 270,000 sheep. In The Netherlands, ammonia emissions from agriculture are responsible for 42% of the acidification attributable to domestic sources. Policies set forth in the 1990s aim to reduce by 70% the ammonia emissions compared to the 1980 benchmark. The European Union is working on a directive to reduce ammonia emissions that is being modeled after the Dutch regulation.

Features of the Dutch policy that regulates phosphate, nitrogen and ammonia include a mandated reduction of the pig population by 10%, compulsory minerals accounting and reporting by all intensive livestock farms, a total ban on application of manure in autumn and winter, a ban on application on frozen ground, compulsory use of injection manure application, compulsory covering of manure storage tanks and reservoirs, strict requirements for ammonia emissions from intensive livestock facilities including a requirement that all new livestock housing meet the strict ALARA (as low as reasonably achievable) standards. All facilities will be required to meet ALARA by 2008. Farmers must have adequate manure storage facilities to store their manure from September through February.

Methane and nitrous oxide arising from CAFOs are greenhouse gases that may contribute to global climate change. In The Netherlands, agricultural activities account for an estimated 45% of the total methane emissions and 35 to 40% of the N2O emissions. Measures being taken to reduce ammonia emissions should allow The Netherlands to reduce greenhouse gas emissions to levels mandated by the Kyoto Protocol. Thus far, the U.S. has not taken any steps to control emissions of greenhouse gases from livestock production.

9.5.3 Missouri

The Missouri Department of Natural Resources has been monitoring a Premium Standard Farm (PSF) concentrated animal feeding operation in northern Missouri since the beginning of 2000.[19] Hydrogen sulfide and ammonia concentrations are monitored on a 24-hour basis. The monitor has recorded high concentrations of both ammonia and hydrogen sulfide. Missouri has an ambient air standard for hydrogen sulfide and an ambient acceptable level (AAL) for ammonia of 144 ppb. The Department added a second monitor at another PSF facility late in Fall 2001.[20]

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The Missouri Department of Health, the Missouri Department of Natural Resources, the US EPA and the US Agency for Toxic Substances & Disease Registry cooperated in a health evaluation near some of PSF's facilities in the fall of 2001. The health evaluation concentrated on the two pollutants hydrogen sulfide and ammonia. A health evaluation is to determine if a more full-scale health study is needed. The results of the evaluation have not been released.[20] In a recent Consent Decree with the US EPA and a citizen's group, PSF has agreed to continue to monitor for a number of air emissions including ammonia.[21]

9.6 Odor legislation

States can regulate air emissions without referring to a specific chemical constituent. The 1998 national survey of animal confinement policies, referred to above, found thirteen states where odor standards were imposed as a matter of state policy or court decisions.[4] We look at three states that require that odor from CAFOs be held below a threshold. In Missouri and Colorado, the threshold is based on a dilution standard. The Colorado dilution standard of 7:1 means that an air sample collected at the emitter property line is diluted with seven volumes of fresh air. If odor can still be detected by using an olfactometer and panel of smellers, there is a violation. (See description in section 3.4) North Carolina has an idiosyncratic method of deciding on an odor violation, which is covered below. Table 3 summarizes the information in this section.

9.6.1 Missouri

On January 1, 2002, all very large CAFOs in Missouri must have an odor control plan in place describing measures to be used to control odor emissions (10 CSR 10-3.090, Code of State Regulations). All Class 1A CAFOs, those having more than 7000 animal units must comply (twenty-one facilities in total). This air quality specific program approach dates from 1999. A number of farm organizations went to court alleging the state lacked authority to regulate emissions. The state has prevailed at the County Circuit Court and the Missouri Court of Appeals.[22] At this time only 1 of Missouri's 21 Class 1A CAFOs has an approved odor control plan. All the others have not been approved. In general, the disapproved odor control plans lacked specific odor control and reduction strategies. Nearly all of the CAFO owners have appealed the state's disapproval of their plans.[20]

Missouri uses a dilution threshold as a standard. An instrument called a scentometer is used in the field at a dilution threshold of 5.4:1 to determine if a significant odor is present. If odor is detected, an air sample is taken and sent for further evaluation by an olfactometry panel. If the panel detects the odor at a dilution threshold of 7:1 or greater, or at an intensity greater than a reference standard of 225 ppm of n-butanol, then a violation has occurred.

9.6.2 North Carolina

North Carolina CAFOs with liquid waste systems are required to first meet a number of best management practices for things such as dead animal disposal. Besides these management practices requirements, certain swine operations fall under the regulation's complaint response and odor management program. Compliance with the rules depend on facility size and distance from an occupied residence, business, school, hospital, church, outdoor recreation facility, park, historic property, or childcare center. According to materials gathered in the Minnesota GEIS process, the North Carolina complaint response system is quite involved and seems to be a time consuming process. It consists of the following steps.

Complaint response system

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When a citizen complains to the state, they are asked to log complaints and weather conditions for 30 days on a form provided by the North Carolina Air Quality Division (NCDAQ). Once the logbook is returned to the state, the following formal investigation takes place.

a. An inspection is scheduled during weather conditions and time of day similar to when typical objectionable odor was reported
b. Evaluation is made at the location of the residence of the complainants
c. An "odor snapshot" is made by regional office investigator (one of 5 rankings)
d. The snapshot evaluation is reported to a regional supervisor
e. The regional office submits a recommendation to Division Director
f. The Division of Air Quality Director makes a final decision whether an objectionable odor exists.

If a determination of Objectionable Odor is made, the NCDAQ will require a Best Management Plan (BMP) of a facility—this is a revision of the original submitted plan. The BMP must be submitted within 90 days. Then ensues a process of plan approval and revision. If the BMP is found to be inadequate, the NCDAQ notifies the operation that it must submit a revised BMP under the same time schedules. Only then can the state order a facility to initiate any specific action.

> If the revised plan fails to adequately control, odors, the facility is required to install add-on control equipment and must submit a permit application for this installation within 90 days of receiving notification that their revised BMP was not adequate.[24]

Thus far only 25 facilities have had an Objectionable Odor determination. Each is currently in the process of providing a BMP to NCDAQ. As of early 2001, none had moved to the final step in the process, the installation of add-on control technology.

9.6.3 Colorado

Missouri and North Carolina demonstrate the significant length of time required to decide what action to take to abate odor. A different approach was followed by the state of Colorado where a referendum on the state ballot led to regulations addressing odorous gases and odor emissions from new and existing housed commercial swine feeding operations. The list of rules is extensive. They include, a cover requirement of anaerobic process wastewater lagoons, aerobic lagoon requirements, land waste application setback requirements, and mortality waste handling requirements. Housed commercial swine feeding operations must use technologies to minimize off-site odor emissions from all aspects of the operation (confinement structures, waste treatment facilities, manure management and land application), develop a comprehensive odor management plan and obtain an operating permit.

The regulation applies to all CAFOs that contain more than 800,000 pounds of live animal weight. Colorado CAFOs of this size must meet two ambient odor concentration standards, a dilution standard of 7:1 at the facility boundary and a dilution standard of 2:1 at any receptor (building, school or a municipal boundary). "The plans must also identify the odor monitoring that the facility intends to conduct in order to ensure compliance with the odor standards identified above."[25] While the requirements apply to more than 110 individual facilities, there are only eight owners of these facilities. The new regulations have reduced odor complaints substantially according to Phyllis Woodford of the Department of Public Health and the Environment.[26]

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9.7 County and Local Action

Citizens who are not satisfied with state level governmental action to mitigate the effects of CAFOs have two other venues to protect their rights. They may pursue restrictions at the local government level or they can go to court in a private cause of action.

Rural counties have not generally adopted the zoning protection of more urban areas. However this seems to be changing.[27] In Missouri, reticence to zoning restrictions in a rural county was overcome by the arrival of large confinement operations. A resident of a township next to Premium Standard Farm's facility in Missouri, describes the area's change of view that caused it to adopt zoning.

> You've got to make plans and provide for the control of the situation before it occurs. Otherwise, by the time you realize you need zoning, its too late, and they've set the hook.[28]

While the eminent arrival of a CAFO might cause citizens to demand more protection from local government, local government is often prevented from playing a part in how CAFOs are regulated. State legislation to regulate animal agriculture has often been passed with the provision that local governments are prevented from intervening. Preemption of local action has been widely discussed in the literature.[27] Abdalla and Becker give several examples of the preemption of local government's abilities to deal with CAFOs. The authors explain resort to preemption laws by agricultural interests as simple economics.

> The economics of political influence clearly leads to a general preference for state level regulatory authority by organized interest groups. Monitoring and lobbying at the state level is much less expensive than providing these services at hundreds of local governmental units.[29]

9.7.1 Iowa

In Kuehl v. Cass County (1996) the Iowa Supreme Court held that all agriculture, including an animal feeding operation, is exempt from any county zoning. Before this decision, Humboldt County adopted four ordinances governing "large livestock confinement feeding facilities." While a district court upheld three of the ordinances, as a proper application of "home rule" authority, the Iowa Supreme Court struck down all the ordinances in their decision in Goodell v. Humboldt County, Iowa in 1998.[30] Presently an ordinance from Worth County is proceeding through the courts. This will test whether counties can regulate CAFOs based on public health. Whatever the outcome of the latest case, the Iowa preemption law has made county government reticent to try to regulate the location of CAFOs.

9.7.2 North Carolina

A website at the School of Public Health at the University of North Carolina contains reports on six county in the state that have passed ordinances regulating CAFOs. Ordinances required such things as operating permits, closure plans, graduated setback requirements and well testing. The Moore County ordinance for instances, required that confinement buildings and lagoons be set 2 miles from any golf course.[31] In 2001, two North Carolina court decisions struck down two county ordinances and put the remainder in jeopardy. The courts found that the General Assembly did not want to impose an unnecessary economic burden on hog production caused by each county passing its own set of rules. Chatham County has appealed the Court of Appeal's decision to the NC Supreme Court. A decision is expected in early 2002.[32]

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9.7.3 South Carolina

The preemption strategy is not always successful as demonstrated by an attempt in South Carolina to push local government out of the regulatory picture.

> What started out as an attempt to adopt state laws that preempt counties from enacting measures to deal with confined animal feeding operations resulted in a measure that provides for considerable regulation of the activity and significant local involvement in the process.[33]

9.8 State Moratorium on Expansion

We have omitted one form of government action to this point. Moratoria have sometimes been adopted to give state officials time to review and update environmental regulations. In April 2001, Governor Jim Hodges of South Carolina imposed a 15-day moratorium on CAFO expansion to give environmental regulators more time to consider permit regulations.[34] Short-term limitations on any expansion of CAFOs also have taken place in Kentucky, Missouri and Arkansas.[30]

In one state the controversy over CAFO expansion has been so contentious that a continuous moratorium on large CAFO expansion has been put in place. North Carolina placed a two-year moratorium on the expansion of CAFOs with lagoon systems, when House Bill 515 passed in 1997. The moratorium has been extended twice and is now due to expire in September 2003.[35] Such reaction leads one to speculate whether stricter regulation earlier in the process may have better for the industry in North Carolina. The moratorium originally resulted from a number of lagoon breaks but also from the perception that the original regulation was too lax.

It is not even clear that weak legislation, preferred by nearly every industry, is in the best interest of producers in other parts of the nation.

> The Mo and Abdalla study found that overall, the stringency of environmental regulation did not appear to impact hog inventory growth." and "...the amount of staff devoted to animal waste management had an unexpected, but strongly positive relationship to hog inventory growth.[36]

9.9 Individual Legal Action

Local citizens have access to the courts where one can bring a private cause of action under nuisance. However, in many states, state government has attempted to blunt individual legal action through "right to farm" legislation. Hamilton explains the motivation for such statutes.

> Most lawyers and farmers have more than a passing familiarity with the legal concept upon which the laws were originally based—existing farm operations should not become nuisances due to the later development of non-agricultural uses in the surrounding area.[37]

Right to farm legislation has prevented neighbors and environmental groups from using individual nuisance action to require management changes or new locations for CAFOs. DeLind found that successful court action by neighbors against a Michigan swine confinement operation was the impetus for changing the law to give neighbors fewer rights by providing right to farm protection for what she calls hog hotels.[38]

> The official outcome, in other words, undermined both the original set of grassroots concerns and weakened the basis for further local-level action and representation.[39]

However, courts in several states including Iowa have ruled that right to farm laws give only limited protection from nuisance action. Richardson and Feitshans point to the Bormann case decided in

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1998 by the Iowa Supreme Court as reducing the effectiveness of this protection for animal agriculture.[40] In that case, removing a citizen's right to nuisance action within a declared agricultural area was found to be a categorical taking of private property for public purposes without just compensation. Thus, the Iowa Legislature had exceeded its authority by authorizing the use of property in such a way as to infringe on the rights of others.[41]

In addition to limiting nuisance suits, another method of reducing the risk of animal agriculture operations from individual legal action has been the "fee shifting" provision. Hamilton gives the example of a 1995 Iowa law that assesses all costs and expenses of the defense side to the losing plaintiff in a nuisance action against a CAFO. Hamilton finds that "From a legal standpoint there are several reasons why this type of "soft" fee shifting is not a significant threat to most people who would file a nuisance challenge."[42]

In the last several months, two Iowa cases have set the stage for an expansion of the Bormann decision to land not in a designated agricultural area. In August 2001, an Iowa district court judge ruled for the first time that an Iowa law that protects CAFOs against nuisance suits is unconstitutional.[43] The decision allowed the Gacke case against Pork Xtra, L.L.C. to proceed in a Sioux County, Iowa court.[44] In January 2002, Pork Xtra was assessed $100,000 in damages.[45]

In December 2001, a court in Calhoun County Iowa made a similar determination that the defendants in Kleemeier v. Beazly Group, Inc and Pork Innovations could go forward. The judge found that the defendant's affirmative defense against nuisance action by neighbors had relied on an unconstitutional statute.[46]

Actual examples of substantial plaintiff victories from CAFOs under nuisance exist in other states. On September 9, 2001 Buckeye Egg Farm in Ohio, was hit with a judgment of $19.7 million for nuisance violations including fly infestations and odor. According to Feedstuffs, Buckeye, which has barn capacity of 11 million hens and 4 million chicks, is considering bankruptcy protection. Buckeye is the fifth largest commercial egg producer in the U.S.[47]

Nuisance need not be only a private court action. The Illinois Attorney General is presently prosecuting at least two swine CAFO operations under two counts of state law--air pollution and public nuisance--as well as under a third count of common law nuisance. There are two noteworthy dimensions of these cases. First, the Illinois AG cites considerable case law indicating that technical measures and depictions of odor and emissions are not required to prosecute air pollution and nuisance violations. Indeed, the nuisance statute itself was created, in part, to allow general citizens equitable access to courses of legal action without recourse to expensive technical measurements or scientific assessments.

In fact, a ruling by a Ninth Circuit Court Judge in one of these cases, affirmed the evidentiary possibility of neighbors proving their case by experiential testimony. Moreover, the state Illinois Environmental Protection Agency (IEPA) that follows-up on odor complaints, does not conduct technical assessments of odor or emissions. Instead, representatives from the IEPA will respond to neighbor odor complaints by making site visits and carefully documenting the presence or absence of odor with their own sensory judgments. Interestingly, the IEPA has issued warnings to prospective CAFO builders and operators (prior to construction of a CAFO) that just because they receive an approved state operating permit does not preclude action against them for violating the state's odor and nuisance standard. In fact, there are cases in Illinois where the Illinois Department

of Agriculture will issue an approval for construction and operation while the IEPA will issue a simultaneous warning of potential air quality violations against neighbors.

It should be noted that the air pollution and nuisance statutes of Illinois are similar, if not identical to those found in other states. Hence the issue becomes not one of statutory authority of the Attorney General to prosecute such cases on behalf of neighbors, but more likely a political decision based upon a weighing of competing interests. More importantly, these statutes and associated case law recognize the evidentiary value of experiential assessments of odor by neighbors.

9.10 Non Regulatory Approaches

9.10.1 North Carolina

In July 2000, then North Carolina Attorney General Mike Easley signed an agreement that required Smithfield Foods, by far the state's largest pork producer, to pay $15 million to fund research and testing on better technologies to treat hog waste. Premium Standard Farms has committed $2.5 million for the same research questions under a similar agreement with Easley who is now Governor. In July 2002, a report is due.

> Smithfield-affiliated farmers then have three years to convert their facilities to the recommended technologies. In addition, the agreement requires Smithfield to pay $50 million for environmental improvements such as mapping and closing abandoned waste lagoons in the eastern half of the state.[48]

The technologies being examined must make substantial reduction in a number of emissions including ammonia, odor, disease vectors and airborne pathogens. Since this is early in the agreement, it is well to withhold judgment on whether or not Smithfield facilities will solve their odor and water emission problems.

9.10.2 Oklahoma

Oklahoma is another state in which a livestock producer has signed an agreement with the State Attorney General to change waste treatment systems at facilities.

> Seaboard Farms, the state's largest corporate hog producer, signed an agreement Tuesday (12/04/01) to spend about $3 million to better treat sewage and —for the first time – control odors scientifically.[49]

Seaboard agreed to several measures including installing a manure treatment system similar to human waste treatment systems and agreed to share monitoring results with the state. The agreement allowed the company to open a second 25,000-sow facility similar to the one where the new treatment devices will be installed.

9.10.3 Missouri

A third case of a settlement of a court case resulted in changes by Premium Standard Farms (PFS) in Missouri. In 1997 Citizens Legal Environmental Action Network (CLEAN) filed suit against PFS for its waste handling procedures. In 1999, the US EPA joined the citizen suit. Settlement of the court case in Missouri has resulted in a civil penalty of $1,000,000. However PSF was allowed to receive credit for payment of $650,000 to the State of Missouri for a previous State Consent Decree. The PSF website describes the settlement as $350,000.[50] The payment of civil penalty was small in comparison to what PSF pledged to invest in upgrades to its facilities in Missouri, which has been

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reported as high as $50M.[51] [52] Although the PFS agreement is a legal settlement, we treat it in this section because of the requirement that new technologies be introduced and the joining of government entities in citizen suits.

9.11 Role of Research in Public Policy

Government does not always wait for research recommendations before taking action. We have referred often to Minnesota's Animal Agriculture GEIS process for which the state legislature committed $1.4 million beginning in 1998. While the process was underway, in the 2000 legislative session, the ability of the Minnesota Pollution Control Agency (MPCA) to enforce feedlot rules was compromised as follows.

> Lacking evidence of an immediate public health threat, the MPCA may not require operators of feedlots under 300 AU to spend more than $3000 without 75% cost-share, and feedlots under 500 AU cannot be required to spend more than $10,000 without cost-share of 75% of the upgrade, or $50,000, whichever is less.[53]

One reason to expect legislators not to wait for a research process to be complete is the same reason courts side with neighbors who have only their own experience and not exhaustive studies to impart. When legislators heard from their constituents who produced small numbers of livestock, that they did not want to be caught up in regulations for "the big guys" the legislature acted on what they felt was adequate evidence.

Our two colleges have been asked to bring science to regulatory decisions. Similarly in Minnesota and Nebraska, regulatory action was based on a survey of the scientific literature on health and welfare effects of pollutant emissions or on a survey of action in other states. However, both researchers and legislators assert that a scientific recommendation need not necessarily have all the answers before regulations can be promulgated. Regulating air quality from CAFOs can be made on the basis of precaution.

The Precautionary principle provides a guide to environmental policy that places the burden on the proponents of a potentially harmful activity to prove that their actions do not harm human health or the environment. The principle has been stated in many different places and contexts. The1998 Wingspread Statement, which is a consensus document produced by those attending a conference on the issue at the Wingspread Conference Center in Wisconsin, states in part:

> When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically. In this context the proponent of an activity, rather than the public, should bear the burden of proof.[54]

The precautionary principle already forms the basis of at least a dozen treaties and international laws including the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer, the 1992 UN Framework Convention on Climate Change and the 2000 Cartagena Protocol on Biosafety.[55] [56] [57]

The precautionary principle has often been applied to the introduction of new chemicals into the environment. Kriebel and Tickner assert that science informs policy in many ways. They find that, "A shift from reaction to precaution is entirely consistent with the core values of public health practice."[58]

A public health approach to marshalling evidence may be different from a strictly hard scientific approach according to Krimsky. He describes this difference by referring to Type I and Type II scientific errors. He maintains that minimizing false positives is the priority of the hard sciences while a public health perspective prefers to err on the side of overstating risks (prefer type II errors).[59]

Krimsky demonstrates the wide acceptance of some amount of precaution when he quotes an issue of the journal Chemistry & Industry, which states, "For one thing, it is crucial to avoid even inadvertently suggesting that the 'no evidence of harm' somehow equals 'evidence of no harm.'"[60] However, when considering implementation of precautionary measures, it is imperative that all consequences of such measures be thoroughly evaluated.

9.12 Conclusion

Governments have intervened to mediate between CAFOs and their neighbors in a number of ways. This chapter has sought to demonstrate the range of such intervention. States regulate hydrogen sulfide and TRS. Other states have limited the emissions of odor and ammonia. Local governments have sometimes been allowed to intervene to protect citizens against air emissions, but in most cases the state legislature has reserved this role for itself. Both, where states have acted and where they have not, the courts have intervened to give neighbors of CAFOs protection from air emissions and odor. This chapter is designed to demonstrate to the Iowa DNR and to Iowa government in general that there are examples of Laws, Regulations and Decisions designed to regulate air emissions and odor from CAFOs.

Appendix: Federal and International Air Quality Standards

Federal Standards

CAFO effects on water quality have been addressed by a Unified National Strategy developed by the USDA and USEPA in 1999. Air emission effects of CAFOs have not yet found the same level of federal attention. USDA formed an Agricultural Air Quality Task Force, which has been meeting and in July of 2000 drew up a white paper on research and technology transfer.[61]

Both the USEPA and the Agency for Toxic Substances and Disease Registry (ATSDR) have standards for both H2S and ammonia. These have been cited in Chapter 8.

Specifically for Hydrogen Sulfide, acute exposure guideline levels have been printed in the Federal Register for March 15, 2000.[62] There are several Proposed Acute Exposure Guideline Levels (AEGLs) applicable to the general population. AEGL-1 is set at 30 ppb for both a 10-minute and 30-minute exposure. AEGL-1 is designed to limit exposure to prevent "discomfort, irritation, or certain asymtomatic, non-sensory effects" which are not disabling. According to the web page of the American Petroleum Council. http://www.api.org/ehs/h2s/FalkeAbstract.htm AEGL-1 has not passed all the various reviews and is still considered a draft while two other AEGLs have been adopted.*

* AEGL values were developed for hydrogen sulfide by the National Advisory Committee on Acute Exposure Guideline Levels (NAC/AEGL Committee). These values were published in the Federal Register on March 15, 2000 (U.S. EPA, 2000) for public comment. After reviewing comments, the AEGL values were sent unchanged from the Federal Register Notice to the National Academies for review at their meeting on July 24-25, 2000. Following verbal

International Examples

Jurisdictions often base their standards on peer-reviewed literature and upon choices made by other jurisdictions. The State of Nebraska in adopting their standard of 100 ppb for TRS [see 9.4.2 for the relation between HS and TRS], cited data from the World Health Organization.

> The World Health Organization (WHO) reviewed information on health effects and recommended a daily (24-hour) value of 0.1 ppm H_2S. This value was based on the eye irritation effects at 10 ppm and a safety factor of 100. WHO noted that changes in heme synthesis were found at 1 ppm in pulp mill workers. Since the WHO made its recommendation in 1983, Bhambhani and Jappinen have conducted studies that indicate that eye irritation is not the most sensitive critical health effect.[63]

Table 10-1
Hydrogen Sulfide Standards for Various Jurisdictions

Jurisdiction	Type	Standard
Minnesota MPCA	Nuisance	30 ppb and 50 ppb
Minnesota Dept. of Health	Acute	60 ppb
Minnesota Dept. of Health	Sub-chronic	7 ppb
Nebraska Dept. of Health	Acute	100 ppb
California OEHH	Nuisance	30 ppb
California OEHH	Chronic	8 ppb
EPA – IRIS Chronic	Chronic	.7 ppb
EPA -- AEGL-1 (proposed)	Acute, non-disabling	30 ppb
ATSDR	Acute	70 ppb
ATSDR	Acute	30 ppb
WHO		100 ppb

comments at the National Academies' review, the AEGL-1 values are currently being re-evaluated by the NAC/AEGL Committee for endpoint and key study selection.

Table 10-2
Ammonia Standards for Various Jurisdictions

Jurisdiction	Type	Standard
Minnesota Dept. of Health-draft	Acute	3200 ug/m3
Minnesota Dept. of Health-draft	Chronic	115 ppb
Netherlands Dept. of Agriculture	Not a number std.	
Missouri Dept. of Natural Resources	One producer	141 ppb
EPA	Chronic	141 ppb
ATSDR	Acute	500 ppb
ATSDR	Intermediate	300 ppb

Table 10-3
Odor Standards for Various Jurisdictions

Jurisdiction	Standard
Colorado Dept. of Public Health and Environment	7 to 1 dilutions at the property line
Colorado Dept. of Public Health and Environment	2 to 1 dilutions at the property line
Missouri Dept. of Natural Resources	5.4 to 1 dilutions at the property line
North Carolina Division of Air Quality	Objectionable odor at the source

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Additional Letters

N.D. DEPT OF HEALTH
BISMARCK, ND

15 MARCH '16

I AM CURRENTLY THE OLDEST MALE LIVING IN THE CITY OF BUFFALO, ND. I CREDIT MY GOOD HEALTH AT MY AGE TO MY DOCTOR, HE TOLD ME A FEW YEARS TO WALK, WALK, WALK! SO THAT I HAVE BEEN DOING QUITE A BIT OF AND MOSTLY OUTDOORS. ESPECIALLY WHEN THE WEATHER IS FAVORABLE.

I AM SOMEWHAT APPREHENSIBLE (APPREHENSIVE) AS TO WHAT A CAFO CLOSE TO OUR CITY COULD HAVE ON THE AIR (STENCH AND UNPLEASANTNESS) AND POSSIBLY EVEN ON OUR HEALTH. PROBABLY MORESO ON SOMEONE MY AGE. I AM RAPIDLY APPROACHING 90 YEARS OLD.

I REALLY DON'T SEE MUCH GOOD OR BENEFIT OF A CAFO OPERATING SO NEARBY.

SINCERELY,

Kenneth A. Ronning
P.O. Box 166
Buffalo, ND 58011

To the North Dakota Department of Health,

I, Jessica Peterson, am opposed to the passing of this proposed permit for the pig factory. The pig factory will bring significant damage to our community, family, and friends. I am a resident of Tower City. I work in Buffalo, my son goes to daycare here, and my husband and his family own a business in Buffalo. My in-laws, niece, and nephew also live in Buffalo as do many of my friends. There is significant research out there that proves there are health risks with breathing in the pathogens that can be emitted in the air from pigs. There is also significant research out there stating how most of the CAFO's produce way too much manure that the land can't handle which leads to over application of the manure/fertilizer which the crops cannot absorb. Therefore, that may lead to run off and contamination of our drinking water also.

Since children can take in 20-50% more air than adults they are more susceptible to lung disease and health effects. We have young children that go to daycare in Buffalo, we also have a preschool, and a k-3 elementary school. These kids would be exposed to all of these air pollutants, therefore, increasing their risks of health problems. These pollutants can travel anywhere from 40-100 miles from its source.

Aside from all the health risks there is also a significant economic impact that would negatively affect our community. Property values would decline and most importantly we would lose some of our lifetime residents. My husband and I have dreamt of buying a farm near Buffalo but that would be severely impacted by this pig factory. My husband also farms land around the proposed site. We are very concerned about the run off from all of the excrement's from the pigs. With 9,000 pigs, there is significant risk of there being too much nitrogen in the soil which will run off into our fields, which will harm our crops, and could contaminate our water.

Please, do not pass this proposed permit. Our livelihood depends on it. My son's health, my families health, my health, and my friend's health, all depend on it.

Sincerely,

a concerned resident

Jessica Peterson

Jessica Peterson

To Whom it May Concern at the ND Department of Health:

My husband and I are concerned with the proposed Rolling Green Family Farms CAFO to be located near our home town of Buffalo.

We both have health issues, including allergies, thyroid and migraines. We understand that the gases and fumes emitted from these hog CAFO's are detrimental to people with health issues like ours.

We have read that the ND Dept of Health has a mission statement to "*protect and enhance the health and safety of all North Dakotans and the environment in which we live*". We feel it is your duty to watch out for anything that will hurt the health, safety and well being of the taxpaying, voting people of the state of ND.

We have attached our health summaries listing our issues.

Carolyn Dostert
Alan Dostert
Buffalo, ND

Health Summary

Current Health Issues

Health Issue	Date Noted
Hypothyroidism	
Allergic rhinitis	
Dysplasia of cervix	
Hyperlipidemia	
Encounter for long-term (current) use of other medications	01/14/2009
History of colonic polyps	01/14/2009
Acute mucoid otitis media of both ears	12/23/2015

Medications

metFORMIN 1000 MG tablet
Commonly known as: GLUCOPHAGE
Instructions: Take by mouth 2 times a day with meals. use of dose
Documented by Abstract Provider

fluticasone 50 mcg/spray nasal spray
Commonly known as: FLONASE
Instructions: Use 2 sprays in each nostril daily
Approved by Michael Sand, DO
Prescribed on 4/17/2014
Prescribed quantity: 16 g
Request a renewal

levothyroxine 125 mcg tablet
Instructions: Take 1 tablet by mouth 1 time per day.
Approved by Michael Sand, DO

Prescribed on 1/21/2013
Prescribed quantity: 90 tablets

Request a renewal

ALLEGRA PO
Instructions: Take 1 tablet by mouth 1 time per day.
Documented by Abstract Provider

Allergies

Allergen	Reaction
Other: See Comments	Itching
Potato	Itching
Environmental Allergens	Other (Specify in Comments)

Immunizations

Immunization	Date
Tetanus Toxoid,not adsorbed	2/1/2006

Preventive Care

Name	Status	Last Done
Pap Smear	Overdue since 1/19/2015	1/19/2012
Dexa/heel Scan	Overdue since 2/18/2015	2/18/2013
Flu Vaccine	Overdue since 10/1/2015	
Tetanus Vaccine	Overdue since 2/1/2016	2/1/2006
Colonoscopy	Overdue since 2/3/2016	2/3/2011
Screening Mammogram	Not due until 6/16/2016	6/16/2015
Lipid Screening	Not due until 1/18/2018	1/18/2013

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Health Summary

Current Health Issues

Health Issue	Date Noted
Other forms of migraine, without mention of intractable migraine without mention of status migrainosus	11/02/2006
Routine general medical examination at a health care facility	10/08/2008
Gout	10/08/2008
Osteoarthrosis, unspecified whether generalized or localized, involving lower leg	01/19/2012

Medications

naproxen 220 mg tablet
Commonly known as: ALEVE

Instructions: Take 220 mg by mouth 2 times a day as needed.

Documented by Abstract Provider

Allergies

Allergen	Reaction
Banana	Anaphylaxis (High)
Alfalfa	Hives (High)
Food Allergies	Unknown/Not Verified

Immunizations

Immunization	Date

TDAP	11/9/2013, 10/8/2008	

Preventive Care

Name	Status	Last Done
Colonoscopy	Overdue since 4/10/1962	
Lipid Screening	Overdue since 4/10/2001	
Flu Vaccine	Overdue since 10/1/2015	
Tetanus Vaccine	Not due until 11/9/2023	11/9/2013

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February 21, 2016

I want to address two of my many concerns regarding the 9,000 pig operation that is to be built near Buffalo, ND:

First, I have lived in Buffalo for 36 years. Early on Don and I made the decision not to purchase a lake cabin in Minnesota but instead to spend our summer weekends right here in our yard in Buffalo, ND.

In the last 6 years we have been blessed with the addition of 3 grandchildren to our family. All nine of us spend not only summer weekends but spring, summer and autumn days and evenings outside in Buffalo, ND. Routinely our son's and their families gather on Sundays at our house and we spend hours together outside in our treasured lilac surrounded lot.

As a result of that time spent outside our grandchildren have come to enjoy an array of outdoor activities: running through the sprinkler, splashing in the pool, squirting water guns at each other, jumping on the trampoline, digging for worms or playing tractors in the dirt, driving their gator around the spacious yard and growing pumpkins in the garden. T-ball & kickball too are played providing a great source of outdoor exercise and fresh air for them.

The hammock attached to two age old trees provides much fun for them as does the bridge in the yard with a troll lurking underneath. I have numerous, 20-25, yard ornaments and animal statues which allow the kids to strategically place in the yard where ever their imaginations allow. Three watering cans are needed as each grandchild takes the task of watering Grandma's flowers seriously.

They enjoy going for fun rides around town on Papa's gulf cart or in his Wildcat. The decision of which park to play at is never an easy one to make, therefore it always ends up being "both of them". A ride in the country out to Jerry's farm a mile south of town to pick raspberries and corn is a must. If raspberries and corn aren't in season they have to go simply to see how many rabbits are running around his farm yard. Other Wildcat rides are taken to check nearby fields, explore shelter belts keeping an eye out for deer in the woods and to look for eagle nests built high atop trees. They also love the "adventure" of exploring the trail alongside the railroad tracks, checking on the families of ducks and geese along the way. It is not uncommon for the fresh air and motion and hum of the vehicles to relax Chase and Connor to the point of catching an unexpected nap on the way back home.

The facts indicate the enjoyment of our outdoor activities would come to an end if the 9,000 pig operation is built. Our life style would change drastically.

Second, since the news of this pig operation coming to our community I really think about and appreciate our city water. Now, each time I run tap water my appreciation grows. The possibility of such an operation moving fills me with wonder: I wonder how long I will enjoy a glass of refreshing cold tap water? I wonder how much contaminated water we are going to drink and use before it is realized and deemed contaminated? Will I know it is contaminated before filling the kiddie pool? I wonder now each time I run bath water or take a shower, how long I will have clear, clean water? I wonder how long it will be before we have to rely on bottled water for all our needs and how much that will cost and what hassles that will bring? I even wonder how the water

in the toilet bowl will be affected after a 9,000 pig operation is built near our town?

Please consider us and those like us who appreciate simply the greatness of fresh air and clean water. Without them much of our daily enjoyment would be taken away.

Sincerely

Sherry Peterson

MARCH 10, 2016

100 Broadway S.
Buffalo, ND 58011
701-633-2322

CYNTHIA BERGET ALLEN

NORTH DAKOTA DEPT OF HEALTH

RE: PROPOSED P16 FARM BUFFALO, ND

I HEREBY STATE THAT I AM OPPOSED TO THE ABOVE P16 FARM AND AS A RESIDENT OF BUFFALO, NORTH DAKOTA, I AM CONCERNED ABOUT HEALTH ISSUES AND ENVIRONMENTAL IMPACT THEREFORE.

SINCERELY,

Cynthia Berget Allen

TO: N D Department of Health and Water Quality

I am an older adult living in Buffalo, ND. I'm on prescription drugs for high blood pressure, blood thinner, chronic sinus, allergies (on an inhaler), dry eyes, and anxiety. I have had three TIA's, and have been diagnosed with thickening of the heart wall. At night I sleep with a C Pap machine to keep my oxygen level stable.

I have a half block of yard to mow and plant a vegetable garden and flower beds. Working outdoors is my therapy. I use a three wheeler to haul tools and cut down on walking. I also enjoy being able to hang out my laundry. After reading a bulletin from the EPA, I am concerned about having to curtail my activities because of particulates in the air. The bulletin mentions checking the news for Air Quality Index. The air quality in Fargo would not likely register the toxic air we are experiencing in Buffalo.

Since the Rolling Green CAFO owners who reap the benefits live out of state, taking the money away from our tax payers, I don't find the justice in endangering our air quality and water supply.

I sincerely hope you can sympathize with our plight and deny the proposal of Rolling Green Farms.

Janice Diemert

Janice Diemert

My name is Betty Fraase and I want to address the North Dakota Department of Health about my concerns regarding the possibility of 9,000 pigs 1-1/2 miles from my home.

I am 80 years old and have lived on my farm in Howes Township since I got married over fifty years ago. I enjoy being outdoors, either mowing my yard or working in my flower gardens. My family loves to come home to visit and we spend lots of time outside grilling.

I have very serious concerns about this pig facility so close my house and the manure application proposed for farmland directly across the road from my 640 acre farm and home. I have high blood pressure and a thyroid condition which require daily medications. I worry that the foul gases and fumes will impact my life on a daily basis making me more susceptible to anxiety and stress, and other serious illnesses.

I want to continue enjoying the life I created here on our family farm. I do not want my life negatively affected in so many ways. I beg you to deny the permit to Rolling Green Family Farms. Please protect my health.

Thank you,

Betty Fraase

Betty Fraase
Buffalo, ND

To ND Heath and Water Quality

I'm writing in regards to the proposed hog farm near us. We live in the southwest corner of Section 25 in Buffalo Township.

Bill has dementia, irregular heartbeat, edema, high blood pressure, Thyroid problems, Kidney disease and COPD. He is homebound so it's that important to be able to have the windows open for fresh air and for him to get outside for a change of pace and stress relief.

We are also concerned about our water supply. Such a large hog farm would use a tremendous amount of water. How can thousands of gallons of untreated manure not affect our water and air quality? Composting the dead hogs would create stench, germs, flies and rodents.

Please deny the permit for the hog farm. Thank you for considering our feelings.

Bill Sheldon
by Marlene Sheldon
3477 144 Ave SE
Buffalo ND 58011-9763

Marlene Sheldon
3477 144 Ave SE
Buffalo ND 58011-9763

To ND Health and Water Quality

I'm writing in regards to the proposed hog farm near us. We live in the southwest corner of Section 25 in Buffalo Township.

I'm writing in concern for our water supply and quality. A 9000 plus hog farm would need alot of water. Spreading Thousands of gallons of raw sewage would certainly affect our water quality. Composting dead animals will contaminate the air, cause stench and attract flies and rodents.

I'm caretaker for my husband, Bill, in our home. I don't leave him alone and seldom leave the farm more than once a week. I have allergies that affect my eyes, irritable bowel syndrome and osteporosis. It's important to have clean air for me to get outside to relieve stress and exercise for my osteporosis. In the Summer I do all the outside chores, upkeep, painting, mowing, gardening flower and vegetables and caring for animals. In the Winter I care for the animals and walk for excerise. One of the nicest things about summer is having the windows open.

Thank you for considering our concerns and please deny the hog farm permit.

Thank you. Marlene Sheldon

000783

To: North Dakota Department of Health

My name is Hal Grieve. I have lived in Buffalo North Dakota since 1962. I grew up in town, went to school and church here, started my first real job here and have hoped to retire here. The news of this factory piglet producing sow farm by Rolling Green Family Farm being built may have me rethinking about retiring in Buffalo or North Dakota for that matter. My back door will be about two miles away, as the bird flies, from this commercial pig farm.

First there is medical evidence saying the air born particulates can affect the respiratory system because of the ammonia, hydrogen and methane. The presence of the odor may raise blood pressure; create depression and PTSB because once it is here we are stuck with it no matter what the ill effects are.

Next is the vast amount of water this facility will need and then the run off from the facility and area fields that the manure is put on. This run off goes into the Maple River then the Red River and on into Lake Winnipeg. There will also be questions regarding effects on ground water under the lagoons.

Rolling Green Family Farms is anything but what its name implies. This is a corporate farm of investors who have worn out their welcome in neighboring states and came to North Dakota looking for and finding lenient zoning and farming laws. From what I understand it is nearly impossible to find out who and where these investors are really from. These are not our friends and neighbors who have devoted their lives carving a living out of the land along with raising a few animals.

As a life resident of North Dakota and one who still lives, works, and finds the beauty in enjoying the fresh air of our outdoors, I ask the Health Department to please deny, again please deny the building of the proposed hog farm near Buffalo, North Dakota.

Hal Grieve
204 4th Ave S
Buffalo, ND. 58011

Hal Grieve

Dear North Dakota Department of Health

I am writing again to express concerns over the proposed swine operation to be built just outside of Buffalo. Since first hearing about the concentrated animal feeding operation I've had time to do research of my own. To find an article or report stating this type of operation is a great opportunity for the people and communities near the operation, or had anyone living near an operation approached someone in our community stating so, it would ease my mind. Neither has happened.

I have lived in Buffalo for 41 years and before that three miles south of the proposed site for 17 years. I am an outside person, spending my time off outside working in my vegetable and flower garden, taking care of the yard, reading, walking and bike riding. Most recently I have been able to share all of this with my seven year old grandson who is with us often.

I fear my way of life as I have known it will change dramatically if the swine operation becomes reality. And, not for the better. The respiratory symptoms from exposure to the air around an operation this large can be nothing but detrimental to those within its path. While my daughter has not said as much, I fear she will not allow my grandson to stay for extended periods of time as he has his entire life. She, who is a doctor, has sent me links to many health related articles.

My mother, who lives in Buffalo, has COPD and congestive heart failure. The air quality within a short time could have a serious impact on her life. I tried to avoid mentioning the odor but feel it deserves attention as it will be a reality. It goes beyond just being a nuisance. How can it not depress someone if they are not able to enjoy life the way they once had, and planned to for the rest of their lives? Depression is real. PTSD is real. Both are medical conditions associated with the odor from these large operations.

I am not opposed to livestock operations, only to those whose existence will negatively affect so many people.

I am asking you consider all concerns; environment, health and social and deny the permit to Rolling Green Family Farm. Buffalo has many things to offer it residents and those in the surrounding area. Hopefully that continues for decades to come.

Thank you for your time.

Terryl Grieve
204 4th Ave S
Buffalo ND 58011

Buffalo, N.D
March 14, 2016

N.D. Health and Water Quality Division:

My name is Carolyn Pfeifer and I live in Buffalo, ND at 500 Pearl St. I am an elderly woman who lives alone, and I am writing to voice my concern about the out-of-state corporation which is attempting to build a huge hog-raising facility very close to our town.

With 9000+ pigs in one small area, the amount of manure and other waste products is bound to be enormous.

Living in the Red River Valley where we are subject to periodic flooding, we are bound to have some serious problems. I would hate to see our water system threatened by the run-off from this farm.

I am also worried about the allergens from this operation which will be released into the air. Research shows that these allergens can travel several hundred miles. Since I suffer from sinus infections caused by my allergies, this really frightens me.

I beg you to consider the adverse consequences of this gigantic hog farm. We sincerely hope that you can put a stop to it.

Yours truly,
Carolyn Pfeifer

To: ND Department of Health and Water Quality

The concerned citizens of Buffalo, ND have done much research about CAFO's and how they affect the neighbors and community surrounding them. We have heard the statements from people that maybe this is o.k. "as long as it isn't in my back yard." We have heard that the Ag special interest groups want this CAFO to come into our community, not their communities. We are concerned about how much weight these special interest groups will have regarding the location of this CAFO. We are asking the North Dakota Department of Health to consider our health and well being, our right (as tax paying citizens of the state of ND) to live where we, our children and grandchildren will have healthy air to breath and water to drink. We believe in farming and livestock, we want to protect our local farm families health and their right to continue to have their family farming businesses grow with out the interference of an out of state entity. As we understand it, the North Dakota Department of Health exists to, has a purpose to and has a mission statement to protect the health and environment of ALL citizens of ND. Again, protecting our health and the environment we live in is your job. The concerned citizens of Buffalo, ND are asking that the testimonies given to you today be reviewed and considered and that the ND Department of Health send a clear message to everyone that the location of this CAFO and any future CAFOs in the state of ND be farther away from cities and family farms. We feel the proposed location of Rolling Green Family Farms Swine CAFO is wrong. The proposed building site and the land where the manure will be spread are TOO close to the family homes in our community and their locations will affect the health and well being of all the people who live in our community.

We have heard we are waisting our time as the swine CAFO is "a done deal" and that the ND Department of Health has already made the decision. We have also heard that the ND Department of Health will do what they have been told to do by the "powers that be" in Bismarck. These statements are terribly upsetting to us. We trust that the people we send to our capitol and the people representing us, the citizens of ND, will work for all the people, not just the ones that are members of a special interest group that has lobbyists in our capitol. We hope that you will not approve this illegal permit, just because it has been submitted, but that you will review all testimony and do your job to protect the citizens of our community and our state.

Will you, the ND Department of Health, do your job, according to your own mission statement, to protect the health and environment of the tax paying, voting citizens of our community and every citizen in the state of ND, or will you protect the business interests of special interest groups and out of state corporations?

Thank you, Carolyn Dostert

2. Letters of Concern

To: The North Dakota Department of Health

I would like to thank the members of The North Dakota Department of Health for giving us a chance to share our concerns. When I recently was made aware of the proposed pig CAFO – friends of mine from other areas of the state told me – "don't waste your time as the decision has already been made in Bismarck!" Your being here today has reassured me that the system still works.

I am Bill Marcks and I was raised on our family farm near Buffalo, North Dakota. After college I served in the US Army, worked in the Fargo Public Schools and eventually returned to my home town of Buffalo about thirty years ago. I am a past Mayor of the community and am proud to be involved in our American Legion, the City of Buffalo Historic Preservation Commission, the Buffalo Community Club and the City Park Board.

The proposed Concentrated Animal Feeding Operation to be located southeast of Buffalo could be devastating to the quality of life I enjoy now with my friends, family and neighbors in our small community of about 200. I am alarmed by the potential for serious health risks for me and everyone exposed to the daily emissions of such a large swine factory. I currently take medication for high pressure and allergies and do not want my health compromised.

Our group of Concerned Citizens in Buffalo is certainly not opposed to local family farms with animals but resistant to corporate control and potential devastation of our water and air quality, and much more. I challenge you to show us communities who feel they are better off with this type of factory farming.

It simply is not true that the employees of this hog operation will be our neighbors, friends or families. The employees will not be family farmers. This is much different from what makes North Dakota a leader in agriculture. We have been leaders because of our strong family farmers and ranchers who own their farms and understand what it means to be connected to the community where they live and work.

As part of the Concerned Citizens of Buffalo, I have done my own research to learn about the huge impact of this type of factory farming. I want a voice in my destiny, for the community I call home, and a sense of well being for my family, friends and neighbors. I strongly oppose any permit for the Rolling Green Family Farm Swine CAFO and ask the ND Department of Health to stop them from moving into our neighborhood and possibly around the state.

TO: North Dakota Department of Health

My name is Liane Rakow Stout and I was born and raised in Buffalo, ND. I am very proud of the quality of education that I received at the Buffalo Public Schools. The consolidated Maple Valley School District has continued this tradition of quality education for the 215 children from our community as well as our neighboring towns of Fingal, Oriska and Tower City. Education is an important part our communities and has given us a way of life we appreciate. We have a strong sense of caring and concern for all who live here.

Our rural life style is based on sustainable agriculture and locally owned family farms. It was a shock to our community when we were informed by a public notice in January that a proposed Concentrated Animal Feeding Operation (CAFO) for 9,000 swine was to be located several miles southeast of Buffalo. I have been involved with a group of concerned citizens who have been reviewing and researching the complex environmental impact and health risks of this type of operation. These are areas of great concern:

Water and Air Pollution: The potential of water pollution from the waste produced by 9,000 swine can contaminate waterways, including the Buffalo Creek, the Maple River and eventually the Red River. The land around the building site is one of the highest elevations in Cass County. Other states with large numbers of CAFO's have experienced 20 to 30 serious water pollution problems a year due to the manure application process to the fields. At the least the quality of daily life in our neighborhoods could be seriously reduced due to the foul-smelling air. Serious respiratory illness can result for workers, and we are especially concerned about similar health impacts, especially to our children and are senior citizens, which includes me.

Property Values and Local Economy: Residential property values often significantly go down when an industrial hog farm moves into the area. We do not understand how this would be good for any growth or sustainability in our community if nobody wants to move here or continue to live here. Once built the Concentrated Animal Feeding Operations usually have their feed trucked in; the animal's regularly trucked out and often low paid labor is used. This scenario robs our community of local economic, environmental, and social benefits, plus saddles us with the costs. We will have to pay for roads used to haul thousands of pigs and truckloads of feed, all with reduced property taxes.

On a personally issue, I have had asthma and chronic allergies my entire life. Any respiratory distress can put me in the emergency room struggling to take each breath. As scary as this for me, I am horrified by the threat to the individuals who will be exposed to the daily emissions of this type of swine factory so close to their homes.

Please carefully consider what we have to lose. I do not want a permit granted to Rolling Green Family Farms. It will cause irreparable damage to the people in the community that I call home.

Liane Rakow Stout

3. Nutrient Management Plan

Hello, my name is Randy Coon and I farm south of Buffalo. The opinions expressed on the topic of nutrient management are solely those of the Concerned Citizens of Buffalo and do not represent any other individual, entity or institution. The large hog confined animal feeding operation (CAFO) proposed near Buffalo will produce large amounts of animal waste. Storage pits beneath the building will have a capacity of 10.2 million gallons, with an estimated 7.0 million gallons that will need to be removed annually. Disposing of this quantity of liquid manure is a significant problem, and using it as a fertilizer for grain crops is essentially the only solution.

Using liquid hog manure as a crop fertilizer does present problems. Manure is not a plant nutrient balances product. In other words, the ratio of nitrogen (N) to phosphorus (P) is such that applying enough nitrogen for crop nutrient requirements will result in excess phosphorus being added to the soil. It is possible for phosphorus to reach high enough levels to cause it to move off-site and get into surface water. North Dakota State University and the University of Minnesota researchers recommend applying enough manure to meet plant phosphorus requirement. The Olson test for phosphorus in the soil measures only the inorganic phosphorus. We strongly recommend the nutrient management plan be required to use phosphorus to set the maximum application rate, and the soil be tested using a total extraction method to determine the total phosphorus (inorganic and organic) in the soil.

Obtaining land application easements, soil testing, liquid manure nutrient testing, application of the manure, and a nutrient management plan are the key components of disposing of the animal waste. Determining the sustainability of this nutrient plan was difficult because five of the six land easement contracts were incomplete. Water quality risk assessment maps provided incorrect legal descriptions and acreages, with one quarter section showing over 200 acres. These maps show boundaries for each parcel and include setbacks which consist of waterways and noncropland acres such as permanent wet lands, shelterbelts, and farmsteads. The maps do not appear to include the Howes Township Ordinance setbacks. These setbacks are important because when the liquid manure is applied, the end-of-field turn involves lifting the applicator but leaving the pump running, dropping the

manure on top of the ground. For these reasons, it would appear that the proposed available acres are overstated.

Nutrient content of liquid manure can vary greatly. A NDSU study recommended using an analysis of 27 pounds of nitrogen, 27 pounds of phosphorus, and 15 pounds of potassium per 1,000 gallons for planning purposes. Soil tests for Field #1 (which had low soil nutrient levels) showed 24 pounds of nitrogen available, 2 ppm of P_2O_5 available, and 182 ppm of K_2O available. A realistic yield goal of 140+ bushel per acre corn would need 175 pounds of N, 102 pounds of P_2O_5, and 170 pounds of K_2O. Using phosphorus to determine the manure application with 80 percent of the P_2O_5 available, 1,000 gallons would add 21.6 pounds of P_2O_5 per acre.

Dividing the 102 pounds per acre required by the 21.6 pounds available per 1,000 gallons would give a 4,722 gallons per acre rate. If 7.0 million gallons of liquid manure were to be disposed of each year, 1,482 acres of corn would be required. Soybean yield goals require no nitrogen, so liquid manure should not be applied for that crop. A corn-soybean rotation would require applying the manure to the same ground every other year. Applying the liquid manure above the recommended rates can lead to nutrients getting into ground water and rivers. Almost all of the proposed acres drain into the Maple River, which further downstream dumps into the Red River. The Red River flows into Canada which could lead to international contamination. This illustrates the reason why it is so important to restrict application rates to match phosphorus requirements.

The proposed location for the facility is in a very unique soils area. Its proximity to the Lake Agassiz shoreline has a significant effect on the area soils. National Resource Conservation Service (NRCS) web soil survey maps provide numerous measurements for these soils, including a Sustainability and Limitations rating. This category is further subdivided into waste management-manure and food processing wastes. These rating are based on soil properties that effect adsorption, plant growth, microbial activity, and erodibility. Rating go from 0.0 to 1.0, with a 1.0 rating classified as "very limited". The "very limited" category included soils that have one or more feature that makes it unfavorable for the specified use. These limitations

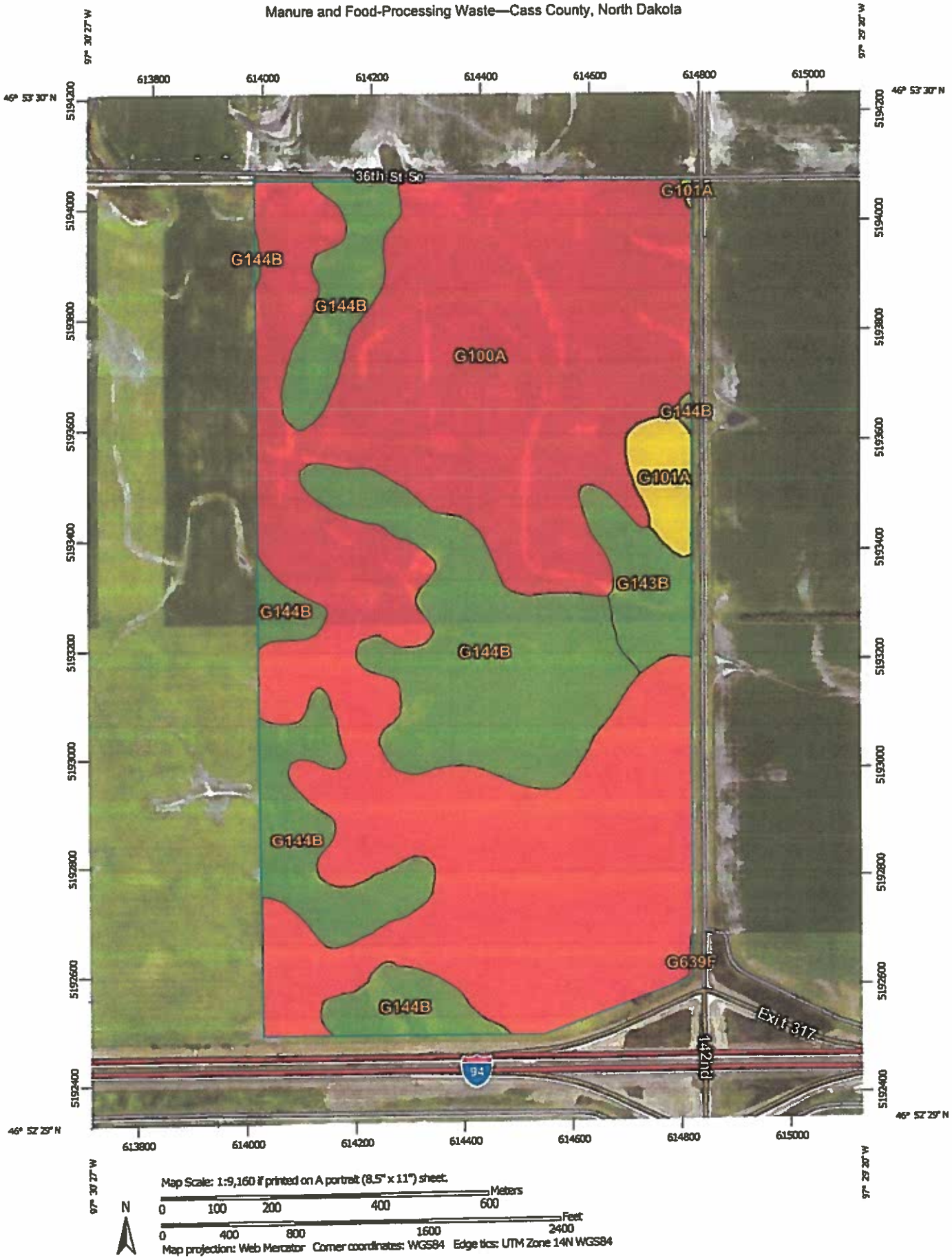
generally cannot be overcome without major spoil reclamation, special design, or expensive installation procedures. These soils are classified as Hamerly-Tonka soils. The quarter section presented by Power Point is adjacent to the proposed facility. The red acres are the Hamerly-Tonka soils with the 1.0 ("very limited") rating. Of the total acres contracted for manure application, 1,408.6 are classified as Hamerly-Tonka with the "very limited" rating. If the Hamerly-Tonka soils are to be considered for manure application, we strongly recommend an environmentally responsible nutrient management plan with strict adherence to application rules and very close monitoring by the Department of Health to prevent pollution and environmental problems.

Further contributing to the potential pollution problems are the amount of tiled acres that drain into the Maple River. Another Power Point map will help explain the concerns for tiled land. The north half of section 36 of Tower Township is tiled land that has been include as land to be used for manure application. NRCS maps provide information regarding Agronomic Concerns for Pesticide and Nutrient Leaching. Hamerly-Tonka soils in this parcel are again rated at 1.0 on the 0.0 to 1.0 scale with the 1.0 being "very limited" for this use. About two-thirds of this parcel are rated as a 1.0, indicating the risk of pesticide and nutrient leaching. The waterway in the southwest corner of this land drains directly into the Maple River about one-half mile away. Applying liquid manure to this land poses a high level of environmental risk. We recommend these acres not be allowed to be use for application of liquid hog manure, or at a minimum be applied in the spring and under close supervision and monitoring by the State Health Department.

Based on the information we have been provided, it does not appear that sufficient acreage is available to dispose of the 7.0 million gallons of liquid hog manure produced annually. Acreage contracts may overstate the available acres, and drain tiled land and Hamerly-Tonka soil problems have not been addressed. Over applying liquid manure to the soils could present serious environmental problems. It does not seem that the nutrient management plan is achievable, or sustainable. Further compounding the problem of disposing of the manure is the "easement map" which will be presented later. The Concerned Citizens of Buffalo urge the North Dakota State Health

Department to stay true to their mission statement. We ask that you protect the health of the Buffalo area citizens, the air quality, the water quality, and the soils by rejecting this permit request.

Thank you.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Feet
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Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cass County, North Dakota
Survey Area Data: Version 15, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Aug 27, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

000799

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)—Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Hamerly (42%)	High water table (1.00)	77.7	24.1%
			Tonka (28%)	High water table (1.00)		
			Wyard (7%)	High water table (1.00)		
			Vallers, moderately saline (7%)	High water table (1.00)		
			Parnell (5%)	High water table (1.00)		
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Very limited	Hamerly (46%)	High water table (1.00)	143.7	44.6%
			Wyard (24%)	High water table (1.00)		
			Tonka (8%)	High water table (1.00)		
			Hamerly, moderately saline (5%)	High water table (1.00)		
			Vallers (4%)	High water table (1.00)		
G143A	Barnes-Svea loams, 0 to 3 percent slopes	Somewhat limited	Barnes (39%)	High water table (0.19)	57.9	18.0%
			Svea (38%)	High water table (0.76)		
			Cresbard (3%)	High water table (0.76)		
G143B	Barnes-Svea loams, 3 to 6 percent slopes	Somewhat limited	Barnes (42%)	High water table (0.19)	8.6	2.7%
			Svea (21%)	High water table (0.76)		
			Balaton (12%)	High water table (0.76)		
			Swenoda (3%)	High water table (0.76)		
			Cresbard (3%)	High water table (0.76)		
G147C	Buse-Barnes-Darnen loams,	Not limited	Buse (28%)		23.4	7.3%
			Barnes (23%)			

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
	3 to 9 percent slopes		Langhei (7%)			
			Langhei, very stony (6%)			
G523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	Very limited	Fluvaquents, channeled, frequently flooded (40%)	High water table (1.00)	11.1	3.5%
				High perc rate (0.21)		
			Lowe, frequently flooded (28%)	High water table (1.00)		
			Lowe, moderately saline, frequently flooded (20%)	High water table (1.00)		
			Lowe, very poorly drained, frequently flooded (5%)	High water table (1.00)		
			Moritz, occasionally flooded (5%)	High water table (1.00)		
Totals for Area of Interest					322.5	100.0%

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Very limited	232.6	72.1%
Somewhat limited	66.5	20.6%
Not limited	23.4	7.3%
Totals for Area of Interest	322.5	100.0%

Description

The interpretation for Agronomic Concerns, Pesticide and Nutrient Leaching evaluates limitations of a soil that increase the hazard of contaminating aquifers, springs, and local water tables.

The soil features considered are saturated hydraulic conductivity and depth to seasonal high water table.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soil is limited by all of the soil features that affect the interpretation. Numerical ratings indicate the severity of individual limitations; the highest numerical rating identifies the most limiting soil feature(s) considered in the rating process. Less restrictive soil features have a lower numerical value than the maximum used to rate the soil. They are identified to provide the user with additional information about soil limitations for the specific use. Restrictive soil features also need to be considered in planning, design, installation, and management. "Not limited" (numerical value for the most restrictive feature = 0.00) indicates that the soil has features that are very favorable for the specified use. "Somewhat limited" (numerical value for the most restrictive feature = 0.01 to 0.99) indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning. "Very limited" (numerical value for the most restrictive feature = 1.00) indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special planning, or expensive installation procedures.

The results of this interpretation are not designed or intended to be used in a regulatory manner.

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

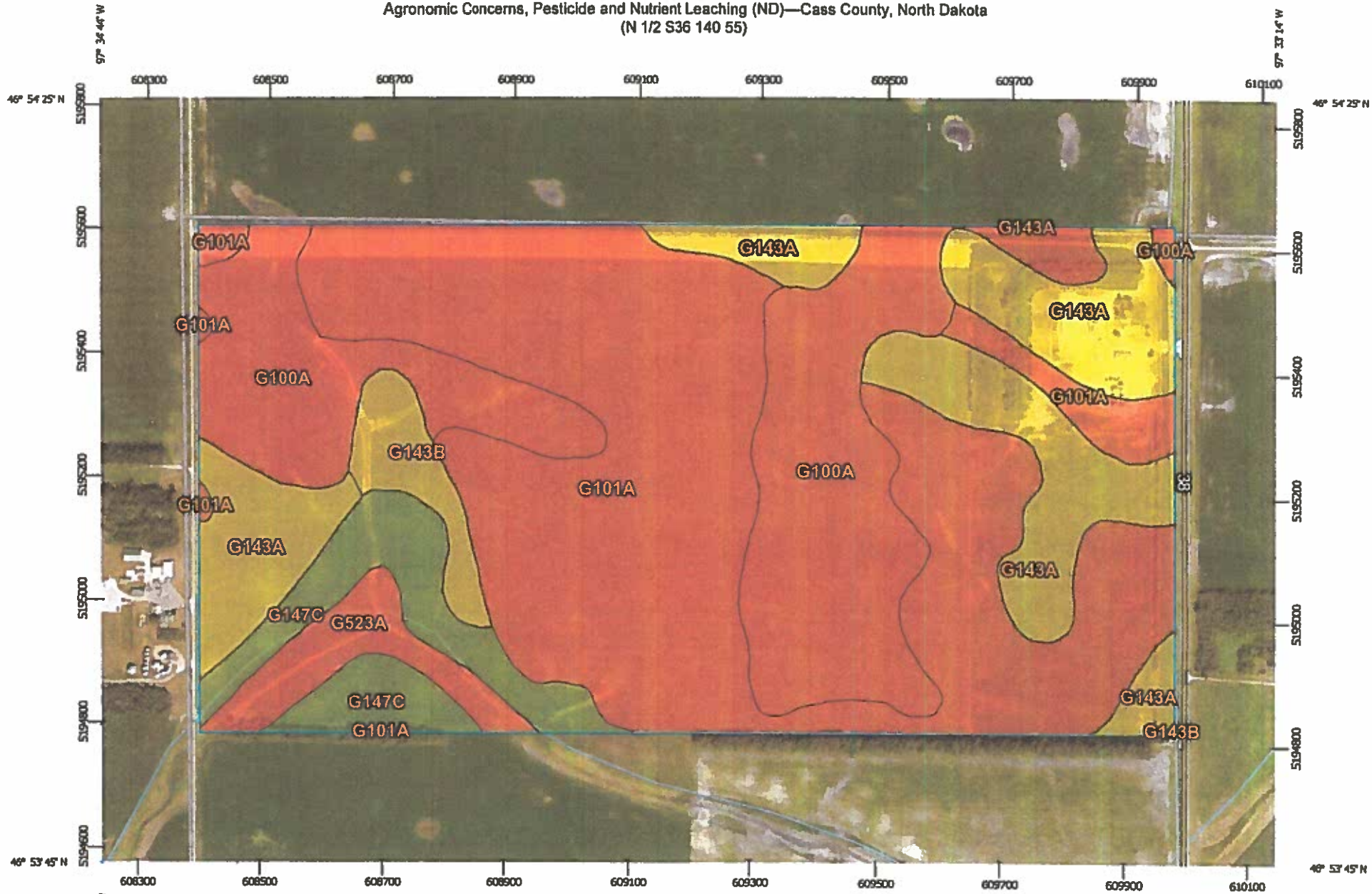
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)—Cass County, North Dakota
(N 1/2 S36 140 55)



Map Scale: 1:8,700 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 100 200 400 600

Feet: 0 400 800 1600 2400

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

000803

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Background
- Aerial Photography

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cass County, North Dakota
Survey Area Data: Version 15, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Aug 27, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

000804

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)—Summary by Map Unit—Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G6A	Vallers loam, 0 to 1 percent slopes	Very limited	Vallers (67%)	High water table (1.00)	6.0	1.0%
			Hamerly (13%)	High water table (1.00)		
			Vallers, moderately saline (8%)	High water table (1.00)		
			Tonka (5%)	High water table (1.00)		
			Parnell (3%)	High water table (1.00)		
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Hamerly (42%)	High water table (1.00)	111.1	17.8%
			Tonka (28%)	High water table (1.00)		
			Wyard (7%)	High water table (1.00)		
			Vallers, moderately saline (7%)	High water table (1.00)		
			Parnell (5%)	High water table (1.00)		
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Very limited	Hamerly (46%)	High water table (1.00)	38.1	6.1%
			Wyard (24%)	High water table (1.00)		
			Tonka (8%)	High water table (1.00)		
			Hamerly, moderately saline (5%)	High water table (1.00)		
			Vallers (4%)	High water table (1.00)		
G143A	Barnes-Svea loams, 0 to 3 percent slopes	Somewhat limited	Barnes (39%)	High water table (0.19)	23.6	3.8%
			Svea (38%)	High water table (0.76)		
			Cresbard (3%)	High water table (0.76)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)—Summary by Map Unit—Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G143B	Barnes-Svea loams, 3 to 6 percent slopes	Somewhat limited	Barnes (42%)	High water table (0.19)	171.2	27.4%
			Svea (21%)	High water table (0.76)		
			Balaton (12%)	High water table (0.76)		
			Swenoda (3%)	High water table (0.76)		
			Cresbard (3%)	High water table (0.76)		
G143C	Barnes-Buse-Langhei loams, 6 to 9 percent slopes	Not limited	Barnes (24%)		37.2	5.9%
			Buse (23%)			
			Langhei (18%)			
			Renshaw (3%)			
G144B	Barnes-Buse loams, 3 to 6 percent slopes	Somewhat limited	Barnes (25%)	High water table (0.19)	66.2	10.6%
			Svea (14%)	High water table (0.76)		
			Balaton (10%)	High water table (0.76)		
			Swenoda (3%)	High water table (0.76)		
			Cresbard (3%)	High water table (0.76)		
			Sioux (2%)	High perc rate (0.22)		
G250A	Divide loam, 0 to 2 percent slopes	Very limited	Divide (70%)	High water table (1.00)	14.0	2.2%
			Marysland (14%)	High water table (1.00)		
			Wyrene (4%)	High water table (1.00)		
				High perc rate (0.08)		
G523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	Very limited	Fluvaquents, channeled, frequently flooded (40%)	High water table (1.00)	144.3	23.1%
				High perc rate (0.21)		
			Lowe, frequently flooded (28%)	High water table (1.00)		
			Lowe, moderately saline, frequently flooded (20%)	High water table (1.00)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Lowe, very poorly drained, frequently flooded (5%)	High water table (1.00)		
			Moritz, occasionally flooded (5%)	High water table (1.00)		
G546A	Lowe loam, saline, 0 to 1 percent slopes, occasionally flooded	Very limited	Lowe, moderately saline, occasionally flooded (78%)	High water table (1.00)	14.1	2.3%
			Lowe, very poorly drained, frequently flooded (8%)	High water table (1.00)		
			Lowe, occasionally flooded (5%)	High water table (1.00)		
			Harriet, occasionally flooded (4%)	High water table (1.00)		
			Moritz, saline-sodic sub, occasionally flooded (4%)	High water table (1.00)		
Totals for Area of Interest					625.8	100.0%

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Very limited	327.6	52.4%
Somewhat limited	261.0	41.7%
Not limited	37.2	5.9%
Totals for Area of Interest	625.8	100.0%

Description

The interpretation for Agronomic Concerns, Pesticide and Nutrient Leaching evaluates limitations of a soil that increase the hazard of contaminating aquifers, springs, and local water tables.

The soil features considered are saturated hydraulic conductivity and depth to seasonal high water table.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soil is limited by all of the soil features that affect the interpretation. Numerical ratings indicate the severity of individual limitations; the highest numerical rating identifies the most limiting soil feature(s) considered in the rating process. Less restrictive soil features have a lower numerical value than the maximum used to rate the soil. They are identified to provide the user with additional information about soil limitations for the specific use. Restrictive soil features also need to be considered in planning, design, installation, and management. "Not limited" (numerical value for the most restrictive feature = 0.00) indicates that the soil has features that are very favorable for the specified use. "Somewhat limited" (numerical value for the most restrictive feature = 0.01 to 0.99) indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning. "Very limited" (numerical value for the most restrictive feature = 1.00) indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special planning, or expensive installation procedures.

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Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Concerns Regarding the Nutrient Management Plan for Rolling Green Family Farms Proposed Buffalo, ND Location

Prepared by

Concerned Citizens of Buffalo

For Presentation to

The North Dakota Department of Health

March 17, 2016

CONCERNS

Reviewing the Rolling Green Family Farms nutrient management plan has resulted in several areas of concern. Items identified in the text of this document will be summarized and presented as concerns and concerned questions. The identified items are:

1) Land easement application forms are incomplete

2) Legal descriptions and acreage errors on the Water Quality Risk Assessment Maps

3) Crop rotations were not listed making it difficult to determine nutrient needs

4) Soil test levels of Phosphorus should be used to determine manure application rates

5) Available acreages appear to be overstated --- township setbacks are not on maps and land for the facility are included as eligible acres

6) NRCS waste management soil ratings were not addressed

7) Pollution from the manure application will ultimately end up in the Maple River which feeds into the Red River

8) Hamerly-Tonka soils are rated "very limited" for application of manure and food processing wastes --- they account for 1,408.6 acres of the total listed for manure application

9) Application of liquid manure on tiled land --- what is the policy in other states

10) Who is going to monitor and enforce the nutrient management plan?

    ----over application

    -----setbacks

    ------water pollution

Nutrient Management Using Liquid Hog Manure

A large confined animal feeding operation (CAFO) produces vast amounts of animal wastes. The hog CAFO proposed for the Buffalo, ND area will have storage pits with a holding capacity of 10.2 million gallons. Estimating the gallons of liquid manure produced annually is dependent on the number of hogs, their weight, whether it is a gestating sow or a sow with a litter, and the amount of water used for cleanup, etc. For a facility the size of the one proposed in the Buffalo area an estimated 7.0 million gallons of liquid hog manure will be produced per year. Disposing of this quantity of manure is a significant problem, and using it as fertilizer for grain crops is essentially the only solution.

Using liquid hog manure as a crop fertilizer does present problems. Manure fertilizer is not a plant nutrient balanced product. In other words, the ratio of nitrogen (N) to phosphorus (P) is such that applying enough N for crop nutrient requirements will result in excess P being added to the soil. It is possible for P to reach levels high enough to cause it to move off-site and get into surface water. Accordingly, Linderman (2012) recommended North Dakota producers apply enough manure to meet the P requirements of the crop and use commercial fertilizer to bring the N to desired levels. Similar recommendations have been made for Minnesota (Schmitt and Rehm 1992) with application rates based on soil tests for P. Although the soil tests submitted as part of the Nutrient Management Plan (Appendix D) indicated a "low" phosphorus risk, environmental concerns would suggest using the University recommenctions for nutrient management. Liquid hog manure also contains potassium (K). Nutrient content for commercial and manure fertilizer are measured differently. For example, a common commercial fertilizer is 11-52-0. This fertilizer contains 11 percent N, 52 percent P, and no K. A ton (2,000 pounds) of this fertilizer has 220 pounds of N, 1,040 pounds of P, and no K. Liquid hog manure is typically expressed as pounds of N, P_2O_5, and K_2O per 1,000 gallons.

Nutrient content of liquid hog manure varies greatly with pounds of N per 1,000 gallons ranging from 15 to 50, pounds of P ranging from 8 to 20, and pounds of K ranging from 8 to 20 (Saskatchewan Soil Conservation Association 1997). Numerous studies have estimated the nutrient value of liquid hog manure. Table 1 presents the estimates for two studies from North Dakota State University and one from the University of Minnesota. The nutrient content for N, P_2O_5, and K_2O reported in the Linderman study was used for this analysis. Nitrogen in the liquid hog manure contains both inorganic and organic matter. The inorganic form of nitrogen in manure is found as ammonium nitrogen (NH_4-N) which is immediately available to plants. The relationship between the inorganic and organic content of the liquid hog manure can vary greatly, but Schmitt and Rehm (1998) estimated that 50 percent of the nitrogen would be available in the first year, 35 percent in the second and third years, and 15 percent would be lost. (All supporting documents referenced and relating to this analysis are presented in Appendix C.)

Table 1. Pounds of Nitrogen, Phosphorus, and Potassium Estimated by Selected Studies, and Values Used for this Analysis

Source	N	P_2O_5	K_2O
	----------Pounds per 1,000 Gallons----------		
Linderman (2002)	27	27	15
Weiderholt et al. (2005)	26	26	20
Schmitt and Rehm (1992)	36	27	22
Selected for Analysis	27	27	15

Obtaining land application easements, soil testing, liquid manure nutrient testing, application of the liquid manure, and a nutrient management plan are the key components of disposing of the animal wastes. A copy of the land easement contracts is presented in Appendix A. Based on the incomplete information provided on five of the six contracts, it is difficult to determine what crops are to be grown and possible crop rotations. Acres reported on the land easement agreement appear to be total cropland acres or Farm Service Agency cropland acres. Without the listing of the crops to be planted on the contracted actress, it is difficult to determine how much liquid manure can be used beyond year one.

Water quality risk assessment maps for each of the fields contracted for liquid hog manure application are presented in Appendix B. These maps show the boundaries for each parcel and indicate the total cropland acres. Setbacks are included but only include water ways and noncropland areas such as permanent wet areas, shelterbelts, and farmsteads. No setbacks are indicated for compliance with township ordnances. Subtracting the risk assessment reported with from the total cropland acres provided the setback acres (Table 2). Also, acres for the CAFO location (NW ¼-4-139-54) have not been removed from the fertilization application acres. The legal description for fields 18 & 19 are incorrect, causing further confusion. Total acres for field 16 & 17 add up to 207.4 acres. Errors and omissions in this data set complicate the calculation of how many acres are available for liquid manure application.

Appendix D presents the nutrient management plan and associated soil tests. Soil tests indicate the N, P_2O_5, and K_2O nutrient levels in the soil, and realistic yield goal nutrient requirements are presented. The realistic yield goal nutrient requirements are available for corn, soybeans, and edible beans. Soil test results for four selected fields are presented in Table 3. The soil tests indicate that the P_2O_5 levels for the four fields range from "very low" to "medium", and one field has K_2O levels that are "high" and the other three were "very high". Table 4 presents the nutrient levels needed for corn to produce yields of 140 bushels per acre or more. Similar data were available for soybeans and dry edible beans are presented in Tables 5 and 6, respectively.

Table 2. Water Quality Risk Assessment Map Acres, Setback Acres, and Listed Acres for Liquid Manure, 2015

Field Number	Map Acres	Setback Acres	Listed Acres
1 & 2	285.6	5.1	280.5
3	156.4	--	156.4
4 & 5	293.7	10.9	282.8
6	78.9	0.9	78.0
7 & 8 & 9	306.4	15.1	291.3
10	157.7	17.5	140.2
11	158.2	0.2	158.0
12	114.0	1.7	112.3
13 & 14 & 15	498.5	10.1	488.4
16 & 17	151.4	4.5	146.9
18 & 19	301.9	1.2	300.7
20	57.6	--	57.6
21	140.5	32.8	107.7
22 & 23 & 24	566.0	8.3	557.7
25	153.1	3.1	150.0
Total			3,308.5

Table 3. Soil Test Results for Four Selected Fields Contracted for liquid Hog manure Application

Field Number	N	P_2O_5[1]	K_2O[2]
	---(lbs)---	---(ppm)---	---(ppm)---
1	24	2	182
6	28	4	166
17	42	8	239
22	42	10	125

[1]Phosphorus (ppm) rankings of 0-3 are in the very low category, 4-7 are low, 8-11 are medium, 12-15 are high, and 16+ are very high (Franzen 2013).

[2]Potassium (ppm) rankings of 0-40 are very low, 41-80 are low, 81-120 are medium, 121-160 are high, and 161+ are very high (Franzen 2013).

Table 4. Required Nutrients for Corn With A 140 Bushel Per Acre or Above Realistic Yield Goal, for Four Selected Fields

Field Number	Yield Goal	N	P_2O_5	K_2O
	---bu/acre---	---lb/acre---	---lb/acre---	---lb/acre---
1	146	175	102	170
6	141	169	98	164
17	148	177	103	172
22	162	194	113	188

Table 5. Required Nutrients for Soybeans With A 37 Bushel Per Acre Realistic Yield Goal, for Four Selected Fields

Field Number	Yield Goal	N	P_2O_5	K_2O
	---bu/acre---	---lb/acre---	---lb/acre---	---lb/acre---
1	37	--	57	81
6	37	--	57	81
17	37	--	57	81
22	37	--	57	81

Table 6. Required Nutrients for Dry Edible Beans With A 1,476 Pounds Per Acre Realistic Yield Goal, for Four Selected Fields

Field Number	Yield Goal	N	P_2O_5	K_2O
	---bu/acre---	---lb/acre---	---lb/acre---	---lb/acre---
1	1,476	74	34	51
6	1,476	74	34	51
17	1,476	74	34	51
14	1,476	74	34	51

Determining the fertilizer application rates requires several calculations. For nitrogen, there could be a credit from the previous crop. Crops such as soybeans, edible beans, peas and lentils, and chick peas typically have a nitrogen credit (Franzen 2013). The nitrogen credit for these crops has been estimated to be 40 pounds of N per acre. Nitrogen required would be the N level necessary for the realistic yield goal less the existing N in the soil less the N credit. This would give the pounds of N required, but as previously stated, about half of the N in liquid hog manure is available the first year. For soil tests with P in the "very low" or "low" category, the full amount of P_2O_5 required could be applied. Application of liquid hog manure results in 80 percent of the P_2O_5 available in the first year.

An example will help illustrate the calculations. In order to obtain a 146 bushel per acre corn yield on field 1, the nutrients required would be 175 pounds per acre of N, 102 pounds per acre of P_2O_5 (because the soil test indicated "very low" parts per million) and no K_2O (because soil levels are already "very high"). Nitrogen required would be 174 pounds less the 24 pounds already in the soil less the 40 pounds soybean credit (assuming the corn is planted on a field that was soybeans the previous year). A total of 111 pounds per acre of N should be added to the soil. As previously stated 50 percent of the N in liquid hog manure is available in the first year, so the 27 pounds of N per 1,000 gallons of manure actually provides 13.5 pounds of N the first year. A total of 8,222 gallons would be needed to be applied to meet the N requirement. The 27 pounds of P_2O_5 in the liquid manure is only 80 percent available to the crop in the first year, so the product has 21.6 pounds of P_2O_5 per 1,000 gallons. A nutrient requirement of 102 pounds of P_2O_5 per acre would require 4,722 gallons to be applied. If the 8,222 gallons of manure necessary to reach the N goal were applied, 178 pounds of P_2O_5 would be added to the soil and be available in first year. This far exceeds the maximum recommended level of 102 pounds per acre. If the

manure were applied using the P soil test to determine the gallons per acre, 1,482 acres would be required to use the 7 million gallons of liquid hog manure produced per year.

If the application of the liquid manure was based on the recommended P level soil tests, the 7 million gallons of liquid manure could be disposed of in year 1, based on the acres available (Table 2). Without knowing what crops are going to be planted and the rotations, it is difficult to guarantee the same result in subsequent years. At a minimum, the manure would have to be applied to the same land every second year based on the available acres. Soils in this area are naturally high in K, so typically no K_2O would need to be applied. The liquid hog manure would add K to soils every other year with this scenario, building K levels to a point where it could contribute to soil salinity. Also, the acres may be overstated because of the plant citing acreage was included and no township setback acres are included in the nutrient management plan.

Another potential problem for the acreages is the National Conservation Resources Service Manure and Food Processing Waste soil ratings. These ratings are based on soil properties that affect absorption, plant growth, microbial activity, and erodibility. The ratings cover manure and food processing waste in solid, slurry, and liquid form. These ratings go from 0.0 to 1.0, with a 1.0 rating being classified as "very limited". The "very limited" category includes soils that have one or more features that make it unfavorable for the specified use. These limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Soil maps showing the "very limited" areas for each field contracted (by quarter section) are presented in Appendix E. For the land that has been contracted for manure application, 1,408.6 acres are classified as 1.0, or "very limited" (Table 7). These soils are classified as Hamerly-Tonka and characterized by slow water movement or ponding. Applying liquid manure to these soils could present serious environmental problems.

A map showing the locations of the land contracted for application indicates manure would have to be hauled as far as 8 miles to the northwest and 6 miles to the south. Also, applying liquid manure to tiled land is currently new to North Dakota. Much of the tilled land identified in the acreage contracts drains directly into the Maple River, which in turn ends up in the Red River. This could become an international problem if nitrogen and phosphorus leach or erode into the local waterways. It is also important to know who will be responsible for monitoring and enforcing sound environmental regulations. Based on the data currently available, it does not appear that the nutrient management plan for this CAFO is sustainable.

Table 7. Field Nutrient Easement Acres Reported, Water Quality Risk Assessment Acres, and National Resources Conservation Service Manure and Food Processing Waste Soil Type Acres Rated Very Limited

Field Number	Legal Description	Land Acres	Water Quality Acres	Very Limited Acres
1 & 2	E ½-9-139-54	284.9	285.6	171.5
3	NW ¼-4-139-54	150.0	156.4	54.5
4 & 5	N ½-36-140-55	293.0	293.7	86.4
6	W ½ SW ¼-12-139-55	78.0	78.9	43.2
7 & 8 & 9	E ½ -32-139-54	308.8	306.4	101.9
10	NE ¼ -14-139-55	157.7	157.7	59.9
11	SE ¼ -10-140-55	158.0	158.2	97.8
12	NW ¼ -14-140-55	114.0	114.0	64.8
13 & 14 & 15	11-140-45	500.0	498.5	281.6
16 & 17	NE ¼ -2-139-55	150.0	151.4	12.4
18 & 19	E ½ -4-139-54	300.7	301.9	215.6
20	S ½ -SE ¼ -11-139-55	60.0	57.6	21.9
21	NW ¼ -12-139-55	120.0	140.5	67.0
22 & 23 & 24	29-140-54	550.0	566.0	93.4
25	NE ¼ -32-140-54	155.0	153.1	36.7
Total				1,408.6

APPENDIX A

Land Application Easements

10D. LAND APPLICATION EASEMENTS

Land application easements for nutrient application are attached.

MANURE SPREADING AGREEMENT

I, JOSEPH J. HARBEKE (Property Owner's Name) owning fields with the following legal descriptions and approximate acres:

- Legal Description NE ¼ 14-139-55 Approximate Acres: 157.68
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____

These fields located in Cass County do hereby give Rolling Green Sow Farm permission to apply effluent and/ or solids to the above listed acreage as fertilizer. The acreage will be used for raising _____. The application rate of effluent and/or solids from the Rolling Green Sow Farm will not exceed the crop's nutrient needs in a 12-month period and will be in accordance with good farming practices.

This agreement is for 15 years and shall be renewed automatically for the same amount of time specified above, unless written notification of said parties' intent to not renew the Agreement is received by Registered Mail at least one Hundred Eighty (180) days in advance of the expiration of this Agreement. If the above property is to be sold or disposed of by the Property Owner or his Estate, that his Easement be an attached Condition of Sale and Above terms will stay in effect with the new Property Owner.

SIGNED:

Property Owner: Joseph J. Harbeke (Signature) JOSEPH J. HARBEKE (Print Name)

Facility Owner: _____ (Signature) _____ (Print Name)

MANURE SPREADING AGREEMENT

I, Randal Melvin (Property Owner's Name) owning fields with the following legal descriptions and approximate acres:

- Legal Description 11-140-55 Approximate Acres: 500
- Legal Description NE¼ 2-139-55 Approximate Acres: 150
- Legal Description E½ 4-139-54 Approximate Acres: 300.68
- Legal Description S½ SE¼ 11-139-55 Approximate Acres: 60
- Legal Description NW¼ 12-139-55 Approximate Acres: 120
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____

These fields located in Cass County do hereby give Rolling Green Sow Farm permission to apply effluent and/ or solids to the above listed acreage as fertilizer. The acreage will be used for raising _____. The application rate of effluent and/or solids from the Rolling Green Sow Farm will not exceed the crop's nutrient needs in a 12-month period and will be in accordance with good farming practices.

This agreement is for 15 years and shall be renewed automatically for the same amount of time specified above, unless written notification of said parties' intent to not renew the Agreement is received by Registered Mail at least one Hundred Eighty (180) days in advance of the expiration of this Agreement. If the above property is to be sold or disposed of by the Property Owner or his Estate, that his Easement be an attached Condition of Sale and Above terms will stay in effect with the new Property Owner.

SIGNED:

Property Owner _____ (Signature) Randal Melvin (Print Name)

Facility Owner: _____ (Signature) _____ (Print Name)

MANURE SPREADING AGREEMENT

I, Tim Berntson (Property Owner's Name) owning fields with the following legal descriptions and approximate acres:

- Legal Description section 29 140-54 Approximate Acres: 550
- Legal Description NE¼ sec. 32 140-54 Approximate Acres: 155
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____

These fields located in Cass County do hereby give Rolling Green Sow Farm permission to apply effluent and/ or solids to the above listed acreage as fertilizer. The acreage will be used for raising Corn/soybean The application rate of effluent and/or solids from the Rolling Green Sow Farm will not exceed the crop's nutrient needs in a 12-month period and will be in accordance with good farming practices.

This agreement is for 15 years and shall be renewed automatically for the same amount of time specified above, unless written notification of said parties' intent to not renew the Agreement is received by Registered Mail at least one Hundred Eighty (180) days in advance of the expiration of this Agreement. If the above property is to be sold or disposed of by the Property Owner or his Estate, that his Easement be an attached Condition of Sale and Above terms will stay in effect with the new Property Owner.

SIGNED:

Property Owner _____ Timothy M. Berntson
Signature Print Name

Facility Owner: _____ _____
Signature Print Name

MANURE SPREADING AGREEMENT

I, Melvin Family RE LLP (Property Owner's Name) owning fields with the following legal descriptions and approximate acres:

- Legal Description NW ¼ 4-139-54 Approximate Acres: 150
- Legal Description E ½ 4-139-54 Approximate Acres: 284.92
- Legal Description N ½ 36-140-55 Approximate Acres: 293
- Legal Description W ½ SW ¼ 12-~~139~~ 140-55 Approximate Acres: 78
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____

These fields located in Cass County do hereby give Rolling Green Sow Farm permission to apply effluent and/ or solids to the above listed acreage as fertilizer. The acreage will be used for raising _____. The application rate of effluent and/or solids from the Rolling Green Sow Farm will not exceed the crop's nutrient needs in a 12-month period and will be in accordance with good farming practices.

This agreement is for 15 years and shall be renewed automatically for the same amount of time specified above, unless written notification of said parties' intent to not renew the Agreement is received by Registered Mail at least one Hundred Eighty (180) days in advance of the expiration of this Agreement. If the above property is to be sold or disposed of by the Property Owner or his Estate, that his Easement be an attached Condition of Sale and Above terms will stay in effect with the new Property Owner.

SIGNED:

Property Owner Gerald Melvin (Signature) Gerald Melvin (Print Name)

Facility Owner: _____ (Signature) _____ (Print Name)

MANURE SPREADING AGREEMENT

I, Jonathan Melvin (Property Owner's Name) owning fields with the following legal descriptions and approximate acres:

- Legal Description SE ¼ 10-140-55 Approximate Acres: 158
- Legal Description NW ¼ 14-140-55 Approximate Acres: 113.98
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____

These fields located in Cass County do hereby give Rolling Green Sow Farm permission to apply effluent and/ or solids to the above listed acreage as fertilizer. The acreage will be used for raising _____. The application rate of effluent and/or solids from the Rolling Green Sow Farm will not exceed the crop's nutrient needs in a 12-month period and will be in accordance with good farming practices.

This agreement is for 15 years and shall be renewed automatically for the same amount of time specified above, unless written notification of said parties' intent to not renew the Agreement is received by Registered Mail at least one Hundred Eighty (180) days in advance of the expiration of this Agreement. If the above property is to be sold or disposed of by the Property Owner or his Estate, that his Easement be an attached Condition of Sale and Above terms will stay in effect with the new Property Owner.

SIGNED:

Property Owner Jonathan Melvin — Signature

Jonathan Melvin — Print Name

Facility Owner: _____ — Signature

_____ — Print Name

MANURE SPREADING AGREEMENT

I, Eldwyn Van Bruggen (Property Owner's Name) owning fields with the following legal descriptions and approximate acres:

- Legal Description E ½ 32 - 139 - 54 Approximate Acres: 308.84
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____
- Legal Description _____ Approximate Acres: _____

These fields located in Cass County do hereby give Rolling Green Sow Farm permission to apply effluent and/ or solids to the above listed acreage as fertilizer. The acreage will be used for raising _____. The application rate of effluent and/or solids from the Rolling Green Sow Farm will not exceed the crop's nutrient needs in a 12-month period and will be in accordance with good farming practices.

This agreement is for 15 years and shall be renewed automatically for the same amount of time specified above, unless written notification of said parties' intent to not renew the Agreement is received by Registered Mail at least one Hundred Eighty (180) days in advance of the expiration of this Agreement. If the above property is to be sold or disposed of by the Property Owner or his Estate, that his Easement be an attached Condition of Sale and Above terms will stay in effect with the new Property Owner.

SIGNED:

Property Owner Eldwyn Van Bruggen ELDWYN VAN BRUGGEN
Signature Print Name

Facility Owner: _____ _____
Signature Print Name

APPENDIX B

Water Quality Risk Assessment Maps

DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
PO Box 522 | Mandan, ND | 58554

Water Quality Risk Assessment Map

Name: Rolling Green Sow Farm

Landowner: Melvin Family RE LLLP

Legal: E ½ S9-T139N-R54W, Cass County, ND

Acres: 280.5 Combined

Legend

Boundary | Registered Wells | Setback | Tile Inlets

"L" Nitrogen Leaching – High Risk | "R" Phosphorus Runoff – High Risk

DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
PO Box 522 | Mandan, ND | 58554

Water Quality Risk Assessment Map

Name: Rolling Green Sow Farm

Landowner: Melvin Family RE LLLP

Legal: NW ¼ S4-T139N-R54W, Cass County, ND

Acres: 156.4

Legend

Boundary | Registered Wells | Setback | Tile Inlets

"L" Nitrogen Leaching – High Risk | "R" Phosphorus Runoff – High Risk

DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
PO Box 522 | Mandan, ND | 58554

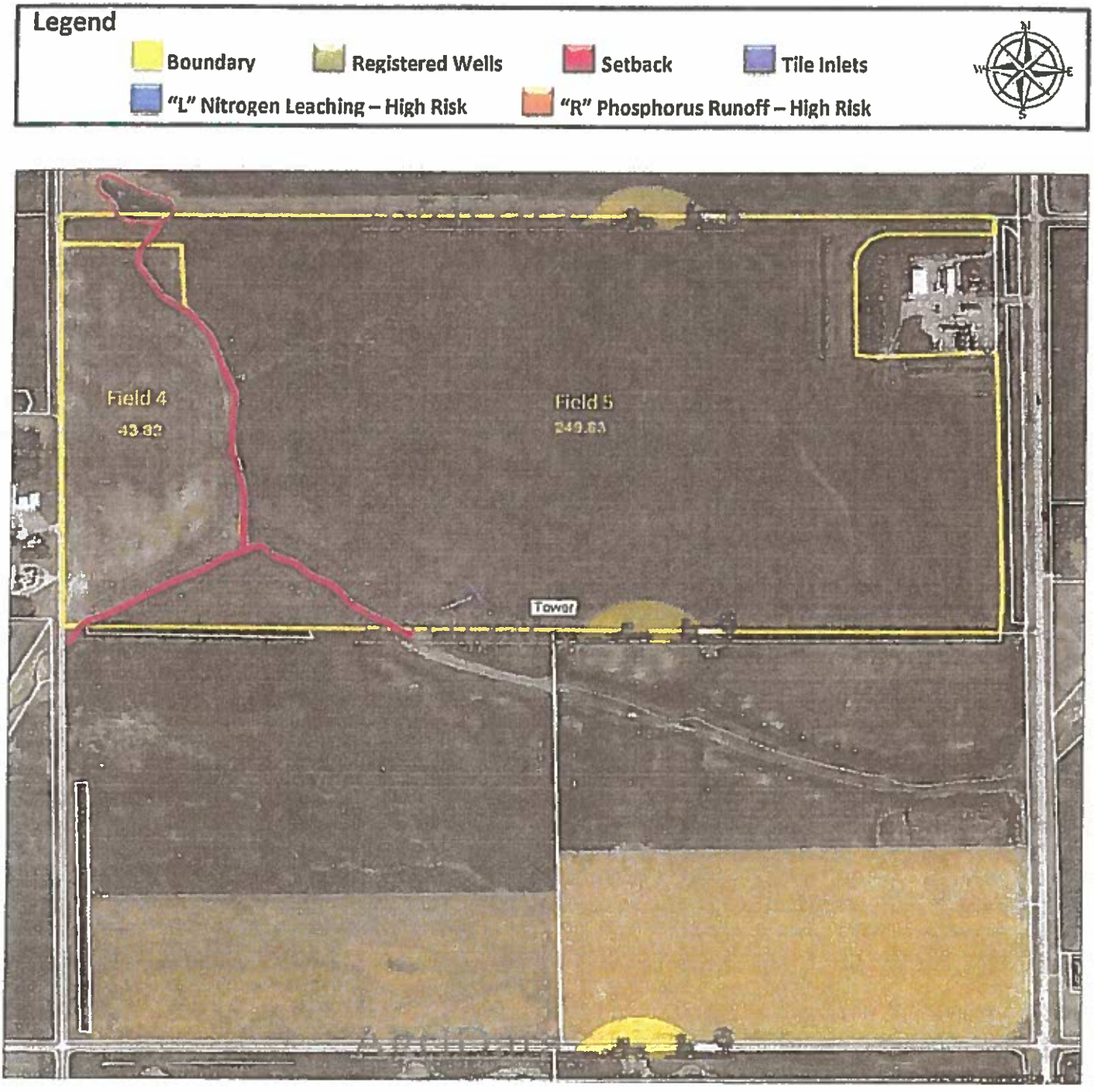
Water Quality Risk Assessment Map

Name: Rolling Green Sow Farm

Landowner: Melvin Family RE LLLP

Legal: N ½ S36-T140N-R55W, Cass County, ND

Acres: 282.8 Combined



DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
PO Box 522 | Mandan, ND | 58554

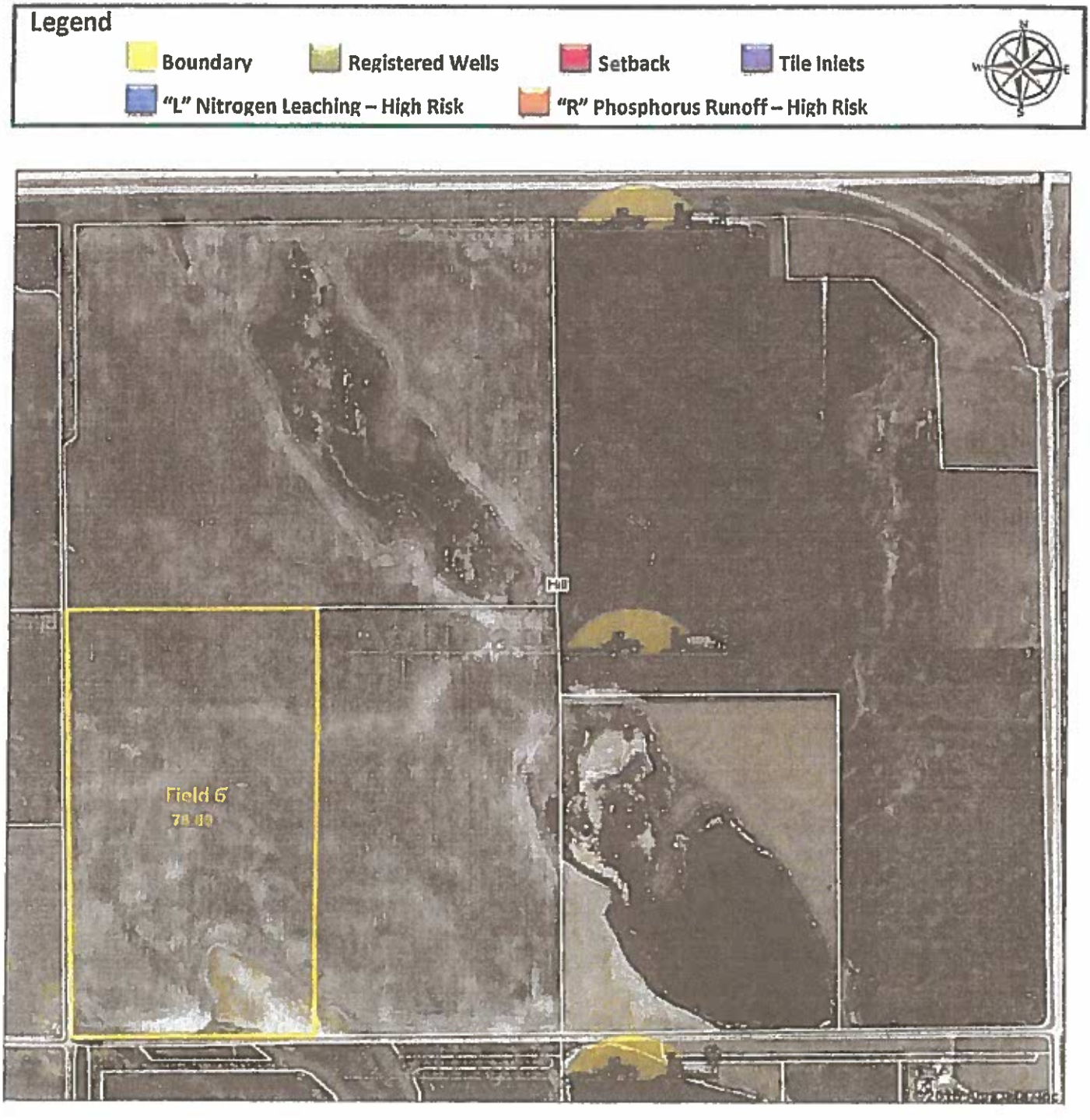
Water Quality Risk Assessment Map

Name: Rolling Green Sow Farm

Landowner: Melvin Family RE LLLP

Legal: W ½ SW ¼ S12-T139N-R55W, Cass County, ND

Acres: 78



DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
PO Box 522 | Mandan, ND | 58554

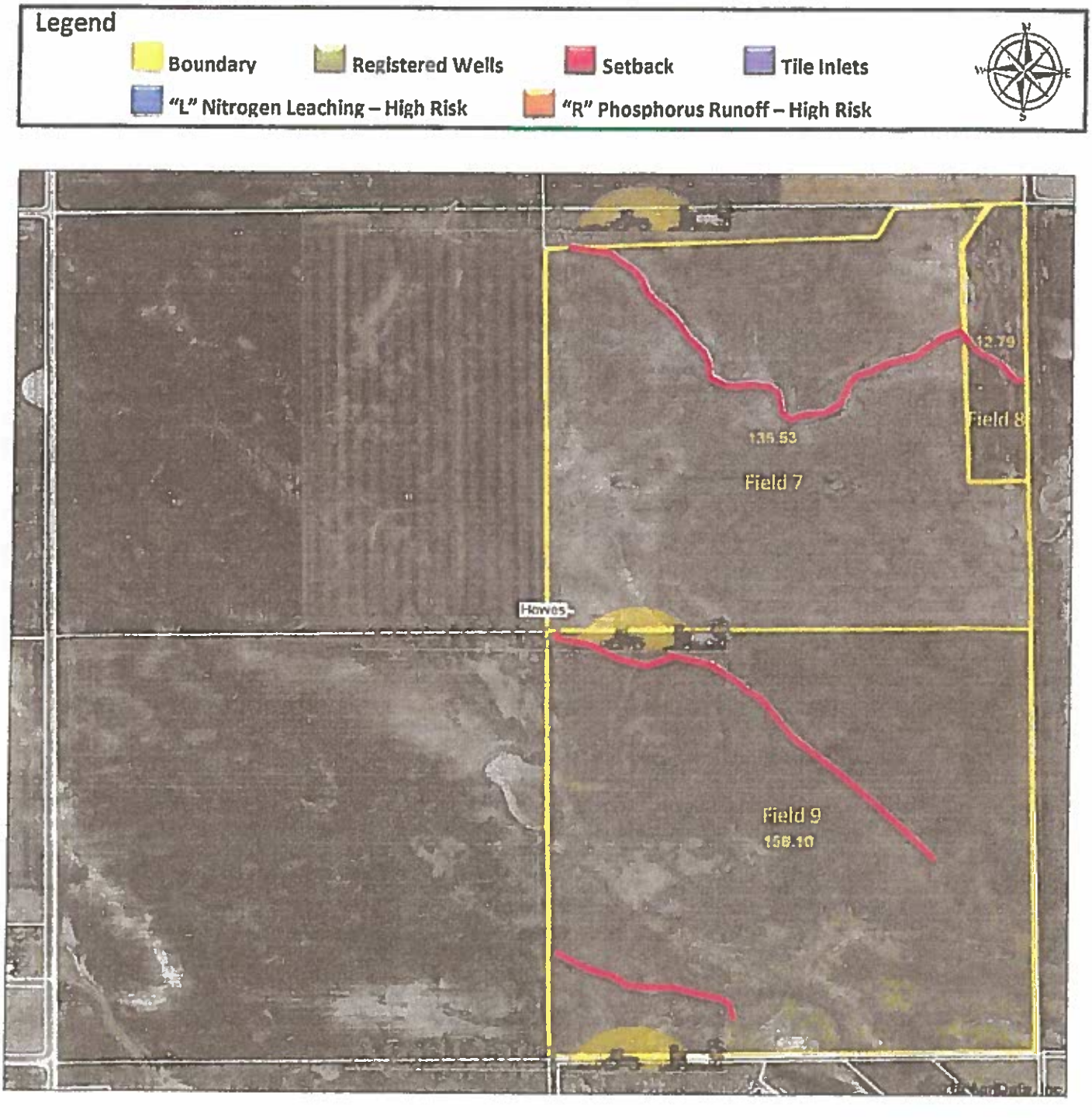
Water Quality Risk Assessment Map

Name: Rolling Green Sow Farm

Landowner: Eldwyn Van Bruggen

Legal: E ½ S32-T139N-R54W, Cass County, ND

Acres: 291.3 Combined



DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
PO Box 522 | Mandan, ND | 58554

Water Quality Risk Assessment Map

Name: Rolling Green Sow Farm

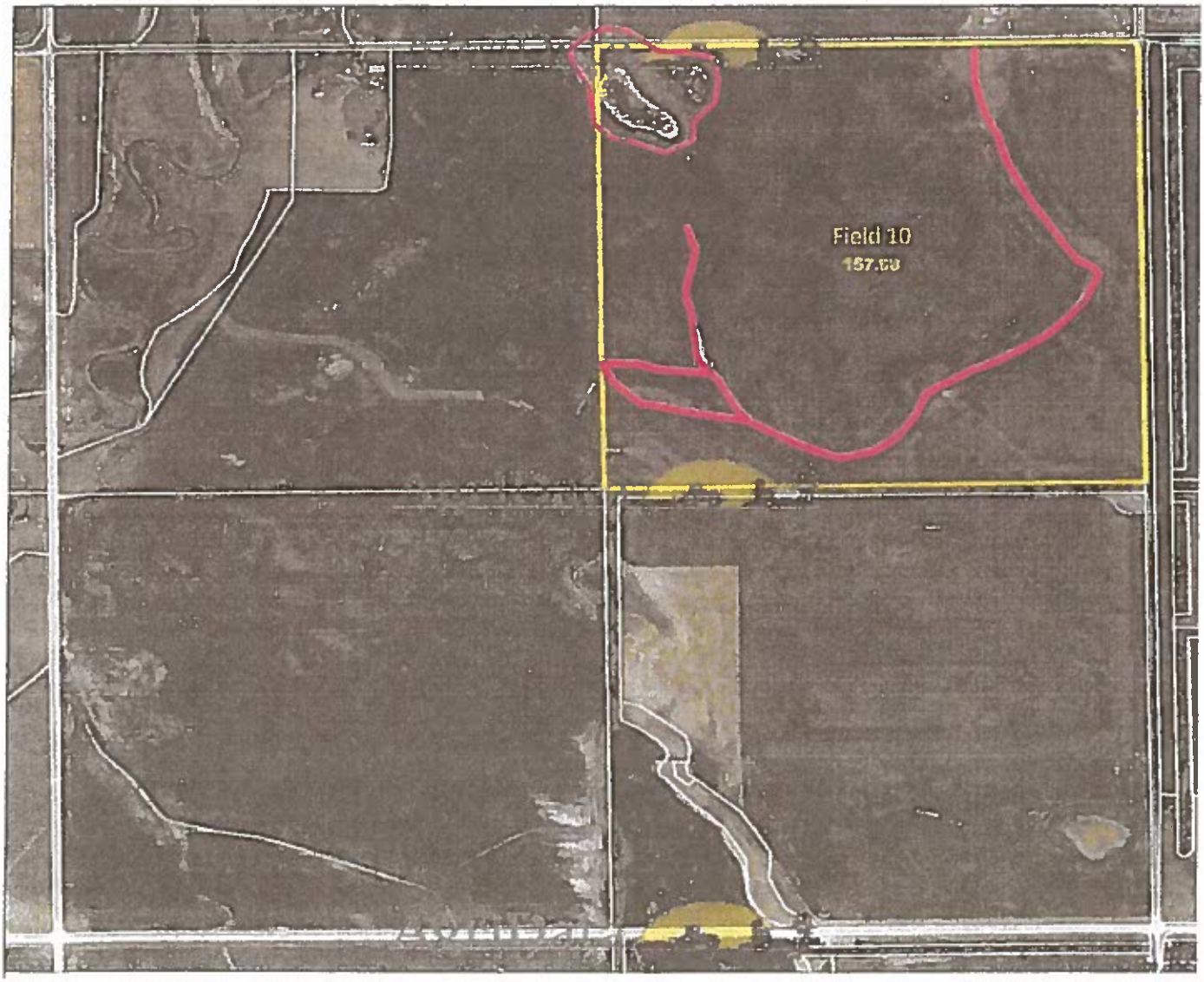
Landowner: Joseph Harbeke

Legal: NE ¼ S14-T139N-R55W, Cass County, ND

Acres: 140.2

Legend

Boundary | Registered Wells | Setback | Tile Inlets | "L" Nitrogen Leaching – High Risk | "R" Phosphorus Runoff – High Risk



DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
PO Box 522 | Mandan, ND | 58554

Water Quality Risk Assessment Map

Name: Rolling Green Sow Farm

Landowner: Jonathan Melvin

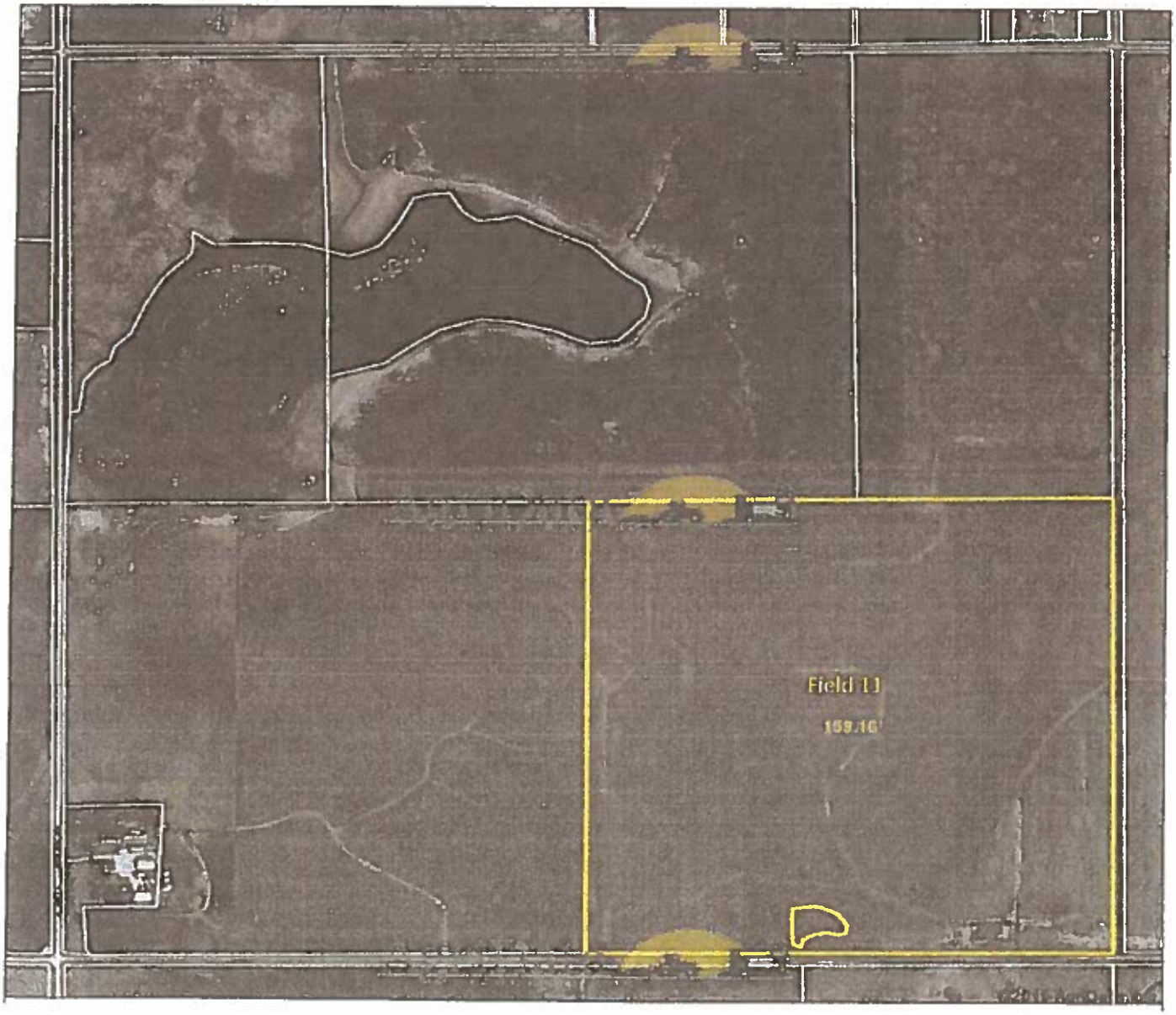
Legal: SE ¼ S10-T140N-R55W, Cass County, ND

Acres: 158

Legend

Boundary | Registered Wells | Setback | Tile Inlets

"L" Nitrogen Leaching – High Risk | "R" Phosphorus Runoff – High Risk



DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
PO Box 522 | Mandan, ND | 58554

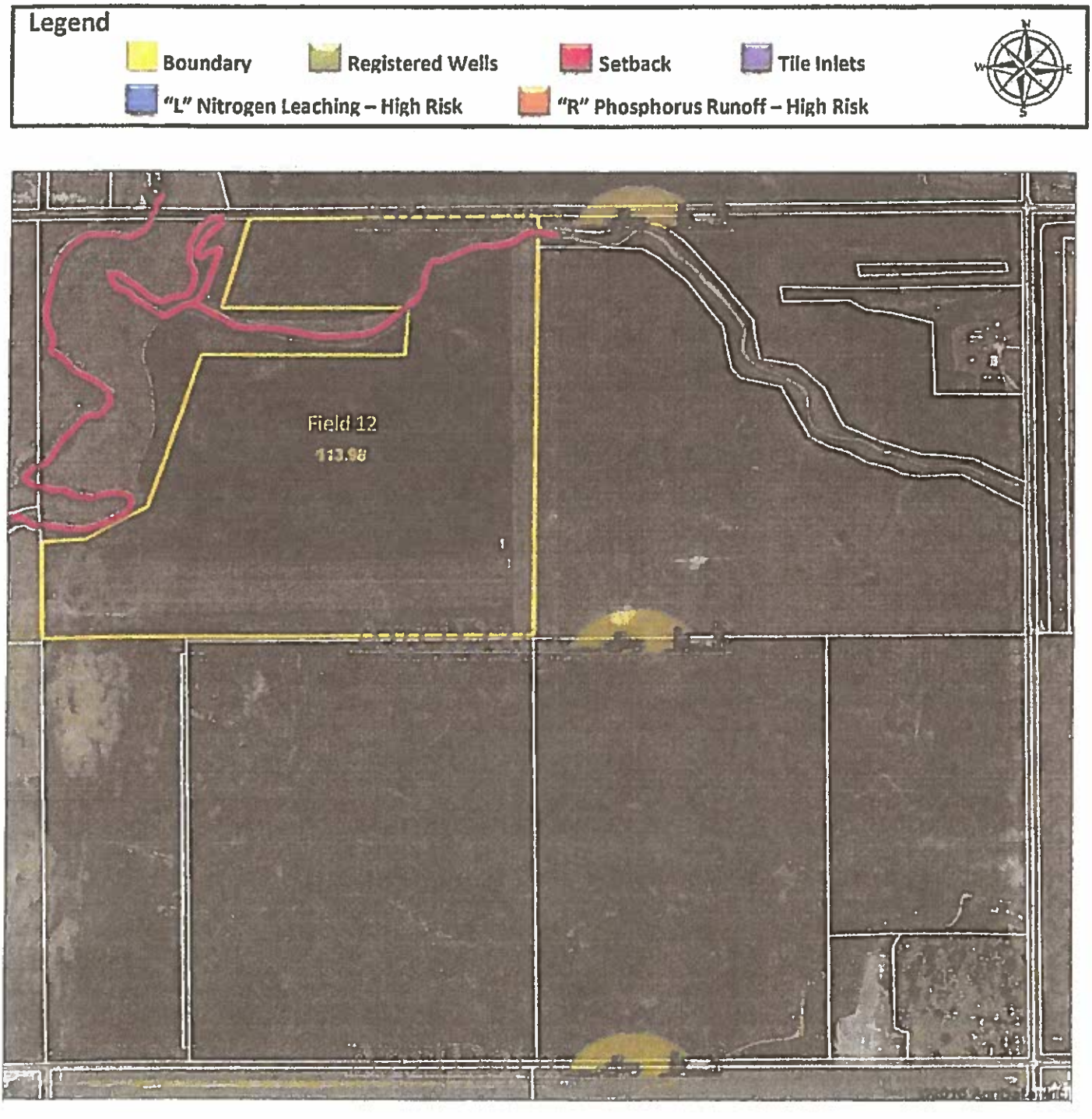
Water Quality Risk Assessment Map

Name: Rolling Green Sow Farm

Landowner: Jonathan Melvin

Legal: NW ¼ S14-T140N-R55W, Cass County, ND

Acres: 112.3



DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
PO Box 522 | Mandan, ND | 58554

Water Quality Risk Assessment Map

Name: Rolling Green Sow Farm

Landowner: Randy Melvin

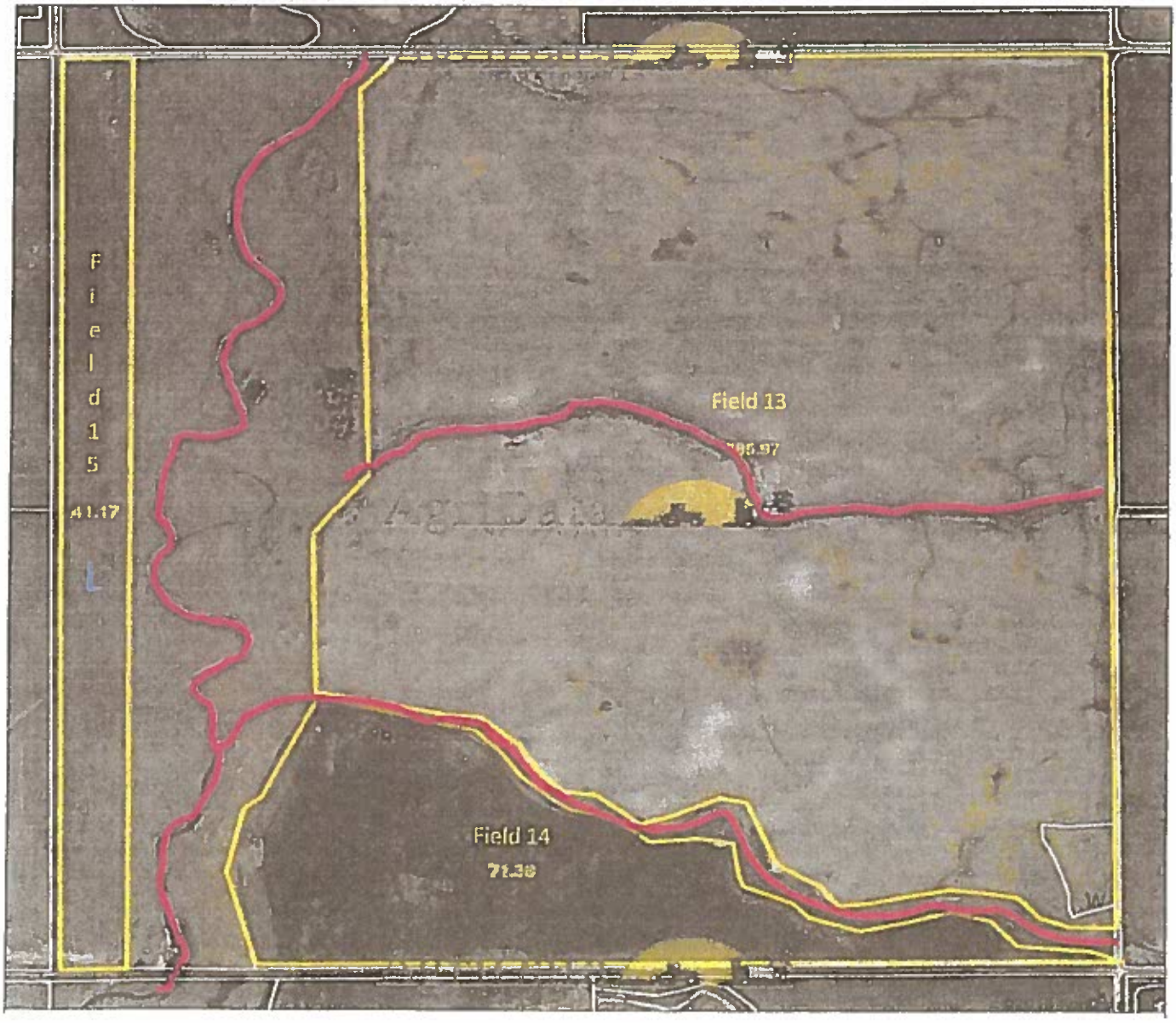
Legal: S11-T140N-R55W, Cass County, ND

Acres: 488.4 Combined

Legend

Boundary | Registered Wells | Setback | Tile Inlets

"L" Nitrogen Leaching – High Risk | "R" Phosphorus Runoff – High Risk



DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
PO Box 522 | Mandan, ND | 58554

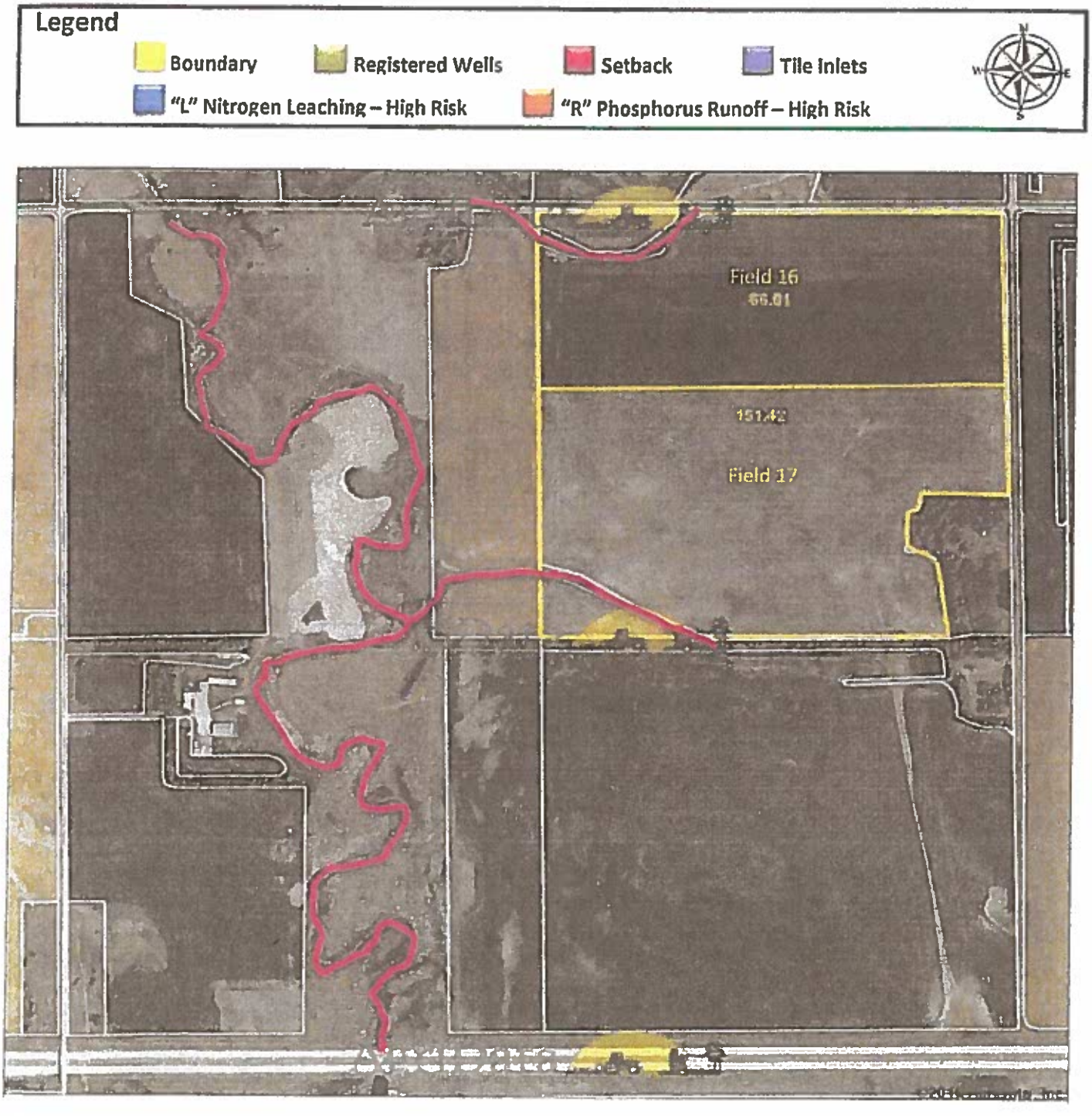
Water Quality Risk Assessment Map

Name: Rolling Green Sow Farm

Landowner: Randy Melvin

Legal: NE ¼ S2-T139N-R55W, Cass County, ND

Acres: 146.9 Combined



DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
PO Box 522 | Mandan, ND | 58554

Water Quality Risk Assessment Map

Name: Rolling Green Sow Farm

Landowner: Randy Melvin

Legal: E ½ S4-T139N-R55W, Cass County, ND

Acres: 300.68

Legend

Boundary | Registered Wells | Setback | Tile Inlets

"L" Nitrogen Leaching – High Risk | "R" Phosphorus Runoff – High Risk

DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
PO Box 522 | Mandan, ND | 58554

Water Quality Risk Assessment Map

Name: Rolling Green Sow Farm

Landowner: Randy Melvin

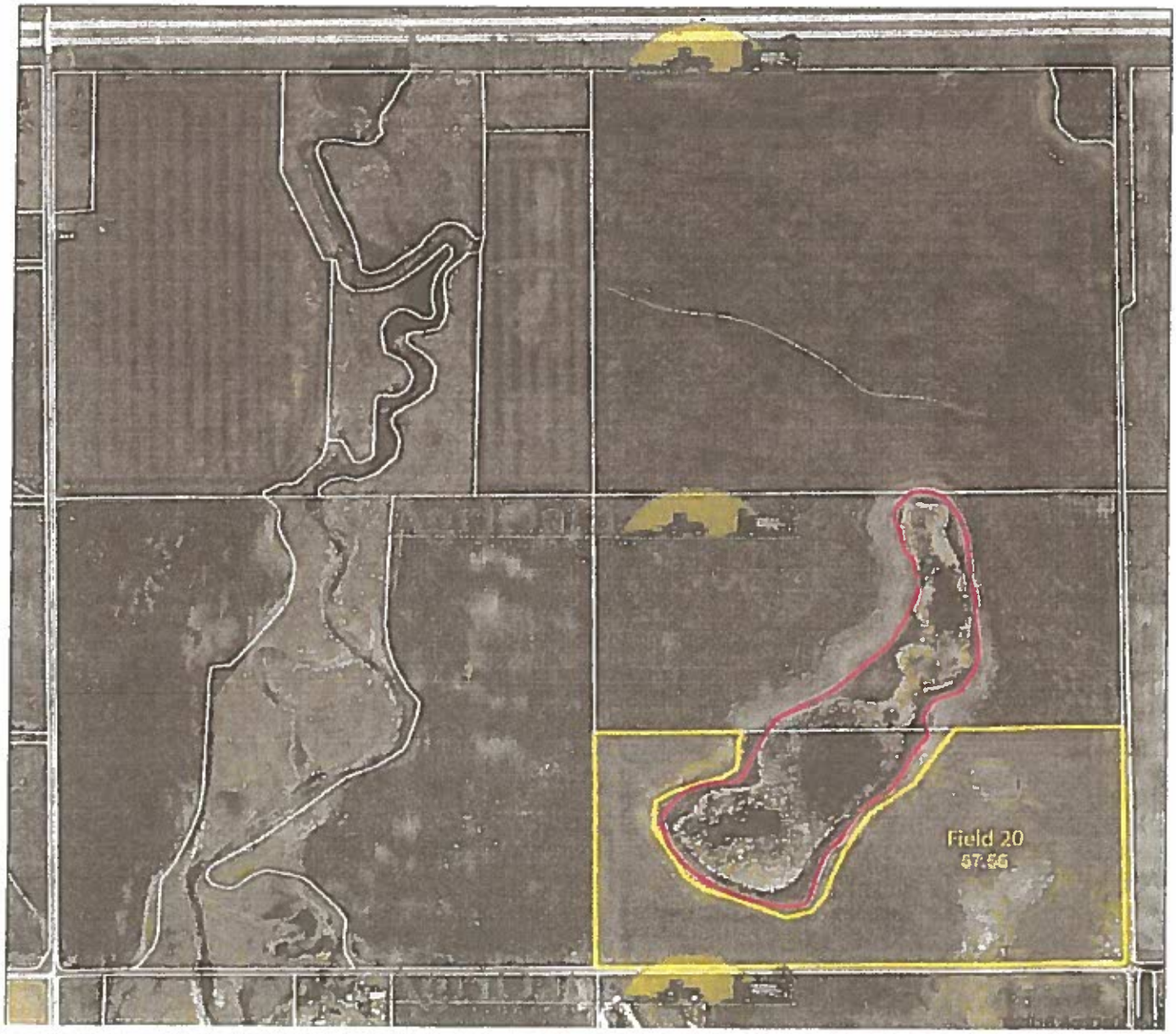
Legal: S ½ SE ¼ S11-T139N-R55W, Cass County, ND

Acres: 57.6

Legend

Boundary | Registered Wells | Setback | Tile Inlets

"L" Nitrogen Leaching – High Risk | "R" Phosphorus Runoff – High Risk



DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
PO Box 522 | Mandan, ND | 58554

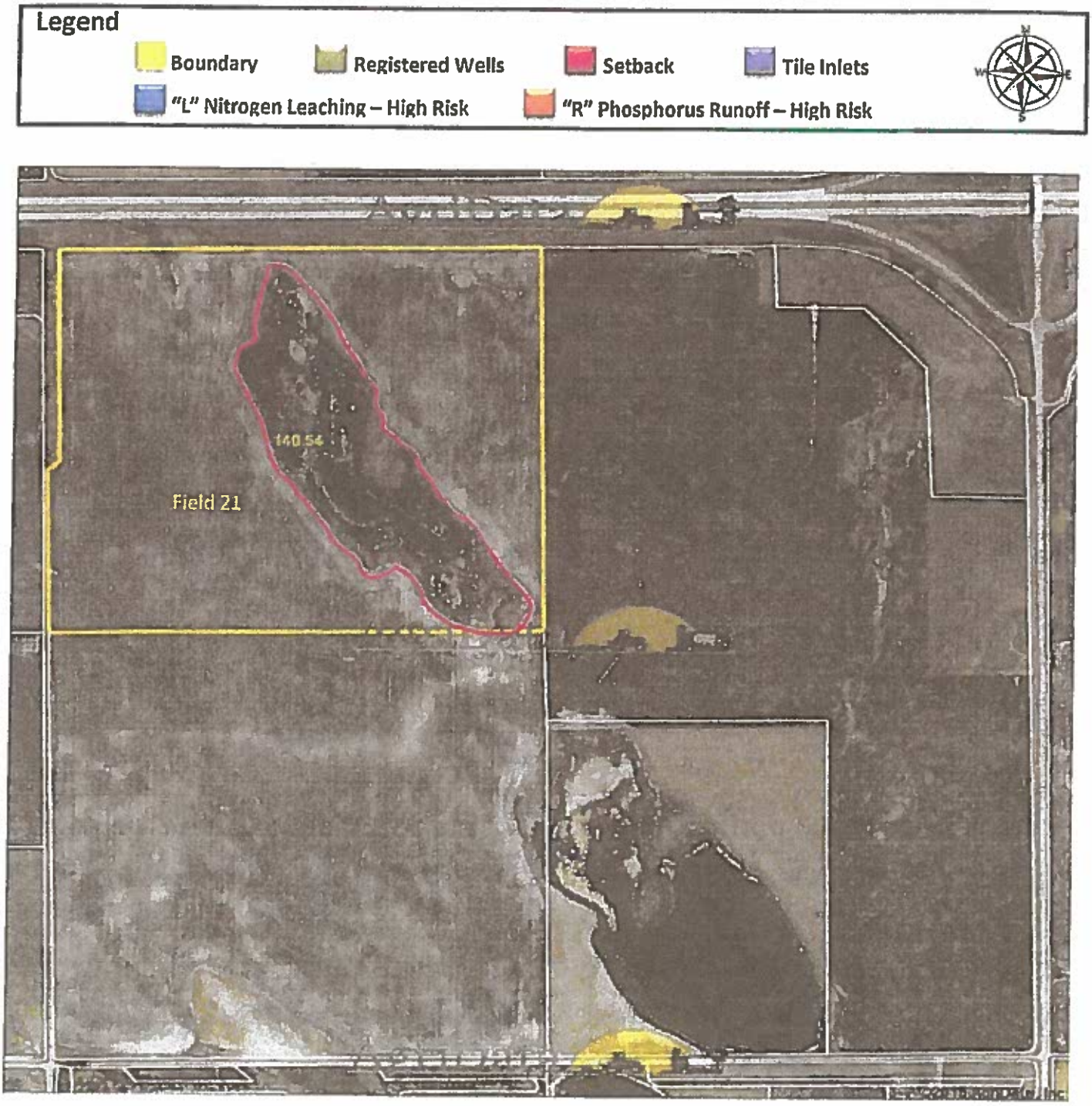
Water Quality Risk Assessment Map

Name: Rolling Green Sow Farm

Landowner: Randy Melvin

Legal: NW ¼ S12-T139N-R55W, Cass County, ND

Acres: 107.7



DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
PO Box 522 | Mandan, ND | 58554

Water Quality Risk Assessment Map

Name: Rolling Green Sow Farm

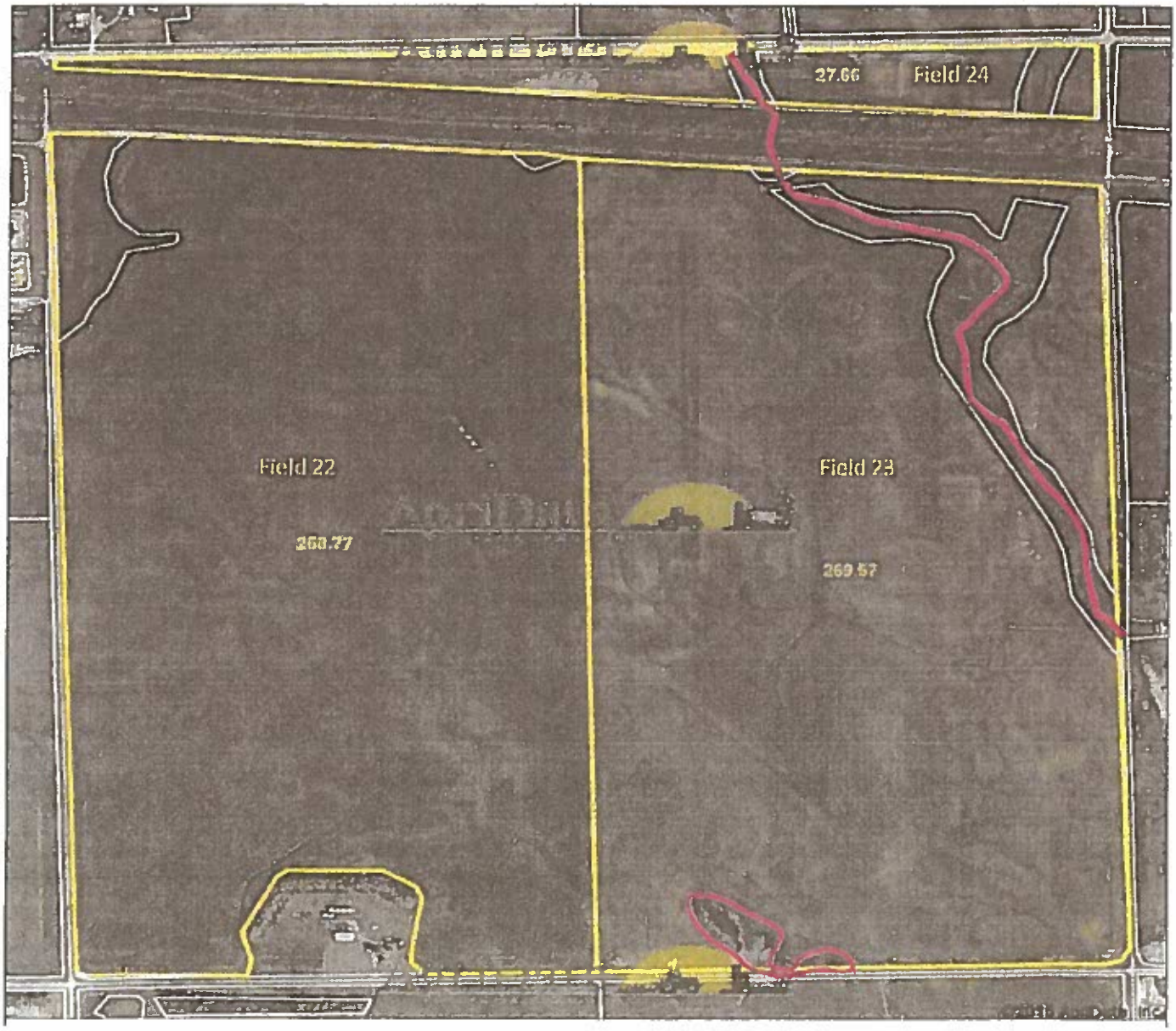
Landowner: Tim Bernston

Legal: S29-T140N-R54W, Cass County, ND

Acres: 557.7 Combined

Legend

Boundary | Registered Wells | Setback | Tile Inlets | "L" Nitrogen Leaching – High Risk | "R" Phosphorus Runoff – High Risk



DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers
PO Box 522 | Mandan, ND | 58554

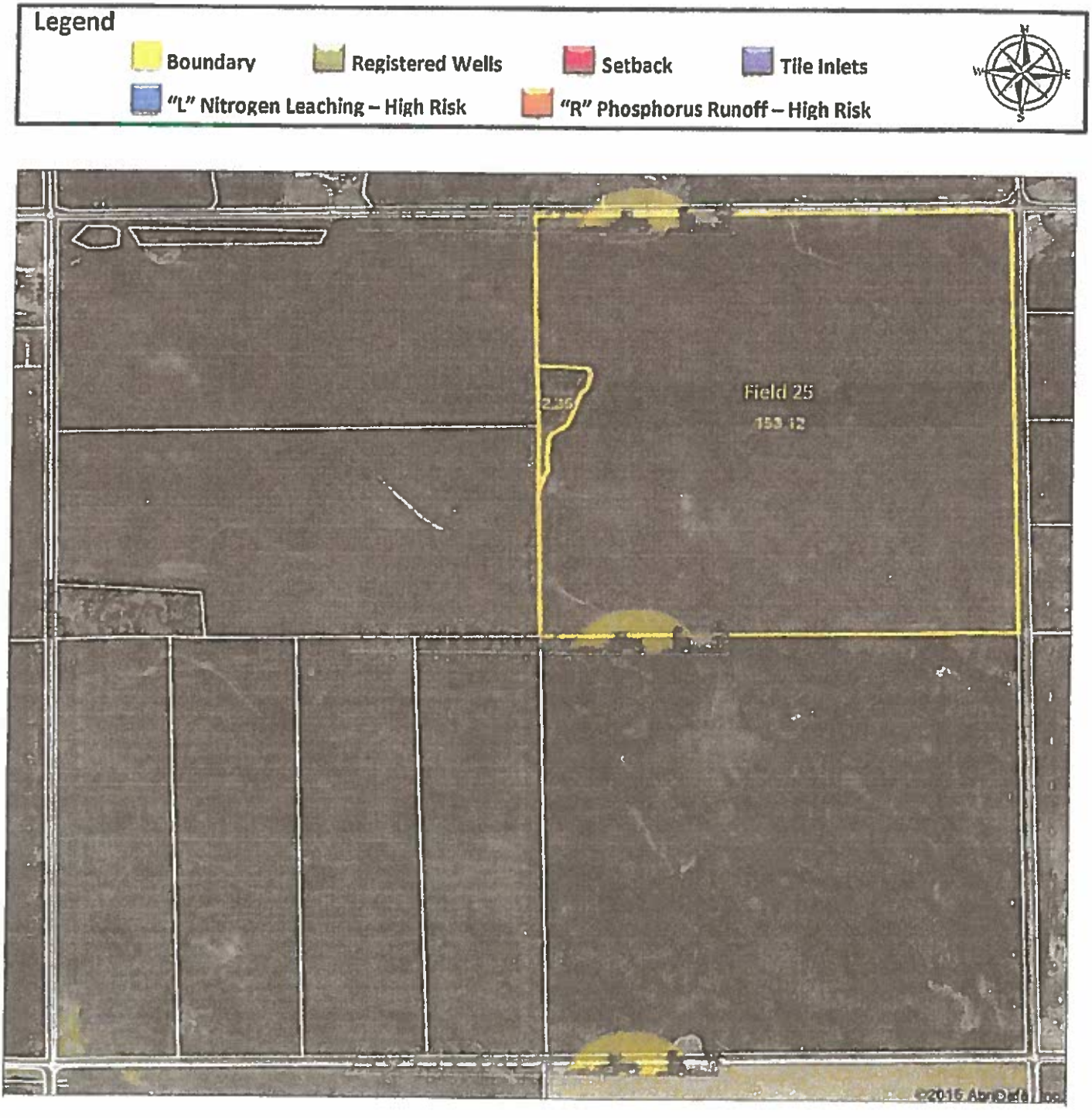
Water Quality Risk Assessment Map

Name: Rolling Green Sow Farm

Landowner: Tim Bernston

Legal: NE ¼ S32-T140N-R54W, Cass County, ND

Acres: 150



APPENDIX C

References and Supporting Documentation

MANURE NUTRIENT UTILIZATION

Charles Linderman
Carrington Research Extension Center
North Dakota State University

Introduction

Efforts to prevent pollution of water from livestock manure began over thirty years ago. Subsequently, systems were designed and built to collect and store manure and to contain runoff from open feedlots. It has been most economical to dispose of manure and feedlot runoff on fields close to the livestock feeding facility. Often, manure nutrient applications exceed crop removal and thus accumulate in the soil. When this happens, nutrients are easily leached or eroded from the manure treated soil. The pollution potential is simply moved from the animal feeding operation to the manure disposal area.

The two manure nutrients that are of most concern are nitrogen(N) and phosphorus(P), two elements important in crop production and that are typically part of most commercial fertilizer applications. When in excess amounts and in the wrong place, however, they result in problems such as high nitrates in groundwater and phosphorus fertilization of surface waters leading to eutrophication.

The most practical way to manage livestock manure is almost always applying it to cropland to utilize the nutrients. The objective should be to utilize all the N and P for crop production, thus keeping those nutrients from becoming pollutants. This will result in some economic benefit to the producer to offset the costs of manure management while preventing harm to the environment and keeping the livestock producer in compliance with regulations.

Manure Application Planning

Common sense would say that the first step in manure application planning should be to soil test and determine the nutrient needs of the planned crop. NDSU Extension has bulletins available on soil sampling and testing, choosing realistic yield goals, and calculating the appropriate fertilizer application rates. When all or some of the fertilizer is to be supplied by manure, it becomes more complicated.

Manure can be sampled and tested in a manner similar to the soil. About 10 to 20 sub-samples should be taken from a solid manure stockpile. Liquid manure should be thoroughly agitated and mixed before sampling. Getting a representative sample is very difficult, as manure can be very non-uniform. The best sample can likely be taken when the manure is being spread. Thus, as a practical matter, the manure test results may not be available until after the manure has been spread. However, this will indicate if nutrients have been over or under applied, and if additional fertilizer need be applied at planting. It is also valuable information for next year, as manure characteristics tend to be stable under given management and feeding situations, but will likely change if management practices change.

Meanwhile, in the absence of actual test results, there are table values such as those in Table 1 that can be used to get started and be reasonably in the ballpark.

Table 1. Typical nutrient concentration of animal manures.			
Species/Form	N	P2O5	K2O
Beef			
Solid	----- lb/ton -----		
Cows	15	10	9
Steers	14	9	14
Dairy			
Solid	----- lb/ton -----		
Cows	11	7	9
Heifers	13	12	19
Liquid	----- lb/1000 gal -----		
Anaerobic storage	25	15	27
Swine			
Solid	----- lb/ton -----		
Gestation	22	27	14
Finishing	22	22	17
Liquid	----- lb/1000 gal -----		
Farrowing	27	27	15
Nursery	34	25	18
Gestation	40	42	18
Finishing	53	39	29

Source: "Manure Management in Minnesota," FO-3553-C. University of Minnesota Extension Service.

Another complication in using manure is the fact that much of the N is tied up in organic form that must be converted to nitrate N to be taken up by plants. Therefore, only a percentage is available the first year after application, another percentage the second year, etc. Table 2 shows percentages of N that can be assumed to be available the first, second, and third years for various types of manure and under various schemes of incorporation of the manure into the soil. When calculating the rate of desired manure N application, do not forget to credit the N available from any manure applied the previous year. P has no gaseous phase, reacts differently, and is simply assumed 80% available the first year.

Table 2. Nitrogen availability by method of application and years since spreading.

	Broadcast/Incorporation			Injection	
	< 12 hours	< 4 days	None	Sweep	Knife
Beef					
Year 1	60	45	25	60	50
Year 2	25	25	25	25	25
Year 3	10	10	10	10	15
Lost	5	20	40	5	10
Dairy					
Year 1	55	40	20	55	50
Year 2	25	25	25	25	25
Year 3	10	15	15	15	15
Lost	10	20	40	5	10
Swine					
Year 1	75	55	35	80	70
Year 2	10	10	10	10	10
Year 3	5	5	5	5	5
Lost	10	30	50	5	15
Poultry					
Year 1	70	55	45	--	--
Year 2	15	15	15	--	--
Year 3	10	10	10	--	--
Lost	5	20	30	--	--

Source: "Manure Management in Minnesota," FO-3553-C. University of Minnesota Extension Service.

Nitrogen vs. Phosphorus

A third complication with manure fertilizer is the fact that it is not a plant nutrient balanced product. Usually, the ratio of N to P in manure is such that applying enough manure N for most crops will result in excess P application. There are situations in the country where this has resulted in soil P levels high enough to cause potential for P to move off site and get into surface waters. There are two strategies to deal with this problem.

1. Apply manure to meet the P requirements of the crop. Make up the difference in N requirement, if necessary, with commercial fertilizer N.
2. If soil test P is at or below the "very high" category, as most North Dakota soils are, apply enough manure to meet the crop requirement for N. If that results in excess P application, do not apply manure to that field until following years' cropping uses the excess P.

In any case, if soil test P is at 150 ppm or above, do not apply manure. Never exceed the N requirements of the crop, as N has a gaseous phase and a soluble phase, and the excess is sure to be lost.

Calibration

Once a proper manure application rate has been calculated, it is necessary to calibrate the manure spreader. If a scale is available, it is simplest and best to weigh a loaded spreader to determine the tons per load. As that is usually not the case, one can measure the length, width, and average depth of the spreader box load and calculate the cubic feet. Then weigh a 5-gallon bucket full of a representative manure sample. As there are approximately 7.5 gallons in a cubic foot, multiply the weight in pounds

of 5 gallons of manure by 1.5 to find the weight of one cubic foot, and then multiply that by the cubic feet in the whole load to determine the pounds per load. Divide by 2000 to get tons per load.

Use a measuring wheel to measure the area covered by a spreader load. (There are 43,560 square feet per acre). Divide the tons per load by the acres per load and you now have tons per acre. Then you can adjust the unloading time of the spreader and/or the tractor speed as necessary to achieve the desired rate.

Summary

A good manure utilization plan includes soil tests, manure tests, calibration of application equipment, and good records. Assistance with developing manure utilization plans is available from the NDSU Extension Livestock Waste Management Specialist.

Table 3. Typical "as-collected manure production estimates.

Livestock species and handling system	Volume	Notes
Beef, open lot	1 to 2 ton per head per year	
Sheep, open lot	0.5 ton per head per year	100 lb. live weight, manure 62% m.c.
Dairy, storage pond, no bedding	4600 to 6000 gallons per head per year	1400 lb. live weight
Dairy, storage pond, with bedding	6800 to 8300 gallons per head per year	1400 lb. live weight
Swine, farrow to finish, storage pond	4900 gallons per sow per year	Based on 16 hogs sold per sow per year
Swine, farrow to feeder, storage pond	1300 gallons per sow per year	Feeder pig sold at 50 lb.
Swine, finishing only, storage pond	220 gallons per finished hog per year	Hogs grown from 50 to 220 lb.
Source: Midwest Plan Service		

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1992

CLEAN WATER

You Can Make A Difference

Fertilizing Cropland with Swine Manure

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MINNESOTA EXTENSION SERVICE
UNIVERSITY OF MINNESOTA

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Manure management should be a top priority on hog farms as we approach the 21st century. Mismanagement of manure can have a substantial negative impact on our water, soil and air resources. When used appropriately, manure has nutritive, and thus economic value. Manure also improves biological activity, soil tilth, and soil chemical properties.

According to 1990 Minnesota Agricultural Statistic Service data, the swine industry in Minnesota generates approximately 11 million tons of manure annually. Hogs and pigs in Minnesota excrete almost 73,000 tons of nitrogen (N) per year that can serve as a nutrient source for crops. This manure also contains 55,000 tons of P_2O_5 (phosphorus fertilizer equivalent) and 58,000 tons of K_2O (potassium fertilizer equivalent). Although some losses of these nutrients are inevitable in handling and storage, manure can replace the need for commercial fertilizer on thousands of Minnesota's cropland acres.

Manure Inventory Assessment

A comprehensive manure management plan is essential for all hog operations. Knowing the amount of manure produced as well as its nutrient content will help a hog farmer plan for the number of acres that will be manured.

The best method to determine nutrient supply from manure is to analytically test it for nutrient content and multiply this by the storage volume. This method does not require numerous assumptions--yet it does require that representative manure samples be collected and storage volume calculations be made. Collecting a representative sample of liquid hog manure is difficult because of the constant settling of the solid portion of the manure. Because much of the phosphorus and the organic N is in this layer, the manure must be agitated enough to suspend the solids that can be resuspended. However, the sediment layer will never totally be removed by agitation.

An alternative method to determine nutrient quantities is to calculate storage capacities and multiply by the average nutrient content, based on the species and storage and handling methods (Table 1). While Table 1 might be a good reference to begin developing application rates, these tabled values will vary significantly among storage facilities and livestock operations. Research results for manure analyses in Minnesota range from 25-300% of the average values.

Table 1. Nutrient analysis of swine manure. Livestock waste facilities handbook, Midwest Plan Service, March 1985.

Form	Dry Matter	Total N	P_2O_5	K_2O
Solid:	%	------- lbs/ton -------		
No bedding	18	10	9	8
With bedding	18	8	7	7
Liquid:		----lbs/1000 gal ----		
Anaerobic storage	4	36	27	22

A third alternative is relatively easy to calculate: Calculate the average amount of manure produced per animal, multiply by the number of hogs/pigs/sows and assume standard storage and handling losses. Table 2 can be used to calculate the initial amount of manure produced by the hogs/pigs/sows. Table 3 lists some average N losses that affect nutrient content from several storage and handling systems. This method may be a good one for planning cropland needs with proposed increases in livestock numbers.

Table 2. Daily swine manure production. Livestock waste facilities handbook, Midwest Plan Service, March 1985.

Animal Size	Manure Produced[u]		N	P_2O_5	K_2O
lbs	lbs	gal	--------	lbs --------	
25	2.3	0.3	0.02	0.01	0.01
65	4.2	0.5	0.03	0.02	0.02
150	9.8	1.1	0.07	0.05	0.05
200	13.0	1.5	0.09	0.07	0.07
gestating sow	8.9	1.1	0.06	0.05	0.05
sow and litter	33.0	4.0	0.23	0.17	0.18
boar	11.0	1.4	0.08	0.06	0.06

[u] linear interpolations of manure production between weight categories is acceptable.

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Table 3. Storage losses of nitrogen.
Livestock waste facilities handbook, Midwest Plan Service, March 1985.

System	N Lost --%--
Solid:	
Daily Scrape and Haul	15-35
Manure Pack	20-40
Open lot	40-60
Liquid:	
Beneath barn pit	15-30
Above-ground storage	10-30
Earthen storage	20-40

Determining Application Rates

Next, manure application rates must be calculated. This requires knowing the nutrient content of the manure, nutrients required by the crop, and availability of applied manure to the crops.

The majority (70-90%) of the phosphorus and potassium applied in manure will be available to the crop the first year after applications. The availability of N varies considerably. This variation is primarily a function of the method of application. Table 4 provides an estimate of the amount of the total N that will be available in the application year and in the year after application.

Table 4. Nitrogen availability and loss as affected by method of application.

	Broadcast-incorp.[v] None	≤12 hrs	≤4 day	Injection Sweep	Knife
	% Total N				
Av. Yr. 1	30	65	45	65	50
Av. Yr. 2-3	30	25	30	30	35
Lost	40	10	25	5	15

[v]The categories refer to the length of time between manure application and incorporation.

Often there is a sense of futility in trying to use manure analysis, application loss coefficients, and crop nutrient requirements to determine manure application rates. Here is a five-step process to get started:

1) Determine nutrient needs of each field's crop based on soil tests, previous crops, yield expectations, etc.

2) Make an initial manure rate selection. Use crop needs and a tabled nutrient composition of the manure, or a previous year's test.

3) While applying the manure at the predetermined rate, collect a representative manure sample--either when loading the spreader in the yard or unloading the spreader in the field. Send it to a laboratory for analysis.

4) After receiving the laboratory analysis (presumably the manure will have been applied), calculate the actual amount of nutrients applied based on data and the application rate.

5) In a record keeping system, record any possible overapplications or underapplications. If fewer nutrients were applied than planned and a fall application was made, starter or sidedressed programs can supply the deficiency. If spring manure applications were made and less N was applied than planned, a sidedressed application of N can be made. Overapplications should be credited for the next year.

Field Spreading Priority

Each livestock producer should determine the amount of manure generated on their farm and the nutrient requirements of the crops where the manure is to be applied. If the manure produced on a farm cannot supply all of the farm's crop nutrient needs, it is economically and agronomically best to base the manure application rates on the phosphorus requirements. This strategy will use lower rates of manure and necessitate supplemental N fertilizer, which can be easily applied using starter N, weed-and-feed N, or sidedress-applied N.

If there is an excess of manure produced in relation to the crop's needs, manure rates should be based on the crop's N requirements. At no time should rates in excess of agronomic needs be used--this is both illegal (state rules, chapter 7020) and environmentally unsound. Rates will have to be based on P requirements if there is a potential phosphorus/surface water problem because of soil erosion, a very high soil test for phosphorus, and/or there is close proximity to water. Additional strategies such as applying manure onto legumes (see Special Use), hauling the manure off-farm, composting the manure and/or acquiring more cropland must also be considered in situations where excess manure is produced.

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A field priority system should be developed to maximize the nutrient value of the manure. Priority should be given, in order, to those fields that: 1) require the greatest amount of N to grow the crop, 2) have the lowest phosphorus and potassium soil tests, and 3) will benefit most from adding the organic material to the soil.

Making a multi-year plan

Thus far we have discussed annual manure management plans. For most planning processes, a three- to five-year forecast is often desirable. This may also be true with manure. In developing a multi-year plan, cropland nutrient needs often change due to crop rotations. The supply of nutrients should not change from year to year unless animal numbers change.

For each year in a rotation, the crop's needs must be determined and appropriate application rates determined. In an operation where cropland needs always exceed the manure's nutrient supply, each field's application rate will change yearly. If there is a near balance in nutrient supply and needs, strategies that can correct for those "excess" and "deficient" years are needed. The primary strategies would be to apply/allow for multiple year needs.

Also, due to manure's residual properties, second and third year credits need to be accounted for in determining crop needs. Approximately 35-50% of the N in the organic fraction is available each year. Thus, second and third year N credits should be given for manure (Table 4). After applying swine manure, approximately 20% of the total N is available to the crop in the second year; approximately 5-10% is available in the third year.

Calibrating Application Equipment

Correct application of manure to cropland is critical to maximize the value of manure to crop producers. For manure to replace commercial fertilizer and not create environmental problems, farmers must be confident about the application rate. All calculations involving calibration of manure must be done using manure on an "as is" basis. All analysis should be interpreted on an "as is" basis and the application rate should be as well. Do not worry about the moisture content or change to a dry matter basis.

Three conditions must be addressed to achieve this confidence in rates. First, **the analysis of the manure loaded into the application equipment must be known** and should not change. For liquid systems, good agitation in the storage facility and in the transport tank are important. Loading procedures that do not separate the solids and the semi-solids can assure this for solid manure systems. Second, **the rate of manure being applied to the field must be known and kept constant.** Calibration must be conducted for all manure applications. And finally, **the application or spread pattern of the manure must be uniform throughout the field** so that all plants will have equal access to the nutrients. Having a predetermined travel plan for applying manure to a field and noting where loads stop and start will help ensure uniform applications.

Liquid systems

Calibration of liquid manure equipment requires that the manure be measured in gallons/acre (GPA). Getting a weight of the tank before and after spreading the manure and dividing by the density of the liquid manure (8.3 lb/gal) is the best way to determine the volume. Combining this with the width of the spread pattern and the distance the tank takes to empty will provide the information to determine the application rate. *For example, Operator A takes a loaded manure tank across a scale and it reads 29000 lb The operator applies manure to a field with four injector knives (2.5 ft centers); it takes 1200 ft to empty the tank. Driving the emptied tank across the scale gives a reading of 8500 lb. The rate is:*

[(29000 lb - 8500 lb)÷8.3 lb/gal]÷{[1200 ft x (2.5 ft/ injector x 4 injectors)]÷43560 ft²/acre} = 8965 GPA

Or, fill the tank to its predetermined volume to avoid needing a scale. However, the listed capacity is often different from what is hauled to the field with a "full" tank. Counting the number of loads needed on a given size field and assuming a set volume per load will allow calculation of a rate per acre, although this does not ensure uniform application within a field. *This example has Operator B filling a 3200 gal tank 90% full for each load, then spreading 29 loads on a 23-acre field. The solution is:*

[(3200 gal/load x 0.90) x 29 loads]÷23 acres = 3630 GPA

Solid systems

Calibration of solid manure equipment is similar to liquid manure equipment. The weight of manure applied can be determined by any one of several ways. Weigh your manure spreader before and after

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going to the field and determine the weight of manure spread. Then determine the width the manure is being spread and the distance it took to unload the manure. Using the ratio of weight per portion of an acre, a per-acre application rate can be calculated. It is best not to unload the entire spreader because the spread pattern at the end of a load is not representative. *Example: Operator C weighs a loaded spreader; it is 9800 lb. After spreading a 12-ft width of manure a distance of 300 ft, the spreader is reweighed and it now measures 6200 lb. The rate calculation is:*

[(9800 lb - 6200 lb)÷2000 lb/ton]÷[(12 ft x 300 ft)÷ 43560 ft²/acre] = 21.8 tons/acre

A practical method is using a scale to determine a weight per load, then counting the number of loads it takes to spread manure on a given field. Calculate the total tons per field and divide by the number of acres in the field to determine rate of application. *For example, Operator D has previously calculated a spreader holds 8.5 tons of manure when fully loaded and uniformly applied 16 loads in a 13-acre field. The solution for rate is:*

(16 loads x 8.5 tons/load)÷13 acres = 10.5 tons/acre

Another method is to lay a tarp or piece of heavy-duty plastic in a field. After the spreader has passed over, collect and weigh the manure from the tarp or plastic. Then determine the area of the plastic, and convert the weight measurement to a per-acre basis. This method generally has a large amount of variability unless several samples are collected and weighed. *In an example, Operator E places five 4 ft by 4 ft plastic sheets in their field and spreads manure across these sheets. The combined weight of the sheets is 38.5 lbs. The solution for the rate is:*

(38.5 lb÷2000 lb/ton)÷[[5 x (4 ft x 4 ft)]÷43560 ft²/acre] = 10.5 tons/acre

After determining the manure application rate, it is often necessary to adjust the rate to better match the recommended rate that you need. The most common method to change application rate is by changing the speed you drive across the field. Solid manure equipment may also have an adjustment that changes the chain speed in the box, thereby changing the manure rate. Liquid manure equipment may have valve opening adjustments to alter the rate. A concern with liquid manure systems is the difference in flow from the start to the end of the tank. Pressurized tanks, flow pumps, and new distributor designs are solving some of these problems in variable flows.

Special Concerns and Issues

Solid versus liquid manure

Nutrients voided by swine are the same whether the manure is to be handled as a liquid or a solid. It is the handling systems that create losses of nutrients or changes in the manure composition resulting in different nutrient analyses between solid and liquid manure.

The available plant nutrients in manure are often found in different fractions. Nitrogen, for example, is fairly evenly split between the feces portion, which contains the majority of organic N, and the urine, which contains most of the inorganic N. Therefore, it is essential to preserve and adequately mix these fractions before field application.

Phosphorus is found mainly in the feces component. Phosphorus is not lost by any chemical or biological process and the majority of this nutrient is available in the year of application. With a liquid storage system, the bulk of the phosphorus is in the settled solids at the bottom of the pit unless you agitate before spreading. Potassium is almost the opposite of phosphorus; almost all of it is in the urine.

Spring/winter/fall application times

Time of manure application can be extremely important if site-specific conditions create an environmental hazard. Fall applications allow for maximum time for the manure to break down before the crop uses the nutrients. While this is generally beneficial, it can also lead to environmental hazards if N loss from the soil is a concern. Fall applications of N are generally not recommended on coarse-textured soils.

With spring applications, there is less opportunity for N losses from a field. However, spring applications result in less time for organic decomposition of the manure, including the release of some nutrients. Spring application also generally delays fieldwork and planting, and could increase soil compaction.

Many producers use winter applications. While there will be significant losses of available N, the organic N fraction will still contribute to the plant-available N pool. The potential for nutrient runoff is

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an environmental concern for winter applications on frozen, sloping soils. If manure is applied to frozen soils and there is runoff from snow melt or rain, nutrients in the manure will be lost with the runoff. This situation is not recommended.

Methods of application

Broadcasting is a way to apply solid or liquid swine manure. Sometimes this is followed by incorporation with a tillage operation. Other times, like with winter applications, the manure is left on the soil surface. Nitrogen loss is a concern with broadcast manure. The amount of loss depends mainly on the time between application and incorporation. Manure that is broadcast but never incorporated can lose about half of its total N. Incorporation within 12 hours is ideal for maximum N efficiency (See Table 4). Local ordinances and neighbors should be considered in determining where and when manure is broadcast due to odors.

With liquid manure systems, several more application options are available to crop producers. Injection methods place liquid manure below the soil surface, thus eliminating the majority of volatilization losses. Traditionally, injection knives placed the manure in a concentrated, vertical band about 6-8 inches below the soil surface with 30- to 60-inch spacings between knives. New injection systems such as sweep and disc injectors are being marketed that spread the manure in horizontal patterns under the soil surface. These systems allow for faster breakdown of the manure and places the manure in a more favorable position for early season plant uptake.

Another option for liquid manure handlers is to apply the manure with an irrigation system. Because this is an efficient method to apply large amounts of manure, excessive rates are often applied. Although application is often uniform, volatilization is still a major concern.

Special uses

Many pork producers grow soybeans and often consider spreading manure on these acres. Although soybeans do not necessarily benefit from the N in the manure, they can benefit from all other nutrients in the manure. The recommended rate should, therefore, be based on P or K requirements of the crop. The soil may also benefit from the organic material addition (soil tilth). When manure is applied to soybeans, the added N reduces the amount of N symbiotically fixed by the nodules. This has neither a consistent positive or negative effect on the soybean yields.

A recent trend with some hog/corn producers in Minnesota is to switch to ridge-till systems. Manure can be worked into this system in two ways. First, the manure can be injected in the ridge valleys as a sidedress application. This is a good method to prevent nutrient loss, yet the nutrients are not in the root-filled ridge and the soil disturbance counteracts some of the ridge-till philosophy. Manure can also be spread into the ridge valleys as a preplant or sidedress application; then incorporated into the ridge with subsequent cultivations. Take care not to broadcast manure onto the young plants because burning will take place. Nutrient movement into the ridges is limited in the year of application, but with several years of ridging, the nutrients will be well mixed into the ridge.

Conclusion

With the increased demand for pork, more manure will be generated. Recycling manure into the soil through a predetermined manure management plan is efficient and practical. This will optimize the nutrient value of the manure while minimizing potential environmental hazards. Manure is a valuable resource on a farm and should be treated as an asset.

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NM-1292

Livestock Manure Utilization in No-till Cropping Systems

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Dave Franzen, NDSU Extension Soil Fertility Specialist
Bridget Johnson, NDSU Extension Livestock Nutrient Management Specialist

Concern for the environment, water conservation and economic savings through reduced fuel use have been the driving forces for adopting no-till crop production in North Dakota. Concern for the environment, economic savings through reduced commercial fertilizer dependence and, more recently, federal government incentives have driven enhanced manure management in the state.

North Dakota livestock producers have increased their reliance on manure nutrient credits to supply their crops with needed plant nutrients. They have done this voluntarily because they realize the value of the nutrients in the manure or they want to take advantage of government incentive programs.

No-till crop producers with livestock are concerned with surface, nonincorporated manure application for several reasons: availability of nutrients to the crop, increased weed competition and nutrient stratification in the soil surface. Environmentally, a major concern is surface water contamination when surface-applied, nonincorporated manure leaves the field in runoff.

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AUGUST 2005

Environmental Issues

The transport of manure nutrients off-site in runoff is a major source of surface water contamination. Phosphorus and nitrogen in surface runoff are the major contributors to the impairment of lakes and ponds through the process of eutrophication. Eutrophication is the result of excessive bacteria and algae growth in surface waters due to nutrient enrichment, usually of nitrogen and phosphates. When this growth dies, other bacteria decompose the material, depleting the waters of oxygen, resulting in fish kills. Eutrophic waters contain high levels of bacteria and algae that cause taste and odor problems. In addition, certain types of algae in eutrophic waters are toxic to livestock and humans.

A recent study in Wisconsin (Bundy, et al., 2001) assessed the amount of phosphorus (P) in runoff from no-till plots with nonincorporated manure applications versus chisel-plowed plots with incorporated manure applications. The researchers found higher concentrations of dissolved P in the runoff from the no-till plots versus the chisel-plowed plots, but the total amount of P lost was lower for the no-till versus the chisel plow. They stated that the increased infiltration of water in the no-till plots lowered the sediment loss and reduced the total P load in runoff.

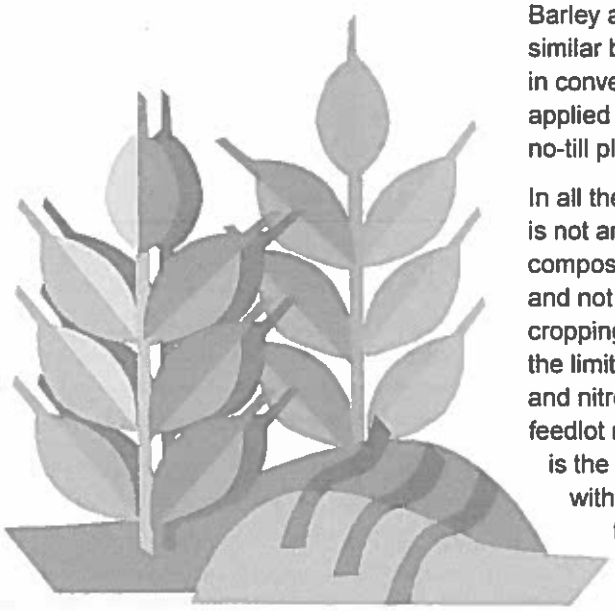
These results showed opposite effects on total P loss than what was expected from surface-applied nonincorporated manure. The researchers suggested examining all aspects of a cropping system when designing nutrient management recommendations to minimize losses of P that cause surface water pollution.

No-till crop production increases the amount of soil macropores and allows for greater water infiltration, which could lead to nitrate (N) contamination in groundwater. A study published in 1995 (Izaurralde, et al.) showed increased nitrogen leaching in the soil profile under no-till compared with conventional tillage. More recent studies (Halverson, et al., 2001; Zhu, et al., 2003; and Gupta, et al., 2004) showed no difference in nitrogen leaching between tillage types. These studies emphasize that no-till has an increased risk of macropore flow that may impact N leaching. Soil type, rainfall, crop rotation and other external factors will influence the amount and rate of the macropore flow. Therefore, proper nitrogen fertilization management is important to prevent producers from applying too much crop-usable nitrogen and increasing the risk of nitrogen leaching in macropore flow.

Nutrient Stratification

Lack of tillage to mix the topsoil and surface application of nutrients in no-till crop production systems can lead to nutrient stratification in the upper several inches of the soil. Several long-term studies (Holanda ,et al., 1998, and Robbins, et al., 1991) have shown nutrient accumulations in the upper 2 to 5 inches of the soil after nine to 13 years of no-till row crop production with surface application of nutrients.

They also report stimulated root growth in the upper portions of the soil and higher nutrient uptake by the plants grown under no-till vs. tillage. They attribute these results to nutrient stratification at the soil surface and more consistent soil moisture conditions under no-till. Yield-limiting problems due to the positional unavailability of nutrients caused by stratification in the upper 2 to 5 inches of the soil are a concern. To address this, banding nutrients at 6 to 8 inches deep may be advisable. However, under dryland conditions, any rainfall will tend to wet the surface more than the subsurface when crops are growing. Therefore, the benefits of deep banding vs. surface application of nutrients are minimized under dryland conditions.



Nutrient Availability

Research has shown that 40 percent of the total nitrogen (N) in beef feedlot manure and 15 percent in composted beef feedlot manure is plant available in the first year it is applied and incorporated (Eghball, et al., 1999a). When beef feedlot manure is applied and not incorporated in a no-till system, research has shown first-year availability of 38 percent of total N for manure and 20 percent for compost (Eghball, et al., 1999b). In this study, surface application of manure or composted manure did not show significant N loss because the N in both manure and compost were in very stable forms. The study also indicates no difference in corn yield between no-till and tillage or manure, compost or fertilizer treatments. Soil-test P levels increased when manure or compost was applied at rates higher than crop uptake, regardless of tillage.

From another study, corn, soybean and wheat yields were not different among chisel plow, moldboard plow or no-till when composted swine manure was the fertilizer source (Singer, et al., 2004). The study also showed soil-test P and potassium (K) levels can be elevated when those nutrients are applied with compost at rates higher than crop uptake.

Barley and oilseed crop yields were similar between manure incorporated in conventional tilled plots vs. surface applied nonincorporated manure in no-till plots (Stevenson, et al., 1998).

In all these studies, nutrient availability is not an issue when manure or composted manure is surface applied and not incorporated under no-till cropping systems. Nitrogen typically is the limiting nutrient in crop production, and nitrogen mineralization from beef feedlot manure or composted manure is the same whether it is incorporated with conventional tillage or left on the surface in no-till systems (Eghball, 2000).

Manure vs. Composted Manure

Composting manure is becoming more popular. In comparison with manure, compost is a more stable product since almost all of the nutrient fractions are in an organic form and the material is semidecomposed. Plants take up the majority of nutrients in an inorganic form. Therefore, the nutrients in composted manure need to undergo biological breakdown (mineralization) in the soil before they are available to the plants. In essence, composted manure is a slow-release fertilizer, so consider the timing of the application.

Studies have shown that the slow mineralization of nutrients in compost increases soybean yields at a higher rate than commercial N fertilizers applied in-season (Singer, et al., 2004). Composting also is a good method of producing a more nutrient-stable soil amendment with a lower moisture content and less volume, compared with raw manures. The composted material can be hauled longer distances at less cost, it has less odor when applied, and pathogens and weed seeds are killed during the composting process if temperatures generated during the process were high enough.

Both manure and compost can improve the soil's physical, chemical and biological properties, which helps increase crops' nutrient uptake efficiencies and lead to higher yields. Research has shown that soils with compost applications had a 13 percent higher organic matter concentration than those without compost (Singer, et al., 2004).

Many crop producers have noted weed problems following manure applications. Of the research conducted to investigate this issue, one study showed that weed production was more highly correlated to the nutrient availability of applied manure than to the weed seeds in the manure (Eghball, et al., 1999a). If weed seeds

are a concern, one sure method of reducing the viability of weed seeds is to compost the manure properly. The temperatures in properly composted manure reach a high enough level to kill weed seeds.

Some disadvantages of using compost would be the loss of some nutrients, particularly nitrogen, during the composting process; additional labor needed to manage the process; and the possible investment in specialized equipment. Standard farm equipment can be utilized to compost successfully; however, some producers choose to purchase compost turners to gain efficiency during the process.

Manure Nutrient Values

The rate of manure or compost applied to fields depends on the crop being grown, soil test levels and nutrient composition of the manure or compost. NDSU Extension Service bulletin SF-882, "North Dakota Fertilizer Recommendation Tables and Equations Based on Soil Test Levels and Yield Goals," is a good resource to help determine crop nutrient needs in conjunction with soil test levels.

Table 1 gives some estimates of nutrients that livestock produce. These numbers are just estimates. Manure or compost should be tested to determine the actual nutrient levels. For information on proper manure sampling procedures, consult NDSU Extension Service bulletin AE1259, "Manure Sampling for Nutrient Management Planning." Manure samples can be sent to the NDSU Soil Testing Lab at 103 Waldron Hall, Fargo, ND 58105. Please call the lab at (701) 231-9589 for sample handling information before submitting samples.

Knowing soil-test levels can help producers plan their manure application rates based on N or P needs. If soil test levels for P are in the low range, then manure application rates can be based on N needs of the crop to be grown. If soil test levels for P are high, then manure application rates are based on P needs of the crop to be grown.

Manure Nutrient Value Examples

1. A producer has 200 head of beef cows that are contained in a feedlot for three months (one-quarter of a year) every spring and the manure is hauled every fall. The soil test shows P levels in the low range and K levels in the medium range. How many acres of no-till corn with an estimated yield of 100 bushels/acre can be fertilized with the manure?

   (200 cows x 79 pounds of N/year) / 4 = 3,950 pounds of available N
   (200 cows x 105 pounds of P/year) / 4 = 5,250 pounds of available P
   (200 cows x 85 pounds of K/year) / 4 = 4,250 pounds of available K

   Since soil test levels are low for P, manure application rates can be based on the corn's N needs. The 100 bushels/acre corn requires 120 pounds of N/acre, 46 pounds of P/acre and 44 pounds of K/acre.

   (3,950 pounds of N) / (120 pounds of N/acre) = 33 acres of corn N needs
   (5,250 pounds of P) / (46 pounds of P/acre) = 114 acres of corn P needs
   (4,250 pounds of K) / (44 pounds of K/acre) = 97 acres of corn K needs

   Therefore, 33 acres of corn can be fertilized with the manure to meet all of the nutrient requirements. The soil test levels of P and K will increase. The level of increase will depend on soil type and field history.

2. Use the same example as above except soil test levels for P are high and K the same. In this case, manure application rates should be based on crop P needs. For this scenario, 100 bushels/acre corn requires 120 pounds of N/acre, 11 pounds of P/acre and 44 pounds of K/acre.

   (5,250 pounds of P) / (11 pounds of P/acre) = 477 acres of corn P needs

   In this situation, manure application would not meet the N and K needs and would have to be supplemented with commercial fertilizers. To develop specific manure application rates, please consult NDSU Bulletin 1187, "Manure Application Planning Workbook."

Table 1. Estimated Available Nutrients Produced Per Animal Per Year*

	Nitrogen	Phosphorous	Potassium
Dairy – Solid (lbs/yr for 1,400-lb cow in bedded pack)	176	122	140
Dairy – Liquid (lbs/yr for 1,400-lb cow in liquid slurry)	214	122	140
Beef – Solid (lbs/yr for 1,100-lb cow in open lot)	79	105	85
Swine – Solid (lbs/yr for 200-lb finished hog in bedded pack)	21	26	20
Swine – Liquid (lbs/yr for 200-lb finished hog in liquid slurry)	26	26	20

*From Nebraska's CNMP Manure Application Workbook

Summary

The concerns that producers have about utilizing manure nutrients for no-till crop production are valid. Research has been conducted to address those concerns and the results are encouraging.

Crop yields are not depressed when manure is applied at the correct rates and in the long term, manure applications have shown positive effects on soil quality. Long-term studies have shown increased carbon sequestration, higher cation exchange capacity, lower bulk density and increased levels of organic matter in soils where manure was applied consistently (Eghball, 2002). These side benefits of manure application have a beneficial impact on water and air movement in soils, which helps enhance crop growth.

Crop producers can help reduce yield differences between conventional and no-till production with manure and compost surface applications. Producers can make a manure or compost application that provides several years' worth of nutrients without depressing yields (Stevenson, et al., 1998). This can result in less frequent applications to fields where annual transportation costs may be prohibitive.

When designing a manure application plan, producers have to make sure they are getting the nutrients they are crediting. The size and species of the animal, housing, feeding ration, manure storage and climate all have impacts on the manure nutrient content. The rate of manure applied depends on the manure analysis, soil-test levels, crop rotation and environmental conditions. If producers implement a sound nutrient management plan, they should feel confident in fully utilizing manure nutrients in no-till crop production.

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For more information on this and other topics, see: www.ag.ndsu.edu

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000856

SAMPLING AND TESTING MANURE FOR NUTRIENT UTILIZATION

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Introduction

New regulations adopted by the U.S. Environmental Protection Agency classify certain animal feeding operations as Concentrated Animal Feeding Operations, or CAFOs. Those operations will be required to adopt comprehensive nutrient management plans or CNMPs to assure that nutrients in the manure do not become pollutants of surface or ground water. Most CNMPs will involve using the manure nutrients for crop production.

Complying with this part of environmental regulation can result in some economic advantage, particularly if a significant amount of purchased fertilizer can be replaced by manure. For that reason, those animal feeding operations that are not CAFOs may also find that utilizing manure nutrients for crop production may be a practice that is both environmentally and economically sound. Two-thirds of producers filling out surveys at recent livestock waste workshops indicated that they have used manure nutrients to reduce fertilizer purchases.

The manure nutrients of most concern in the environment are nitrogen and phosphorus. As it happens, those are also the two nutrients most often added to the soil as fertilizer for crop production. Excess amounts of nitrogen and phosphorus can impact surface and ground water quality.

Planning the utilization of manure nutrients for crop production obviously requires some knowledge about the crops to be grown and yield goals, the nutrient concentrations in the soil, the nutrient concentrations necessary to reach those yield goals, and the amount of fertilizer material which must be added to the soil to reach those goals. Most crop producers in the state are familiar with NDSU Extension bulletins that cover choosing realistic yield goals, sampling and testing soil, and calculating appropriate fertilizer nutrient application rates. Many are using those practices in their crop production programs. However, when using manure to supply the fertilizer nutrients, it becomes much more complicated.

Why Test Manure?

Manure is a highly variable product. Its composition depends on the type of animals, what the animals are fed, and the conditions under which they are fed. In addition, after the manure is produced, it can change greatly due to the conditions under which it is treated and stored. University of Minnesota bulletins list average nutrient contents for dairy, beef, and swine manure. However, their research results found that analyses of manure samples ranged from 25 to 300 percent of those average values. That emphasizes the value and importance of sampling and testing the actual manure being land applied for nutrient utilization.

Sampling

The most important and most difficult step in getting a meaningful manure nutrient analysis is always to get a representative sample. This is accomplished by taking a number of sub samples and combining them to get a composite sample. A clean plastic five-gallon bucket makes a good, cheap, and readily available container for collecting sub samples and mixing a composite sample.

The most variable manure is probably solid manure which has been piled or stacked from an open lot or barn. Therefore, it requires the most sub samples. Using a clean tiling spade or similar device, collect small amounts of solid manure from various locations and depths in the pile. Avoid the dry outside crust and any obviously non representative spots. Twenty or more sub samples should produce a composite sample within an acceptable range of accuracy. Be sure to thoroughly mix the sub samples before taking a composite sample.

Liquid manure stored in pits, tanks, or holding ponds tends to stratify as the solids settle. It needs to be mixed by agitating with a pump when the manure is to be removed from storage. After the liquid is thoroughly agitated, a good composite sample can be obtained from about five sub samples collected in a plastic bucket from five points in the storage or from five separate tank loads while hauling. Liquid in a runoff holding pond can likewise be sampled from five different spots in the pond or five sub samples can be taken at intervals during pump out. Again, thoroughly mix the sub samples before taking a composite sample for analysis.

Manure samples can be analyzed by most soil testing labs. NDSU Soil Testing Lab can handle solid manure samples of about two quart size in a sealable plastic bag. Some private labs have plastic bottles and mailers they can furnish for submitting samples. Air should be expelled from plastic bags before sealing. Some space should be left at the top of plastic sample bottles when they are filled to accommodate any gases produced. It is best to contact the lab before doing manure sampling to be sure the composite sample is sized and packaged as needed by that particular lab. Sample containing bags or bottles should be put into a second sealable bag to help prevent accidental leakage in transit.

Because manure is an organic material it is constantly undergoing mineralization. Samples should be refrigerated and transmitted to a lab as soon as possible.

Timing
Ideally, the time of sampling should be as close as possible to the time the manure is land applied. Practically, it needs to be 10 days or so before hauling to allow time for transmitting and processing the sample. In the case of liquid manure, an acceptable sample requires that the manure be mixed by agitation which is usually done just before hauling begins. That means the manure analysis probably will not be available until the manure has been hauled and applied. However, it is still valuable information.

Even though manure is a highly variable product, it tends toward a pattern on a particular operation if the feed and manure handling conditions remain constant. Therefore, analyses of manure samples from the previous couple years will be a good indication of manure values if the feeding operation has not changed.

What information do we need from a manure sample analysis?
Obviously, we need to know the total nitrogen and phosphorus contents. Also, we might want to know how much of the nitrogen is in the inorganic form versus the organic form. That will help us know how quickly the nitrogen will be available to the crop. Plants can take up only the inorganic form, which is essentially the ammonium-nitrogen and nitrate-nitrogen content of the manure. That portion of the total nitrogen will be available immediately. The organic nitrogen will not be available until mineralization takes place, so it will become available over about a three-year time.

About 80 percent of the phosphorus will be available to the first crop after manure application.
It may be useful to know the moisture content. Also, if we are concerned about total salts, an electrical conductivity value might be useful.

Why not test for potassium or K?
Most labs will do that as part of their standard test and potassium percentage will usually be significant. However, potassium is already high in most North Dakota soils and is not considered a water quality risk. Potassium could be part of any problem of excess total salts. You can calculate total manure potassium application if you wish.

How should information be reported?
The lab you choose should report the nutrient content of the manure on an as-is or as-received basis. Then the nutrient content numbers will reflect the material just as it is when you are land applying it. If it is reported on a dry matter basis, you will need to do an extra calculation using the moisture content to convert the analysis to an as-is basis before you can calculate application rates. The percent of a nutrient on a dry matter basis multiplied by the percent dry matter and divided by 100 will equal the as-is nutrient percent.

Also, the lab will probably report the manure nutrients as a percentage. To make manure application calculations easy, you will want to know the nitrogen and phosphorus contents in pounds per ton of solid manure or pounds per 1000 gallons of liquid manure. Most labs will do this calculation for you in their report. If they do not, simply multiply percent by 20 to get pounds per ton or by 83.5 to get pounds per 1000 gallons.

For water contained in a feedlot runoff holding pond which is to be applied to the land by an irrigation system, the percent of nutrient content can be multiplied by 2266 to get the pounds per acre-inch of water.

Fertilizer applications of phosphorus are given as phosphate or P2O5. Most manure testing labs will report the phosphorus content of the manure in the P2O5 form. If they report elemental phosphorus or P, that number must be multiplied by 2.29 to obtain the corresponding P2O5 value. Elemental potassium, K, can be multiplied by 1.20 to get potash or K2O.

Summary

With a crop rotation plan, yield goals, soil tests, and manure tests in hand, the livestock producer or crop producer planning to utilize available manure has the basic tools needed to develop a manure application plan.

For further information or assistance, contact the NDSU Extension Livestock Waste Management Specialist or watch for future workshops.

SF882 (Revised)

North Dakota Fertilizer Recommendation Tables and Equations

D.W. Franzen
NDSU Extension Soil Specialist

The following soil test recommendation tables are based on field research data obtained in North Dakota, South Dakota, western Minnesota and the Canadian Prairie Provinces.

In the case of some crops, data in the literature also were used to supplement data available from this area. **This publication contains changes from previous publications. Please dispose of older editions.** Changes to tables were based on new or re-evaluated data.

The major changes are:

- Separation of spring wheat and durum recommendations from winter wheat and rye
- Spring wheat and durum nitrogen (N) recommendations
- Simplification of winter wheat and rye N recommendations
- Wheat and rye potassium (K) recommendations

Recommendation Tables

Fertilizer needs should be determined after carefully evaluating the current fertility level of the soil and the nutrient needs of the crop to be grown, and setting realistic yield expectations. We strongly suggest that yield potential be based on a historical yield tendency for a field or a region. Recent research has shown that more productive areas of fields require less fertilizer, particularly N, than less productive areas of the field because they tend to be higher in organic matter and have a higher seasonal moisture content. The exception to this would be saline areas that are commonly high in residual N. Several of our N recommendations are "capped" at a maximum rate. In years that support higher yields than our N recommendation formulas indicate, our data show that greater N release from the soil will support these higher yields without requiring additional supplemental N fertilizer.

Nitrogen

Nitrogen (N) recommendations for most crops except some legumes are based on the amount of nitrate-N (NO_3-N) in the top 2 feet of soil and the yield potential. Nitrogen fertilizer recommendations are not adjusted based on method of placement, but they are adjusted for previous crop and depth of sampling. To determine the amount of recommended fertilizer N, subtract the amount of NO_3N in the soil as determined by soil test and N-credit from the previous crop, if applicable, from the total amount of available N needed for a particular yield goal and crop. Spring wheat and durum recommendations include economic components.

For example:

Your NDSU soil test shows 55 pounds of NO_3N are present in the soil to 2 feet. Your yield history is about 40 bushels per acre (bu/A) of spring wheat. The amount of nitrogen recommended to support a 40-bushel yield is 100 pounds of nitrogen per acre (N/A). The difference between 100 pounds and 55 pounds (the soil test) is 45 pounds of N. Therefore, the N recommendation is 45 lb N/acre.

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Adjusting N Recommendations

In a preplant NO_3N soil testing program, certain adjustments need to be made for the apparent contribution of N from some previous crops.

Previous Crop N Credits

Some crop residues have a lower carbon/nitrogen (C/N) ratio than others, which results in a release of plant-available N through rapid decomposition. Also, the mass of residue of some crops is smaller than others (dry bean compared with wheat or corn, for example). Evidence also indicates that some crops (soybeans) may accelerate the normal N mineralization rate from organic matter. Nitrogen availability is greater after crops with a lower C/N ratio (sugar beet, alfalfa) and crops having a lower mass of residue (soybean, dry bean) with less ability to tie up N during decomposition. We suggest that the following N credits be subtracted from crop N recommendations.

Credits

Previous crop	Credit
Soybean	40 lb N/acre
Edible bean	40 lb N/acre
Pea and lentil	40 lb N/acre
Chickpea	40 lb N/acre
Sweet clover that was harvested	40 lb N/acre
Alfalfa that was harvested and unharvested sweet clover:	
>5 plants/sq. ft.	150 lb N/acre
34 plants/sq. ft.	100 lb N/acre
12 plants/sq. ft.	50 lb N/acre
<1 plant /sq. ft.	0 lb N/acre
Sugar beet	
Yellow leaves	0 lb N/acre
Yellow/green leaves	30 lb N/acre
Dark green leaves	80 lb N/acre

Second-year N Credits

Half of credit given for the first year for sweet clover and alfalfa, none for other crops.

Depth Adjustments

The original data for calibration of the NO_3-N test was based on soil samples taken to a depth of 5 feet. Sampling beyond 2 feet improved nitrogen recommendations somewhat, but in the late 1960s, researchers decided that the extra effort to sample to a depth of 3 or 4 feet was not practical or necessary for most crops. Drought and application of excess N, however, may result in a buildup of available N below 2 feet. When fields are tested for N each year and only the recommended amount of N is applied, an accumulation of nitrogen below 2 feet is unlikely. Sugar beet is the most likely crop to be sampled to the 4-foot depth, but adjustments are not necessary in N calculations. Sugar beet N recommendations for 2-foot and 4-foot samplings are provided in Table 25. If deeper sampling is conducted to refine recommendations or screen for problems in malting barley, sunflower or safflower, the following adjustments would apply:

If the amount of NO_3-N in the 2- to 4-foot depth is less than 30 lb NO_3-N/A, do not adjust the recommendation.

If the amount of NO_3-N in the 2- to 4-foot depth is more than 30 lb NO_3-N/A, reduce the N recommendation by 80 percent of the amount greater than 30 lb/A. For example, if 50 lb NO_3-N/A are in the 2- to 4-foot depth, reduce the N recommendation by 16 lb N/A (80 percent of 50 lb N/A less 30 lb N/A, or 20 pounds).

Phosphorus and Potassium

The phosphorus (P) and potassium (K) recommended in these tables is the amount to be applied as a broadcast application. Since banded fertilizer generally is used more efficiently in the year of application, the amount of P_2O_5 and K_2O in the tables can be reduced by one-third when banding. Data from field trials in drier or cooler years indicates that small grains, corn and canola will respond to seed-placed or side-banded P fertilizer even on soils testing medium to high in phosphorus.

Some crops are very sensitive to fertilizer salt injury. No fertilizer is recommended with the seed for these crops in 15-inch rows or wider. Fertilizer-sensitive crops include all legumes, such as soybean, pea and dry bean. Consult individual soil fertility publications for each crop for more information. For information regarding fertilizer rate limits with the seed in small grains, consult NDSU Extension publication EB-62. It's available online at *www.ag.ndsu.edu/pubs/plantsci/soilfert/eb62w.htm*.

Under no-till and especially ridge-till systems, corn and soybean have responded to banded K even when soil test levels for K are high.

Broadcast recommendations of P or K for low and very low testing soils include buildup P and K rates. When rates are reduced, soil test levels are not increased through time. A long-term P and K strategy should include buildup to medium soil test levels at some future date. Near maximum yield potential is achieved only when these soil test levels are reached. Application of less than maintenance rates will result in a decline in P and K levels through time and an accompanying decline in the productivity of most crops.

Sulfur

Sulfur (S) deficiency most likely will occur on sandy soils throughout the state and on welldrained, mediumtextured soils. It appears most often on higher landscape positions with a thin surface organic-matter layer ("A" horizon) and coarse soil texture (loam to sand and gravel). Our current S soil test characterizes the S status of the soil very poorly. The test commonly underestimates or overestimates the available S in soil for a variety of reasons. Noting the texture, organic matter content, landscape position and rainfall in the past year often is a better predictor of S need than soil testing.

If a soil test is desired nonetheless, since sulfate-S (SO_4-S) is quite soluble, the top 2 feet of soil should be sampled, similar to the procedure recommended for N and chloride (SF-880).

Canola is especially responsive S. In canola, a high composite SO4-S soil test result would result in a recommendation of 10 to 15 lb S/acre, while with a low to medium SO_4-S test result, the recommended rates would be 20 to 30 lb S/acre. Sulfur is recommended for canola on high testing soils because of the variability of soil S levels, the poor relationship of S soil analysis with S responses, and the tremendous effect that S deficiency can have on this crop. Sulfur is not recommended on high testing soils for other crops.

Chloride

The chloride (Cl) soil test is calibrated only for small grains, although a few responses also have been seen in corn within the U.S. In general, responses to Cl in small grains have been in the range of 1 to 6 bu/A on responsive sites. The Cl recommendation is determined by subtracting the amount of Cl found in the top 2 feet of soil from 40 lb/A, although most of the yield response comes generally from the first 10 to 15 lb/A of Cl applied. The most commercially available and cheapest source of Cl fertilizer is 0-0-60 (potassium chloride, muriate of potash), which contains approximately 50 percent Cl.

Other Nutrients

The DTPA (diethylenetriaminepentaacetic acid) analysis is used to test soils for plant-available zinc (Zn), iron (Fe), manganese (Mn) and copper (Cu). Calibration data are available only for Zn on Zn-sensitive crops such as corn, potato, flax and edible bean, and for Cu on wheat/durum and barley. Micronutrient requirements are crop-specific. Additional crops would not be expected to respond to Zn or Cu if not listed above.

Zinc

When corn, potato, flax or edible beans are to be grown on a field testing low to very low in Zn, the recommendation is to apply 10 lb/acre of Zn as zinc sulfate in a broadcast application, or one-third of that rate as a band. Zinc is especially required in these crops if high levels of broadcast P or a starter P fertilizer is applied when soil Zn levels are low. Water solubility is important in efficient dispersion and uptake.

Also, the crop is more likely to achieve a first-year response to zinc sulfate if the fine granular formulation of the product is used instead of the MAP (mono-ammonium phosphate) or DAP (diammonium phosphate)-sized granules usually available. A fine granular application should be made using a fine-granular applicator similar to those used in the past to apply granular herbicide formulations. The distribution of large granules may not be adequate to supply all plants with Zn.

A broadcast application of zinc sulfate should correct a Zn deficiency for four to five years. Zinc chelates at suggested manufacturer rates also may be used but are relatively expensive per pound of plant food and offer no residual soil buildup. Banded chelates at 1 pint to 2 quarts/A often are used at planting. Foliar applications of zinc chelate and other soluble Zn fertilizers at low rates are also effective for correction of deficiencies for a single season. No Zn is recommended on fields testing medium or above or on fields testing very low, low or medium if the crop to be grown is not a Zn-sensitive crop.

Iron

In general, the supply of soluble iron (Fe) to plants from soil is related to the soil carbonate level, which is important when the soil pH is over 7. If carbonates are present, soil wetness, cold soils, excessive tillage and high soluble salt levels influence the presence and severity of chlorosis. Most of our crops are not sensitive to low available iron and are adapted to regional conditions. However, iron chlorosis has been seen in flax, field pea and dry bean and is a particularly serious problem in soybean.

Seed treatment with FeEDDHA (iron-ethylenediaminedi(o-hydroxyphenylacetic) acid) provides an early season greenup, but yield responses have been small. Foliar applications have been inconsistent in increasing yield, and multiple applications may be necessary. The best Fe amendment treatment has been the application of recommended rates of FeEDDHA in furrows at seeding. The best solution on fields where iron chlorosis occurs is

to plant varieties that are more resistant to this problem. NDSU rates about 200 soybean varieties each year for chlorosis resistance. The most recent data can be found at *www.soilsci.ndsu.nodak.edu/yellowsoybeans.*

Manganese

No field responses to manganese in North Dakota have been documented. Therefore, a recommendation is not made for any soil test level.

Copper

Yield increases due to soil-applied copper were documented in North Dakota; however, the responses were on low organic matter, loamy sand soils with low (less than 0.3 parts per million) copper levels. A number of companion trials on similar soils resulted in no yield increase. At best, copper should be applied only to low organic matter, sandy soils with low copper levels, but expect a success rate of about 15 percent. Copper is expensive, and its use should be based on weighing the productivity of responsive soils with the low return of benefits if copper were applied.

Fertilization Recommendation Tables for Crops Commonly Grown in North Dakota

The following tables can be used for the yield potentials shown.

For other yield potentials, use the equations at the bottom of each table.

The abbreviations used in the tables are as follows:

YP = yield potential
STN = soil test nitrogen
STP = soil test phosphorus
STK = soil test potassium
PCC = previous crop credit

Table 1. Soil test calibration levels used in North Dakota.

Nutrient	Name of Test	Categories				
		Very Low	Low	Medium	High	Very High
		ppm extractable				
Phosphorus (P), ppm	Olsen	0-3	4-7	8-11	12-15	16+
Potassium (K), ppm	Ammonium acetate	0-40	41-80	81-120	121-160	161+
Zinc (Zn)*, ppm	DTPA	0-0.25	0.26-0.50	0.51-0.75	0.76-1.00	1.01+
Iron (Fe), ppm	DTPA	no categories				
Copper (Cu)**	DTPA	0-0.10	0.10-0.20	0.20-0.30	0.30+	
Manganese (Mn)***, ppm	DTPA	no categories				
Boron, ppm	Hot water	no categories				
		lbs/acre extractable				
Nitrogen (N)	H2O Extract	*see tables to follow*				
Sulfur (S), lb/a-2 feet	H2O Extract	0-9	10-19	20-29	30-39	40+
Chloride (Cl), lb/a-2 feet****	H2O Extract	0-10	10-20	20-30	30-40	40+

* This calibration is only for sensitive crops such as corn, potato, flax and edible beans.
** This calibration is only for wheat and barley in sandy loam or coarser soils with organic matter less than 2.5%. Response to copper is not common. Responses have been found only in 15% of medium or lower testing locations.
*** Deficiencies of these nutrients have not been confirmed in North Dakota.
**** This calibration is only for small grain.

The amount of nutrient extracted by a particular soil extractant has little meaning or usefulness until it has been calibrated under field conditions. In North Dakota, we use five soil test calibration categories to give meaning to the soil test results. The categories from very low to very high are defined as follows **unless explained differently above:**

- **Very Low (VL)** ..... In this category, the probability of getting a response to applied nutrient is greater than 80 percent.
- **Low (L)** ..... Crops growing on fields in this category will respond to applied nutrient 50 to 80 percent of the time.
- **Medium (M)** ..... The probability of getting a response to applied nutrient is 20 to 50 percent.
- **High (H)** ..... In this category, crops will respond to applied nutrient about 10 to 20 percent of the time.
- **Very High (VH)** ..... The probability of getting a response to applied nutrient is less than 10 percent.

Table 2. Alfalfa.

Alfalfa

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
ton/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/acre				
2	0		34	24	15	6	0	96	66	35	5	0
4	0		67	49	30	12	0	192	132	71	10	0
5	0		84	61	38	15	0	241	165	89	13	0
6	0		101	73	45	17	0	289	197	106	15	0

Inoculation is necessary with proper rhizobium culture.
Bray-I P recommendation = (18.57-0.93 STP)YP
Olsen P recommendation = (18.57-1.16 STP)YP
Potassium recommendation = (55.71-0.38 STK)YP

(Annual rates of P_2O_5 and K_2O)

Table 3. Barley, feed.

Barley, feed

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
bu/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/acre				
40	70		28	20	12	4	0	45	31	17	3	0
60	100		43	31	19	7	0	67	47	26	5	0
80	135		57	41	25	9	0	89	62	35	7	0
100	170		71	51	31	11	0	112	78	44	8	0

Nitrogen recommendation = 1.7 YP-STN-PCC
Bray-I P recommendation = (0.785-0.039 STP)YP
Olsen P recommendation = (0.785-0.050 STP)YP
Potassium recommendation = (1.2860-0.0085 STK)YP

Table 4a. Barley, malting grade, in cooler, moister climates within North Dakota.

Barley, malting grade, in cooler, moister climates within North Dakota

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
bu/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/acre				
40	60		28	20	12	4	0	45	31	17	3	0
60	90		43	31	19	7	0	67	47	26	5	0
80	120		57	41	25	9	0	89	62	35	7	0
100	150		71	51	31	11	0	112	78	44	8	0

Nitrogen recommendation = 1.5 YP-STN-PCC
Bray-I P recommendation = (0.785-0.039 STP)YP
Olsen P recommendation = (0.785-0.050 STP)YP
Potassium recommendation = (1.2860-0.0085 STK)YP

Early planting is critical for greatest success.
Planting later than May 15 will require lower N rates.
Applying potassium chloride (0-0-60) at 15-20 lb K_2O/acre can increase kernel plumpness on well-drained soils if a chloride test is not available.

Table 4b. Barley, malting grade, in warmer, drier climates within North Dakota*.

Barley, malting grade, in warmer, drier climates within North Dakota

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
bu/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/acre				
40	48		28	20	12	4	0	45	31	17	3	0
60	72		43	31	19	7	0	67	47	26	5	0
80	96		57	41	25	9	0	89	62	35	7	0
100	120		71	51	31	11	0	112	78	44	8	0

Nitrogen recommendation = 1.2 YP-STN-PCC
Bray-I P recommendation = (0.785-0.039 STP)YP
Olsen P recommendation = (0.785-0.050 STP)YP
Potassium recommendation = (1.2860-0.0085 STK)YP

Early planting is critical for greatest success. Planting later than May 15 will require lower N rates. Applying potassium chloride (0-0-60) at 15-20 lb K_2O/acre can increase kernel plumpness on well-drained soils if a chloride test is not available.

* This recommendation is most useful for the North Dakota region from north of Williston south and everything west of the Missouri River. In years with low soil moisture, growers further east may benefit from this formula (see Figure 1).

Table 5. Buckwheat.

Buckwheat

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
bu/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/acre				
25	55		30	22	13	5	0	41	29	18	6	0
30	65*		36	26	16	6	0	49	35	21	7	0
35	75*		42	30	19	7	0	57	41	25	8	0
40	90*		48	35	21	8	0	65	47	28	9	0

Nitrogen recommendation = 2.2 YP - STN - PCC
Bray-I P recommendation = (1.320-0.066 STP)YP
Olsen P recommendation = (1.320-0.083 STP)YP
Potassium recommendation = (1.8600-0.0116 STK)YP

* N fertilizer rates greater than 50 lb/acre can cause lodging in wet years.

Table 6. Canola.

Canola

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
lb/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/acre				
1000	65		33	24	15	6	0	47	34	20	6	0
1500	100		49	36	23	9	0	71	50	30	10	0
2000	130*		65	48	30	13	0	94	67	40	13	0
2300	150		75	55	35	18	0	108	77	46	15	0
2500	150		82	60	38	16	0	118	84	50	16	0
3000	150		98	72	46	18	0	142	100	60	20	0

Nitrogen recommendation = 0.065 YP-STN-PCC with a 150 lb max limit
Bray-I P recommendation = (0.036-0.0017 STP)YP
Olsen P recommendation = (0.036-0.0022 STP)YP
Potassium recommendation = (0.054-0.00034 STK)YP

Note: Canola has a high requirement for sulfur Application of 20 to 30 lb/a S is recommended regardless of soil test results for this crop. Apply S as sulfate or thiosulfate form.

* Growers in warmer, drier areas should cap N rates at 120 lb N/a. (Fig.1).

Table 7. Clover (Alsike, Red, Birdsfoot Trefoil, grass-legume).

Clover (Alsike, Red, Birdsfoot Trefoil, grass-legume)

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
ton/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/acre				
2	0		36	25	13	2	0	87	60	34	7	0
3	0		54	37	20	3	0	130	90	50	11	0
4	0		72	49	27	4	0	173	120	67	14	0
5	0		90	62	34	6	0	217	150	84	18	0

Bray-I P recommendation = (20-STP)YP
Olsen P recommendation = (20-1.4 STP)YP
Potassium recommendation = (50.000-0.332 STK)YP

Inoculation is required at seeding with proper rhizobium culture.

Table 8. Corn, grain and popcorn.

Corn, grain and popcorn

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
bu/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/acre				
80*	96		51	37	22	8	0	82	58	35	12	0
100	120		63	46	28	11	0	102	73	44	14	0
150	180		95	69	42	16	0	153	109	65	22	0
200	240		127	92	56	21	0	204	146	87	29	0

Nitrogen recommendation = 1.2 YP-STN-PCC
Bray-I P recommendation = (0.700-0.035 STP)YP
Olsen P recommendation = (0.700-0.044 STP)YP
Potassium recommendation = (1.1660-0.0073 STK)YP

* We suggest that growers not plan for yield potential less than 80 bu/a anywhere in North Dakota due to inefficiency of N uptake under unfavorable soil moisture conditions.

Table 9. Corn, silage.

Corn, silage

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
ton/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/acre				
10	105		51	37	23	9	0	83	59	35	11	0
14	145		71	52	32	13	0	116	83	49	15	0
18	185		92	67	41	16	0	149	106	63	20	0
22	230		112	81	50	20	0	183	130	77	24	0

Nitrogen recommendation = 10.4 YP-STN-PCC
Bray-I P recommendation = (5.62-0.28 STP)YP
Olsen P recommendation = (5.62-0.35 STP)YP
Potassium recommendation = (9.50-0.06 STK)YP

Sweet corn

Table 10. Sweet corn.

Soil N plus Yield potential	fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
ton/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/acre				
4	70		40	29	17	6	0	78	57	36	15	0
6	110		60	43	26	9	0	116	85	54	23	0
8	145		80	57	35	12	0	155	114	72	30	0
10	180		100	72	44	16	0	194	142	90	38	0

Nitrogen recommendation = 18 YP - STN - PCC
Bray-I P recommendation = (11.000-0.533 STP)YP
Olsen P recommendation = (11.0-0.7 STP)YP
Potassium recommendation = (22.00-0.13 STK)YP

Crambe

Table 11. Crambe.

Yield goal	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
lb/a	Lb/acre-2'		lb P_2O_5/acre					lb K_2O/acre				
1,000	50		33	24	15	6	0	47	34	20	6	0
1,500	75		49	36	23	9	0	71	50	30	10	0
2,000	100		65	48	30	13	0	94	67	40	13	0
2,500	125		82	60	38	16	0	118	84	50	16	0

Nitrogen recommendation = 0.05 YG - STN - PCC
Bray-I P recommendation = (0.0360-0.0018 STP)YG
Olsen P recommendation = (0.0360-0.0023 STP)YG
Potassium recommendation = (0.05400-0.00036 STK)YG

Dry bean (pinto, navy, other)

Table 12. Dry bean (pinto, navy, other).

Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
lb/acre-2'		lb P_2O_5/acre					lb K_2O/acre				
See below		45	30	20	10	0	50	20	0	0	0

Nitrogen recommendation =
Irrigated sands 0.05 YP - STN-PCC
Dryland –
Inoculated 40 lb N/acre - STN-PCC

Phosphorus and potassium responses are not related to yield goal, but only to soil test levels.

Table 13. Flax

Yield potential	Soil N plus fertilizer N required	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
bu/a	lb/acre-2'	K_2O, lb/acre				
20	60	38	27	16	5	0
30	80	58	41	24	7	0
40	80	77	54	32	10	0
50	80	96	68	40	12	0

Nitrogen recommendation = 3 YP - STN – PCC, with limit of 80 lb/N.

N is limited to 80 lb/a due to the risk of lodging. If environment is favorable for higher yield, higher N release from organic matter will provide the added N in most situations.

Phosphorus application is not necessary for flax. Phosphorus can be applied, but no yield increase should be expected regardless of soil test level.

Potassium recommendation = (2.200-0.014 STK)YP

Flax

Table 14. Forage/hay grasses, established grass, irrigated, new seedings.

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
ton/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/acre				
2	50*		40	26	12	0	0	69	48	27	6	0

Nitrogen recommendation = 25 YP-STN
Bray-I P recommendation = 45.0-2.5 STP
Olsen P recommendation = 45.00-3.45 STP
Potassium recommendation = 80.00-0.53 STK

* Nitrogen application to native grass stands is discouraged due to selective pressures from less desirable plants with higher N nutrition. Native grass stands sometimes can benefit from P application.

Forage/hay grasses, established grass, irrigated, new seedings

Table 15. Millet and canary seed.

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
lb/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/acre				
1500	50		23	16	9	3	0	40	29	18	7	0
2000	70		31	22	13	3	0	53	38	24	10	0
2500	90		38	27	16	4	0	66	48	30	12	0
3000	105		46	32	19	5	0	79	58	36	14	0

Nitrogen recommendation = 0.035 YP-STN-PCC
Bray-I P recommendation = (0.0171-0.00085 STP)YP
Olsen P recommendation = (0.0171-0.00114 STP)YP
Potassium recommendation = (0.03-0.00018 STK)YP

Millet and canary seed

Mustard

Table 16. Mustard.

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm: VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm: VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
lb/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/acre				
1,000	65		33	24	15	6	0	47	34	20	6	0
1,500	100		49	36	23	9	0	71	50	30	10	0
2,000	130		65	48	30	13	0	94	67	40	13	0
2,500	150*		82	60	38	16	0	118	84	50	16	0

Nitrogen recommendation = 0.065 YP-STN-PCC
Bray-I P recommendation = (0.036-0.0017 STP)YP
Olsen P recommendation = (0.036-0.0022 STP)YP
Potassium recommendation = (0.054-0.00034 STK)YP

NonInoculated 70 lb N/acre – STN-PCC

* There is a cap of 150 lb N regardless of yield potential.

Oat

Table 17. Oat.

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm: VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm: VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
bu/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/acre				
50	65		29	21	13	5	0	55	38	21	4	0
70	90		41	29	18	7	0	77	53	29	5	0
90	115		52	38	23	8	0	100	69	38	7	0
110	145		64	46	28	10	0	122	84	46	8	0

Nitrogen recommendation = 1.3 YP-STN-PCC
Bray-I P recommendation = (0.644-0.032 STP)YP
Olsen P recommendation = (0.644-0.041 STP)YP
Potassium recommendation = (1.2777-0.0086 STK)YP

Pea, field, lentil and chickpea (garbanzo bean)

Table 18. Pea, field, lentil and chickpea (garbanzo bean).

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm: VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm: VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
lb/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/acre				
1,400	20		22	15	9	3	0	37	27	17	7	0
1,800	20		28	20	12	4	0	48	35	22	9	0
2,200	20		34	24	15	5	0	58	42	26	11	0
2,600	20		40	29	17	6	0	69	50	31	13	0

Bray-I P recommendation = (0.0171-0.00085 STP)YP
Olsen P recommendation = (0.0171-0.0011 STP)YP
Potassium recommendation = (0.03-0.00018 STK)YP

Inoculation is necessary with proper Rhizobium culture

Table 19. Potato.

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
cwt/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/acre				
200	80		90	63	35	8	0	147	102	56	10	0
300	120		135	94	53	12	0	221	152	84	16	0
400	160		180	125	71	16	0	294	203	112	21	0
500	200		225	157	89	21	0	368	254	140	26	0

Nitrogen recommendation = 0.4 YP-STN-PCC
Bray-1 P recommendation = (0.5-0.024 STP)YP
Olsen P recommendation = (0.5-0.034 STP)YP
Potassium recommendation = (0.85-0.0057 STK)YP

Under irrigation, N application should be split to reduce nitrate leaching risk. Supplemental N should be directed through the use of petiole/sap testing.

Table 20. Rye.

Nitrogen rates

Areas of **low** productivity (yields below 40 bu/acre) ..... Total available N = 100 lb/acre
Areas of **medium** productivity (yields 40 to 60 bu/acre) ..... Total available N = 150 lb/acre
Areas of **high** productivity (yields greater than 60 bu/acre ..... Total available N = 200 lb/acre
(Total available N = soil test nitrate 2 feet + previous crop credit + fertilizer N)

Phosphorus

Low productivity – apply 25 lb P_2O_5/acre at seeding with the seed up to a soil test of 15 ppm
Medium and **high** productivity – apply 40 lb P_2O_5 at seeding with the seed up to a soil test of 15 ppm.

Potassium

All productive ranges – apply 50 lb/acre 0-0-60 (30 lb/acre K_2O) if soil test K is less than 100 ppm.

Table 21. Safflower.

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
lb/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/acre				
800	40		20	14	9	3	0	34	24	14	5	0
1,200	60		29	21	13	5	0	50	36	22	7	0
1,600	80		39	28	17	6	0	67	48	29	10	0
2,000	100		49	35	22	8	0	84	60	36	12	0

Nitrogen recommendation = 0.05 YP-STN-PCC
Bray-1 P recommendation = (0.027-0.0014 STP)YP
Olsen P recommendation = (0.027-0.0017 STP)YP
Potassium recommendation = (0.048-0.0003 STK)YP

Safflower will extract N from depths of more than 4 feet. Excessive N will delay maturity and lower oil content.

Sorghum, forage and sudangrass

Table 22. Sorghum, forage and sudangrass.

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm: VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm: VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
ton/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/acre				
3	75		30	21	13	5	0	111	75	39	3	0
5	125		50	36	22	8	0	185	125	65	5	0
7	175		70	50	30	11	0	259	175	91	7	0
9	225		90	64	39	14	0	333	225	117	9	0

Nitrogen recommendation = 25 YP-STN-PCC
Bray-I P recommendation = (11.000-0.533 STP)YP
Olsen P recommendation = (11.0-0.7 STP)YP
Potassium recommendation = (43.0-0.3 STK)YP

Sorghum, grain

Table 23. Sorghum, grain.

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm: VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm: VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
bu/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/acre				
60	66		36	26	17	7	0	46	32	18	4	0
80	88		48	35	22	9	0	61	42	24	5	0
100	110		60	44	28	11	0	76	53	30	6	0
120	132		72	53	33	14	0	91	63	35	8	0

Nitrogen recommendation = 1.1 YP-STN-PCC
Bray-I P recommendation = (0.666-0.033 STP)YP
Olsen P recommendation = (0.666-0.041 STP)YP
Potassium recommendation = (0.875-0.0058 STK)YP

Soybean

Table 24. Soybean.

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm: VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm: VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
bu/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/acre				
30	0		40	23	10	0	0	55	33	11	0	0
40	0		54	31	10	0	0	73	44	15	0	0
50	0		67	39	11	0	0	92	55	19	0	0
60	0		80	47	13	0	0	110	66	22	0	0

Bray-I P recommendation = (1.55-0.10 STP)YP
Olsen P recommendation = (1.55-0.14 STP)YP
Potassium recommendation = (2.2000-0.0183 STK)YP

Inoculation or rotation within four years of a well nodulated soybean crop is necessary.

Table 25. Sugar beet.

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
ton/a	lb/acre-4'		lb P_2O_5/acre					lb K_2O/acre				
20	130		80	58	36	15	0	110	77	43	9	0

Bray-I P recommendation = (4.38-0.22 STP)YP
Olsen P recommendation = (4.38-0.27 STP)YP
Potassium recommendation = (6.350-0.042 STK)YP

A minimum of 65 lb N should be in the 0- to 2-foot depth. Soil N plus fertilizer N required with a 0- to 2-foot core only is 100 lb/acre.

Table 26. Sunflower.

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
lb/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/acre				
1,000	50		20	15	9	4	0	36	25	14	3	0
1,500	75		31	22	14	5	0	53	37	21	5	0
2,000	100		41	30	18	7	0	71	50	28	6	0
2,500	125		51	37	23	9	0	89	62	35	8	0

Nitrogen recommendation = 0.05 YP-STN-PCC
Bray-I P recommendation = (0.0225-0.0011 STP)YP
Olsen P recommendation = (0.0225-0.0014 STP)YP
Potassium recommendation = (0.041-0.00027 STK)YP

Tables 27-1 through 27-9. Spring Wheat and Durum Nitrogen Recommendations

(continued on pages 14-15)

To determine recommended N rate:

1. Find the region of the farm and look up the gross optimal available-N from the appropriate region/productivity table (Tables 27-1 through 27-9).
2. Subtract the soil test nitrate-N from the 0- to 2-foot depth.
3. Subtract any previous crop N credits.
4. Consider whether the field has been in a no-till or one-pass tillage system.
   - If the field has been in no-till less than five continuous years, add 20 lb N/acre.
   - If the field has been in no-till five or more continuous years, subtract 50 lb N/acre.
5. Make an organic-matter adjustment for soils with greater than 5.9 percent organic matter.
   - For each full percent of organic matter greater than 5 percent, subtract 50 lb N/acre.

Final N rate may be adjusted plus or minus 30 lb N/acre due to host of factors, including varietal protein traits, soil that tend to favor denitrification, excessive straw from the previous year or less than ideal application methods.

Within each region, the productivity is defined. Productivity category definitions:

- **Langdon Region**
  Low = less than 40 bu/acre
  Medium = 41 to 60 bu/acre
  High = greater than 60 bu/acre
- **Eastern Region**
  Low = less than 40 bu/acre
  Medium = 41 to 60 bu/acre
  High = greater than 60 bu/acre
- **Western Region**
  Low = less than 30 bu/acre
  Medium = 31 to 50 bu/acre
  High = greater than 50 bu/acre

Table 27-1.
Langdon Region Low Productivity.

	Costs cents per pound N								
Wheat price	20	30	40	50	60	70	80	90	100
	Gross Optimal N								
$3	100	90	80	70	60	50	40	30	20
$4	110	100	90	80	70	60	50	40	30
$5	120	110	100	90	80	70	60	50	40
$6	120	115	110	100	90	80	75	65	60
$7	120	115	110	100	95	90	80	75	70
$8	120	115	110	105	95	90	85	80	75
$9	120	115	110	105	100	95	90	85	80
$10	120	115	110	110	105	100	95	90	85

Table 27-2.
Langdon Region Medium Productivity.

	Costs cents per pound N								
Wheat price	20	30	40	50	60	70	80	90	100
	Gross Optimal N								
$3	130	125	120	115	110	100	80	50	20
$4	135	130	125	120	115	100	90	80	70
$5	140	135	130	125	120	115	100	90	80
$6	140	135	130	125	120	115	105	95	85
$7	140	135	130	125	120	115	110	100	85
$8	140	135	130	130	125	120	115	105	85
$9	140	135	135	130	125	120	115	110	95
$10	140	135	135	130	125	120	115	110	100

Table 27-3.
Langdon Region High Productivity.

	Costs cents per pound N								
Wheat price	20	30	40	50	60	70	80	90	100
	Gross Optimal N								
$3	160	145	130	125	110	100	90	75	40
$4	160	150	140	130	120	110	100	90	80
$5	160	155	150	140	130	120	115	105	100
$6	160	155	150	140	135	125	120	116	110
$7	160	155	150	145	135	130	125	120	115
$8	160	155	150	145	140	135	130	125	120
$9	160	155	150	145	140	135	130	130	125
$10	160	155	150	145	140	140	135	135	130

Table 27-4.
Eastern North Dakota Low Productivity.

	Costs cents per pound N								
Wheat price	20	30	40	50	60	70	80	90	100
	Gross Optimal N								
$3	100	90	75	60	0	0	0	0	0
$4	120	100	90	75	40	20	0	0	0
$5	160	140	120	100	90	75	40	20	0
$6	160	145	130	115	100	85	70	20	0
$7	160	150	135	120	105	90	75	40	20
$8	160	150	140	125	110	95	80	65	50
$9	160	150	145	125	115	105	95	85	75
$10	160	155	150	145	140	130	125	115	100

Table 27-5.
Eastern North Dakota Medium Productivity.

	Costs cents per pound N								
Wheat price	20	30	40	50	60	70	80	90	100
	Gross Optimal N								
$3	175	160	140	110	20	0	0	0	0
$4	180	165	145	125	100	40	0	0	0
$5	190	180	165	150	135	125	100	75	0
$6	200	190	185	175	160	150	100	75	20
$7	200	190	185	180	170	155	140	125	115
$8	200	190	185	180	175	160	145	130	120
$9	200	195	190	185	175	165	155	140	125
$10	200	200	195	190	180	170	160	145	130

Table 27-6.
Eastern North Dakota High Productivity.

	Costs cents per pound N								
Wheat price	20	30	40	50	60	70	80	90	100
	Gross Optimal N								
$3	250	230	210	190	140	0	0	0	0
$4	250	250	250	240	175	160	100	0	0
$5	250	250	250	250	225	200	150	125	0
$6	250	250	250	250	240	225	160	150	150
$7	250	250	250	250	250	250	210	180	115
$8	250	250	250	250	250	250	250	225	200
$9	250	250	250	250	250	250	250	250	225
$10	250	250	250	250	250	250	250	250	250

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Table 27-7.
Western North Dakota Low Productivity.

	Costs cents per pound N								
Wheat price	20	30	40	50	60	70	80	90	100
	Gross Optimal N								
$3	100	90	80	70	60	0	0	0	0
$4	120	110	100	90	80	65	50	0	0
$5	120	110	100	90	80	70	60	50	0
$6	120	115	110	105	100	95	90	85	80
$7	120	120	115	110	105	100	100	95	90
$8	120	120	115	115	110	105	105	100	100
$9	120	120	120	120	115	110	110	110	110
$10	120	120	120	120	120	120	120	120	120

Table 27-8.
Western North Dakota Medium Productivity.

	Costs cents per pound N								
Wheat price	20	30	40	50	60	70	80	90	100
	Gross Optimal N								
$3	150	150	145	130	115	100	0	0	0
$4	150	150	150	140	125	110	100	0	0
$5	150	150	150	145	130	120	110	100	25
$6	150	150	150	150	140	130	120	110	100
$7	150	150	150	150	150	140	140	130	120
$8	150	150	150	150	150	150	150	145	140
$9	150	150	150	150	150	150	150	150	150
$10	150	150	150	150	150	150	150	150	150

Table 27-9.
Western North Dakota High Productivity.

	Costs cents per pound N								
Wheat price	20	30	40	50	60	70	80	90	100
	Gross Optimal N								
$3	200	190	175	150	135	120	100	0	0
$4	200	190	180	160	150	140	130	120	0
$5	200	195	185	180	175	165	155	140	130
$6	200	200	190	185	180	170	160	150	140
$7	200	200	195	190	185	175	165	155	150
$8	200	200	195	195	190	185	175	170	165
$9	200	200	200	200	190	190	190	190	180
$10	200	200	200	200	200	200	200	200	200

Table 27-10. Broadcast fertilizer phosphate recommendations for North Dakota for spring wheat and durum based on soil test (Olsen sodium bicarbonate) and yield potential.

	Soil Test Phosphorus, ppm				
Yield Potential	VL 0-3	L 4-7	M 8-11	H 12-15	VH 16+
bu/acre	Pounds P_2O_5/acre				
40	39	28	17	15	15*
60	59	42	26	15	15
80	78	56	35	15	15
100	98	70	43	17	15

Olsen P recommendations = (1.071-0.067STP)YP, where STP is soil test P and YP is yield potential.

* Wheat seeding always should include a small amount of starter fertilizer in a band regardless of soil test. If starter fertilizer banding is not used, rates in H and VH categories should be zero.

Potassium recommendations for spring wheat and durum –

- Soil test K > 100 ppm, no additional K required. KCl (0-0-60-50Cl) may be applied if Cl levels are low.
- Soil test K 100 ppm or less, apply 50 lb/acre KCl (30 lb/acre K_2O)

Table 28. Winter wheat.

Nitrogen rates –

Areas of **low** productivity
(yields below 40 bu/acre) ..... Total available N = 100 lb/acre

Areas of **medium** productivity
(yields 40 to 60 bu/acre) ..... Total available N = 150 lb/acre

Areas of **high** productivity
(yields greater than 60 bu/acre ..... Total available N = 200 lb/acre

(Total available N = soil test nitrate
2 feet + previous crop credit + fertilizer N)

Also, if growing winter wheat in Langdon Region (see Figure 2), subtract 40 lb N/acre.

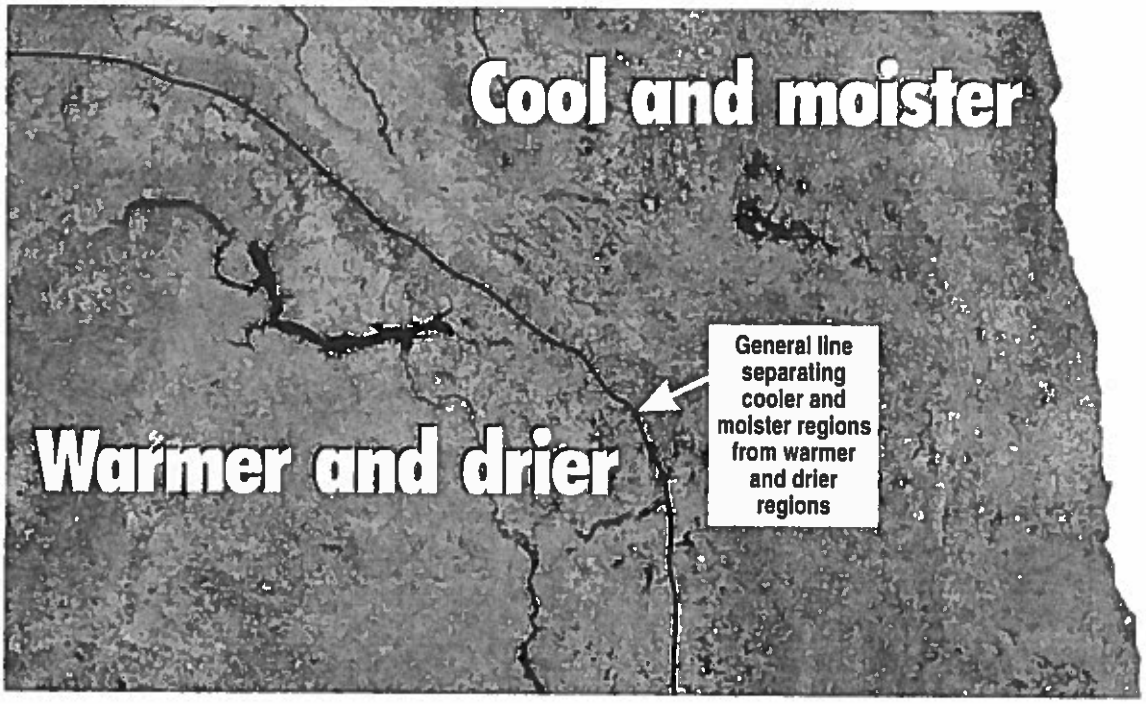
Phosphorus rates –

	Soil Test Phosphorus, ppm				
Productivity level	VL 0-3	L 4-7	M 8-11	H 12-15	VH 16+
bu/acre	Pounds P_2O_5/acre				
<40	39	28	17	15	15*
40-70	60	40	25	15	15
>70	80	60	40	15	15

*Wheat seeding always should include a small amount of starter fertilizer in a band regardless of soil test. If starter fertilizer banding is not used, rates in H and VH categories should be zero.

Potassium rates –

- Soil test K > 100 ppm, no additional K required. (KCl (0-0-60-50Cl) may be applied if Cl levels are low.)
- Soil test K 100 ppm or less, apply 50 lb/acre KCl (30 lb/acre K_2O)



(Image courtesy of NASA, Angela King – image compiler, and Hobart King Geology.com – publisher).

Figure 1.
General climatic delineation between cooler and moister areas in North Dakota compared with warmer and drier areas. In a given year, the line separating the two regions may move considerably east or west.

For use with Tables 4a, 4b and 6.

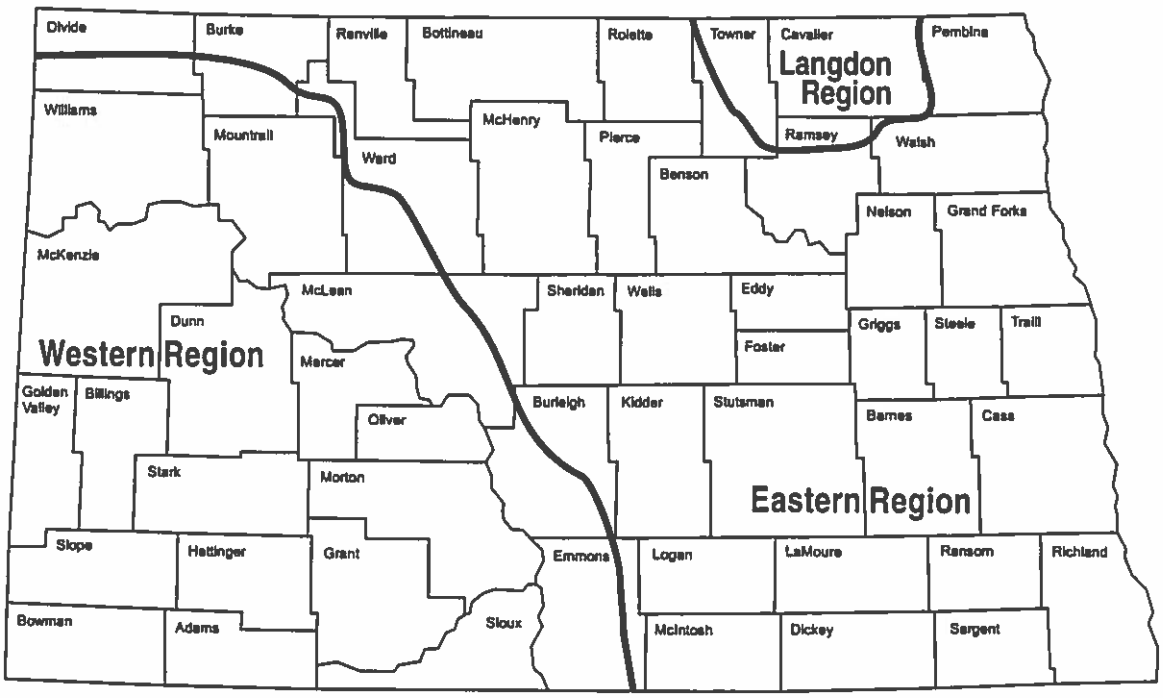


Figure 2.
Agri-climatology regions for use in Tables 27-1 through 27-9 for spring wheat and durum N recommendations, and Table 28 for winter wheat considerations.

For more information on this and other topics, see www.ag.ndsu.edu

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2M-5-07; 2M-12-08; 2M-1-10; 1M-11-13

SF722 (Revised)

Soil Fertility Recommendations for Corn

Corn has been a crop in North Dakota for at least 100 years.

D.W. Franzen
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Soil Science Specialist

However, the acres under corn grain production have been relatively small, compared with small-grain crops, until about 20 years ago. Today, corn consistently is planted on more than 3 million acres each year, with most North Dakota counties having significant acreage.

The surge in acreage has been the result of improved corn genetics supported by NDSU corn inbred research, combined with greater rainfall and the increase of long-term no-till acreage in western North Dakota.

Fertilizer recommendations for corn used until recently were published about 40 years ago and have been changed little since then. However, in the past 40 years, yield expectations have at least doubled from about 80 to more than 200 bushels per acre in many fields. Tillage practices and the hybrids planted have changed as well.

The changes from previous corn fertility recommendations in this publication are primarily the result of recent assessments of corn yield responses to nitrogen (N) through field experiments using modern hybrids and conditions.

NDSU EXTENSION SERVICE

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Nitrogen

The N recommendations in this publication were developed from data accumulated from 2010 through 2013 on 77 North Dakota corn N rate trials. In addition, data from recent N rate studies in northwestern Minnesota, southern Manitoba and the northern tier of counties in South Dakota were used to augment the NDSU data set.

A fall soil test to 2 feet in depth is a very important component of the N recommendation. **Figure 1** illustrates the poor predictive relationship between N applied and yield when the soil test nitrate-N results are not included in the analysis. Including the soil test nitrate-N results in a "law of diminishing returns" relationship of total known available N and yield.

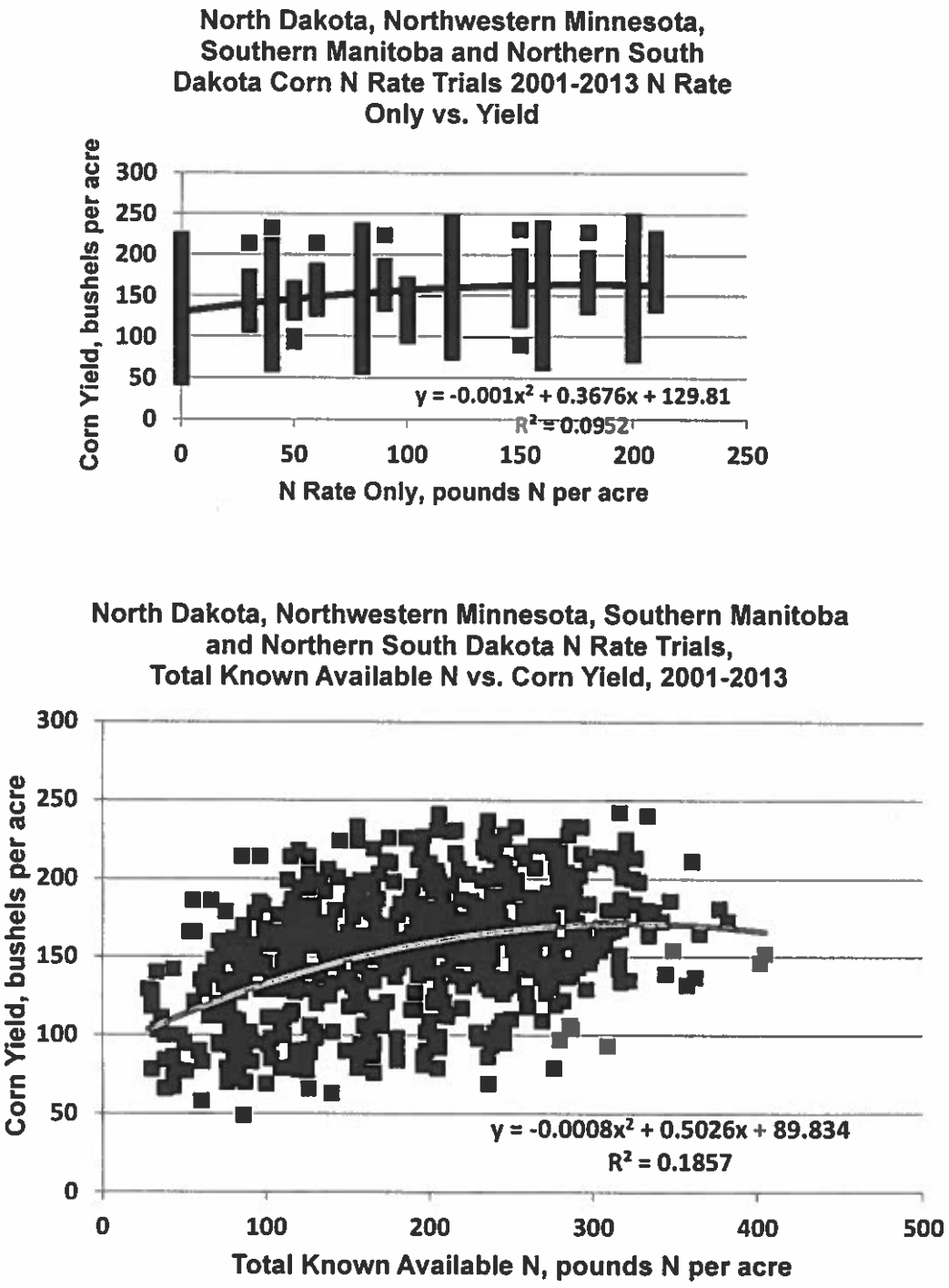

Figure 1. All data from North Dakota, Minnesota, Manitoba and South Dakota relating corn yield to N rate only (top) or N rate with soil nitrate analysis to 2 feet in depth (below).

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A change from previous recommendations is that N recommendations are not linked directly to expected yield. N recommendation categories within high-clay soils and medium-texture soils are divided into those soils with a historic capability to produce more or less than 160 bushels per acre. However, within the higher productivity categories, N rates have supported more than 240 bushels per acre in my experiments. Yields less than this were caused by too much water or not enough, but not by a deficiency of N.

Nitrogen recommendations are based on an economic production function that takes into account the yield response of corn to added N, less the cost of the N. This recommendation system is called the "Return to N" approach, defined by Sawyer and Nafziger (2005).

In our work, we determined the formula that related the total available N to yield for each recommendation category. As available N increases, yield increases until the cost of another pound of N equals the income benefit for the fraction of a bushel of corn the N will produce.

At some rate of N, yield can decrease with added N. The yield decrease often is related to greater lodging; "green snap," which is caused by unusually rapid stalk elongation and poor stalk structure that results in stalk breakage during a high wind event; or other physiological factors.

The response of corn to N is different between west-river soils and soils east of the Missouri River. Part of this difference may be due to the tendency for productive corn acres west of the Missouri River to be in long-term no-till, but some is due to the soils and generally warmer and drier climate of the west-river region **(Table 1)**.

In eastern North Dakota, long-term no-till, defined as continuous no-till six years or longer, is segregated from conventional-tillage sites **(Table 2)**. This phenomena also was seen in North Dakota spring wheat and durum research between 2005 and 2010. In that research, a 50-pound per-acre N credit was recommended in fields in long-term no-till.

In the corn N rate studies, the difference in N recommendations between long-term no-till and conventional-till soils was between 40 and 50 pounds less N per acre for long-term no-till soils. However, rather than incorporate a credit, a separate return to N analysis was prepared.

Within the conventional-till soils in eastern North Dakota, soils are divided into high-clay and medium textures. High clays include the textures of clay, clay loam and silty clay loam. Bearden, Fargo, Hegne and Viking are some of many soils in eastern North Dakota that would fall into this category. These soils have a high susceptibility for denitrification, which is a soil bacteria-led process in which nitrate is converted to nitrous oxide and nitrogen gas, and is lost from the soil into the atmosphere.

Denitrification proceeds when soil pores are filled with water and soil oxygen levels are low. Denitrification can be found anytime that the soil is flooded, but significant denitrification occurs in high-clay soils even when the soil is muddy or saturated but not flooded.

Table 1. Corn N recommendations for west-river soils, considering maximum return to N using corn N price and N cost.

	N cost, $/pound N								
Corn Price	**0.20**	**0.30**	**0.40**	**0.50**	**0.60**	**0.70**	**0.80**	**0.90**	**1.00**
$/bushel									
2	150	120	37	0	0	0	0	0	0
3	150	150	149	94	38	0	0	0	0
4	150	150	150	150	121	79	38	0	0
5	150	150	150	150	150	138	105	71	38
6	150	150	150	150	150	150	149	121	94
7	150	150	150	150	150	150	150	150	133
8	150	150	150	150	150	150	150	150	150
9	150	150	150	150	150	150	150	150	150
10	150	150	150	150	150	150	150	150	150

Table 2. Corn N recommendations for eastern long-term no-till soils, considering maximum return to N using corn N price and N cost.

	N cost, $/pound N								
Corn Price	**0.20**	**0.30**	**0.40**	**0.50**	**0.60**	**0.70**	**0.80**	**0.90**	**1.00**
$/bushel									
2	200	168	137	106	75	43	12	0	0
3	220	200	179	158	137	116	95	75	55
4	232	216	199	185	169	154	137	119	107
5	239	226	213	200	187	176	163	150	137
6	243	232	220	211	201	190	179	169	158
7	246	237	226	217	209	200	191	183	173
8	247	241	232	223	215	207	200	192	184
9	249	243	235	228	220	213	207	200	194
10	252	244	239	232	225	218	212	206	200

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Tiling made little difference in our N rate plots on N efficiency in high-clay soils. Water takes a long time to percolate through high-clay soils. Some estimates of downward water movement are 0.015 inch per hour, or about 1/3 inch per day in a Fargo soil.

High-clay soils are divided into those with historic yields exceeding 160 bushels per acre and those with historic yields less than 160 bushels per acre. In the higher-productivity high-clay soils, side-dress N is encouraged due to denitrification susceptibility; however, these soils have better internal drainage than those with lower yield capability, and growers might be able to achieve maximum economic yield with a greater portion of their total N applied preplant **(Table 3)**. The high-clay soils with lower productivity **(Table 4)** are likely to benefit from a side-dress N application.

The N rate from the recommendation table at a certain N cost and corn price is the maximum to apply preplant to these soils. To apply enough preplant N to these soils to support yields similar to those soils with higher historic yields would result in impractical N rates in excess of 400 pounds per acre.

The answer to higher yield in these soils is not rate but timing. Application of half or more of the recommended N at V6 to V8 would greatly increase yield and N efficiency in wetter years. Considering the tendency for high-clay soil to have sticky, mucky characteristics in wet conditions, the use of a coulter UAN side-dress applicator is recommended.

Medium-textured soils would include fine sandy loams, silt loams, loams, sandy loams, loamy sands and sands. The medium-textured soils with historic yield greater than 160 bushels per acre **(Table 5)** were the most

Table 3. Corn N recommendations for eastern high-clay soils with historic yields greater than 160 bushels per acre, considering maximum return to N using corn N price and N cost.

	N cost, $/pound N								
Corn Price	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00
$/bushel									
2	242	214	186	159	131	103	75	47	19
3	260	242	222	205	186	169	149	131	113
4	270	257	243	229	213	200	186	172	158
5	276	265	254	243	232	220	208	196	184
6	280	270	260	250	240	230	220	210	200
7	285	274	263	252	243	235	226	218	212
8	285	277	270	264	257	251	243	236	229
9	286	280	274	267	261	255	249	243	237
10	287	283	276	270	266	260	254	248	242

Table 4. Corn N recommendations for eastern high-clay soils with historic yields less than 160 bushels per acre, considering maximum return to N using corn N price and N cost.

The values in the table are the maximum to include in a preplant N application, followed by a side-dress N application based on the difference between the value in this table and the corresponding N cost/corn price value in Table 3. Use of an active-optical sensor to direct side-dress N rate instead of the difference between the Table 3 rate and preplant rate from this table is encouraged.

	N cost, $/pound N								
Corn Price	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00
$/bushel									
2	150	150	150	117	67	17	0	0	0
3	150	150	150	150	150	133	100	67	34
4	150	150	150	150	150	150	150	143	118
5	150	150	150	150	150	150	150	150	150
6	150	150	150	150	150	150	150	150	150
7	150	150	150	150	150	150	150	150	150
8	150	150	150	150	150	150	150	150	150
9	150	150	150	150	150	150	150	150	150
10	150	150	150	150	150	150	150	150	150

Table 5. Corn N recommendations for eastern medium-textured soils with historic yield greater than 160 bushels per acre, considering maximum return to N using corn N price and N cost.

	N cost, $/pound N								
Corn Price	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00
$/bushel									
2	222	201	180	160	139	118	97	76	55
3	235	222	208	194	180	166	152	138	124
4	236	234	223	213	202	192	181	171	161
5	249	241	243	223	215	206	198	190	182
6	252	245	238	231	223	216	209	202	195
7	254	248	242	236	230	222	217	211	205
8	255	250	245	240	234	229	223	218	213
9	256	252	247	243	238	233	229	223	218
10	257	253	248	244	239	234	230	224	219

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productive and N-efficient soils in the conventional-tillage category. These soils do not require N to be side-dressed to be N-efficient.

However, the medium-textured soils with less than 160 bushels per acre were the most N-inefficient soils in our studies (**Table 6**). These soils are highly susceptible to leaching and would benefit greatly from side-dressing of part of the N. Soils in this category usually are side-dressed using an anhydrous ammonia applicator, although a coulter UAN side-dress applicator also would work well.

For any subsurface-applied side-dress applicator, application may be made in every other row, rather than every row. An alternative side-dress application would be UAN streamed between each row. The efficiency of this alternative is high except in drier years, where surface dryness leads to greater N inefficiency.

A more risky application method would be to apply up to 100 pounds of urea (46 pounds of N per acre), broadcasting over the whorl using a granular ground applicator or by air. The urea used in an over-the-top application should include a NBPT coating (Agrotain).

The N recommendations for irrigated corn are included in **Table 7**. These are the total N rates recommended through a Return to N model based on data collected in the Oakes area by Knighton, Derby and Albus in the 1990s.

The total N recommended should be divided into preplant, side-dress and the remaining N provided through the irrigation pivot up to tassel initiation. An additional 20 to 30 pounds of N could be applied if yield conditions are exceptional after pollination. No N is recommended through the pivot during pollination.

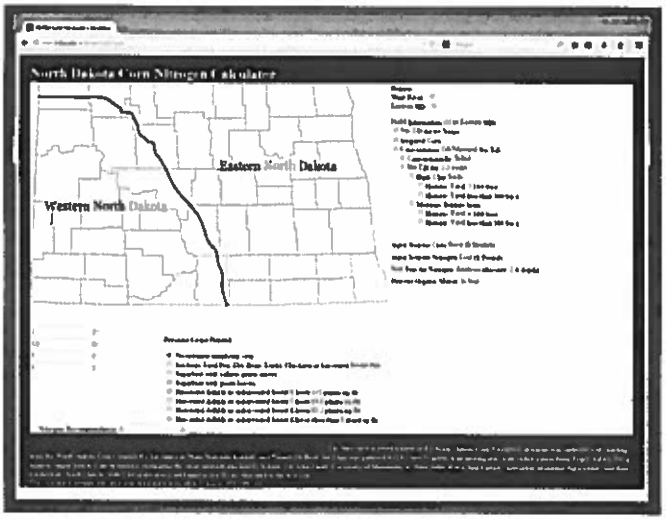
Table 6. Corn N recommendations for eastern medium-textured soils with historic yields less than 160 bushels per acre, considering maximum return to N using corn N price and N cost.

The values in the table are the maximum to include in a preplant N application, followed by a side-dress N application based on the difference between the value in this table and the corresponding N cost and corn price value in Table 5. Use of an active-optical sensor to direct side-dress N rate instead of the difference between the Table 5 rate and preplant rate from this table is encouraged.

	N cost, $/pound N								
Corn Price	**0.20**	**0.30**	**0.40**	**0.50**	**0.60**	**0.70**	**0.80**	**0.90**	**1.00**
$/bushel									
2	150	150	124	0	0	0	0	0	0
3	150	150	150	150	124	41	0	0	0
4	150	150	150	150	150	150	124	62	0
5	150	150	150	150	150	150	150	150	124
6	150	150	150	150	150	150	150	150	150
7	150	150	150	150	150	150	150	150	150
8	150	150	150	150	150	150	150	150	150
9	150	150	150	150	150	150	150	150	150
10	150	150	150	150	150	150	150	150	150

Table 7. Corn N recommendations for irrigated soils, considering maximum return to N using corn N price and N cost. This is the total amount for the season, which includes several split-N applications.

	N cost, $/pound N								
Corn Price	**0.20**	**0.30**	**0.40**	**0.50**	**0.60**	**0.70**	**0.80**	**0.90**	**1.00**
$/bushel									
2	255	241	228	215	201	188	175	162	149
3	263	254	245	237	228	219	210	201	194
4	268	262	256	250	244	238	232	226	220
5	272	267	262	257	252	247	242	237	232
6	273	268	263	258	253	248	243	238	233
7	274	269	264	259	254	249	244	239	234
8	275	270	265	260	255	250	245	240	235
9	276	271	266	261	256	251	246	241	236
10	277	272	267	262	257	252	247	242	237



For the interactive North Dakota Corn Nitrogen Calculator, go to

www.ndsu.edu/pubweb/soils/corn

000880

Phosphorus

In states to the south and east of North Dakota, distinctions are made within states where banded phosphorus (P) would be expected to have a consistent positive yield response and areas where they might not. These distinctions are usually a point north or south of some line within the state.

In North Dakota, we are north of all of these lines, so in North Dakota, every corn acre would benefit in most years from an in-furrow or side-band P application. An example of the dramatic difference possible through banding P in some North Dakota soils is provided in **Table 8** from the Carrington Research Extension Center.

The two most adopted at-seeding P banding strategies are in-furrow, also called "pop-up," and the 2-by-2 band, which is the starter band being placed 2 inches to the side and 2 inches from the depth of seed placement. The in-furrow band, as seen in **Table 8**, is effective at placing fertilizer near the initial small rootlets. However, placing fertilizer in the 2-by-2 band eliminates the risk of seed damage from salt or ammonium concentration near the seed, which results in lower stands with an in-furrow fertilizer placement.

Table 8. Corn yield with in-furrow application of 10-34-0; Hendrickson, 2007.

Rate of 10-34-0, gallons per acre	Corn yield, bushels per acre
0	101
2	121
4	125
6	150
8	156
10	153

Configuration of a 2-by-2 band in modern planters is not easy, but many growers use this configuration and they are able to apply N, P, potassium (K), sulfur (S) and zinc (Zn) easily with their starter with no reduction in stand.

In a 2-by-2 starter band, the N rate should be 50 pounds per acre or less to achieve a starter effect with any P in the band. Nitrogen rates higher than 50 pounds per acre in the starter band produce levels of free ammonia that are not penetrated by roots until later in the season, when the time for helpful early season effects of concentrated P are past.

Most of the P applied to corn is applied as broadcast P. Starter P sometimes can produce most of the yield benefit from a P application; however, corn grain contains about 0.4 pound of phosphorus pentoxide (P_2O_5) per bushel, so more P should be available to the crop than starter alone. The P soil test used in the state should be the Olsen sodium bicarbonate extractant because it is diagnostic of relative soil P availability in acidic and basic soils.

In buildup and maintenance, one fertilization strategy utilized by most of the central U. S. Corn Belt states, P anticipated to be removed is applied (maintenance) along with enough P to increase soil test levels through time (buildup). For example, a typical P application in Illinois that is necessary to increase soil test levels is about 9 pounds of P_2O_5 to increase the soil test 1 pound in the Bray P1 test. Experiments in Minnesota have indicated a range of P_2O_5 rates from 9 pounds to more than 40 pounds to achieve a similar soil test increase.

Most inorganic soil P is held by some soil mineral. No P fertilizer amendment effectively reduces the binding of P to soil minerals. In acid soils from below pH 5 to 6.8, the dominant P-binding element is iron. In alkaline soils with a pH above 7, the dominant P-binding ion is calcium.

In some of my experiments, yields approaching 200 bushels per acre were achieved in soils with P levels in the low range (less than 8 parts per million, or ppm). The corn obviously was taking up large quantities of P, even in soil test levels that were not optimum.

Some of the soil P available to crops is in organic form, which neither the Olsen nor the Bray test are very good at estimating. Recent studies in Minnesota have indicated that the current critical level for P should be closer to 20 ppm Olsen rather than 15 ppm.

North Dakota corn growers with very high yield potential might strive to achieve this higher soil test level if soil conservation methods and terrain were consistent with low wind and water erosion from their fields. General P recommendations for corn can be found in **Table 9**.

Many state best management practices to reduce P pollution into surface waters are based on soil P particulate movement. However, studies in Manitoba indicate that the greatest source of P into surface water bodies in our relatively flat-terrain region is not from particulates but from soluble P in residues and other rotting organic sources, mostly released in early spring.

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Table 9. Corn grain P and K suggested rates.

West River, non-irrigated, pounds P_2O_5 or K_2O per acre.

Olsen Soil Test Phosphorus, ppm					Soil Test Potassium, dry method				
VL	L	M	H	VH	VL	L	M	H	VH
0-3	4-7	8-11	23-15	16+	0-40	41-80	81-120	121-160	161+
78	52	39	26	10	120	90	60	30	0

East River, non-irrigated, pounds P_2O_5 or K_2O per acre.

Olsen Soil Test Phosphorus, ppm					Soil Test Potassium, dry method				
VL	L	M	H	VH	VL	L	M	H	VH
0-3	4-7	8-11	23-15	16+	0-40	41-80	81-120	121-160	161+
104	78	52	39	10	120	90	60	60	60*

* Rate in conventional till is 0. Use the 60-pound K_2O rate for no-till/ridge till.

Irrigation, pounds P_2O_5 or K_2O per acre.

Olsen Soil Test Phosphorus, ppm					Soil Test Potassium, dry method				
VL	L	M	H	VH	VL	L	M	H	VH
0-3	4-7	8-11	23-15	16+	0-40	41-80	81-120	121-160	161+
156	104	78	52	26	120	90	60	60	0

Corn is susceptible to a condition known as "fallow syndrome." Fallow syndrome is a stunting of corn, and often purpling leaves, and general P deficiency following a bare fallow, or following crops that do not support mycchorizae. Mycchorizae are a group of soil fungi that have a symbiotic relationship with many plant families, except for the Chenopodiacae (lambsquarter family) and the Cruciferae (mustard family). When corn follows canola (mustard family) or sugar beet (lambsquarter family), the likely result is fallow syndrome.

Prevent-plant acres generally have not resulted in fallow syndrome the following year, probably because, in most cases, these acres are seeded to a cover crop (highly recommended) or weeds grow for a significant portion of the summer, which also promotes mycchorizal populations.

Work in South Dakota indicates that high rates of P fertilizer banded near the seed are necessary to offset the effects of fallow syndrome. A minimum P fertilizer rate in one study was 150 pounds of 0-46-0 per acre in a 2-X-2 band. Simply increasing an in-furrow 10-34-0 rate from 3 to 6 gallons per acre does not eliminate fallow syndrome.

Potassium

Soil potassium (K) levels have been high for most soils in North Dakota until recently. With greater K removal with soybean and corn grain in recent years, soil test K levels have decreased in eastern North Dakota. The general recommendations for K based on soil tests for corn can be found in **Table 9**.

The soybean harvest usually removes more K each year than corn, but corn is much more susceptible to K deficiency than soybean. Deficiency is magnified during dry growing seasons, when most of the K must travel to the corn roots through diffusion or be intercepted by root contact, compared with wetter seasons, when K can flow to the roots through mass flow.

Sandier soils also are more susceptible to K deficiency because these soils, especially when organic matter is low, do not have enough clay cation exchange sites to hold K, and any added K in surplus of need usually is leached away during or after the growing season. Eroded Arvilla sandy loams/loamy sands are examples of soils with high native susceptibility to K deficiency.

Potassium recommendations sometimes are given based on the ratio of calcium and magnesium to potassium. These recommendations are based on poor soil fertility research and interpretation in Missouri and New Jersey in the late 1940s and early 1950s.

Despite the general soil fertility scientific community discarding these results, the concept of a "balanced soil" persists. Studies in several states indicate that the K extraction method, although not flawless, is a much better predictor of K requirement, compared with the balanced cation approach.

Growers should be aware that extraction of K in our soils often extracts calcium (Ca) and magnesium (Mg) from soluble salts and free lime in our soils, unrelated to Ca and Mg on the clay and organic matter particles. This often results in unreasonable "cation-exchange" values for loam soils, for example, that approach 30 millimhos per centimeter (mmhos/cm), where a true cation-exchange value would be about 15 mmhos/cm. A very good review of the poor basis for the use of base-exchange ratios for fertilization is available in Kopittke and Menzies (2007).

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Sulfur

Sulfur (S) deficiency has become an increasing problem for all North Dakota crops due to increased yield demand, increased rainfall compared with previous records, and decreased S in rainwater and erodible conventional-till fields, decreasing organic matter levels and thickness of the A horizon through time.

The S soil test is nondiagnostic and is available only because soil testing laboratory clients demand it, not because it is a reliable test. A better predictor of the need for S in a particular spring is to understand the soils and pay attention to rainfall and snow pack between the fall and spring planting season.

In soils with higher clay content and high organic-matter levels, S hardly ever is a problem except in the most extraordinarily wet springs. In medium-textured or coarser soils (loams, sandy loams, loamy sands, sands) with lower organic-matter levels (3 percent or less), particularly on hill/ridge tops and slopes, if rainfall/snowfall is normal or higher in the fall, winter or early spring, the application of at least 10 pounds per acre of S as sulfate or thiosulfate is recommended. These are spring fertilizers and should be applied in the spring. In coarser-textured soils, high rainfall after planting may require a second application.

Application of S as elemental S is not nearly as effective as sulfate or thiosulfate forms. The application of S as elemental S the fall before planting most often is not effective because any sulfate produced by very slow oxidation may be leached away by early spring rains, leaving only immediately unavailable elemental S near the soil surface.

Ammonium thiosulfate should not be applied as a row starter, and any ammonium sulfate applied is subject to similar rate restrictions of $N+K_2O$ as other row-placed fertilizers.

Sulfur deficiency appears in the spring as yellow upper leaves, with lower leaves remaining greener. The pattern of deficiency usually is related to the landscape, with eroded areas, hilltops and slopes being particularly vulnerable, especially in medium- and coarser-textured soils. Rescue with sulfate or thiosulfate sources such as ammonium sulfate, gypsum or ammonium thiosulfate are effective in correcting deficiencies, although a preplant application would result in greatest yield improvement.

Liquid solutions should be stream-applied between the rows or applied through an irrigation pivot to avoid serious leaf injury. Dry application on corn up to V4 is possible with little injury. Injury will increase as corn advances in maturity.

Zinc

Corn is one of four crops regularly grown in North Dakota that have shown yield increases from zinc application when soil levels are low. The critical level of soil test zinc, using the DTPA extraction method, is 1 ppm.

Potential zinc deficiency may be avoided by a broadcast application of at least 30 pounds per acre of zinc sulfate 36 percent granules or by adding a compatible zinc chelate of ammoniated zinc product to the starter fertilizer at planting.

The broadcast zinc sulfate application will increase soil test zinc levels for more than 10 years, while the starter chelate application will be necessary each year that the field is planted to corn.

Zinc deficiency is expressed as yellow-striped newer leaves and stunting. The deficiency can be corrected by a zinc chelate application, although when detected, some yield decrease already has occurred.

Additional nutrient deficiencies in North Dakota have not been documented.

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Corn Nutrient Deficiency Symptoms

A deficiency symptom is an indication that the crop is not well, but it is not a nutrient diagnosis by itself. For example, corn may show purpling of leaves early in the season, which can be a P deficiency symptom, but the purpling also can be any soil or environmental condition that reduces the rate of root growth, such as spring compaction, cold soils, very wet soil conditions and a tendency of purpling of certain hybrids.

Therefore, a plant analysis, most often accompanied by a soil sample, except in the case of sulfur, from a "good" area and the "not-as-good" area most often will result in a diagnostic analysis.

The following pages have photos showing mineral deficiencies in corn.

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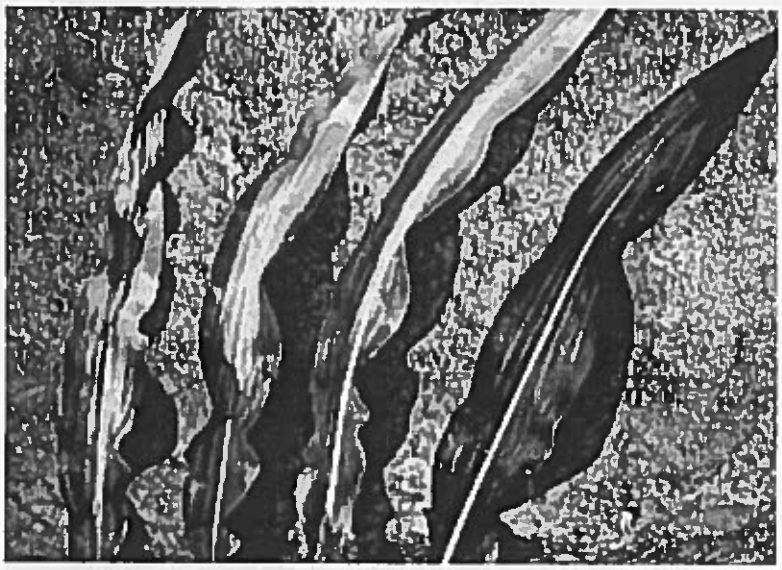

Nitrogen Deficiency

Nitrogen deficiency symptoms can occur at any growth stage through ear development. Symptoms are yellowing lower leaves, starting at the leaf tip and following the midvein in a "V" pattern.

◄ **Nitrogen deficiency in corn. Note how the deficiency starts at the tip and moves down the midvein. The outer leaf edges are the last to turn yellow.**

Phosphorus Deficiency

Phosphorus deficiency symptoms are purpling of leaves, with the lowest leaves most affected.

◄ **Phosphorus deficiency symptoms. These symptoms also can be caused by soil or environmental factors that limit root growth, such as compaction, cold soils and excessive soil wetness.**

Potassium Deficiency Symptoms

Potassium deficiency symptoms are the result of low soil K, and they are intensified by dry soil conditions. The symptoms are yellowing of the leaf margins on older leaves. As the deficiency intensifies, the yellowing moves toward the leaf midvein, with the midvein the last leaf part to be affected.

◄ **Potassium deficiency symptoms in corn. Note the yellowing of lower leaf margins.**

Image courtesy of Manbir Rakkar.

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Sulfur Deficiency

Sulfur deficiency symptoms are yellowing of upper leaves, often with a striped appearance.

◄ Sulfur deficiency symptoms on corn. Note upper leaves are most affected, with yellowing and striped appearance.

Zinc Deficiency Symptoms

Zinc deficiency symptoms are stunted plants with broad striping on upper leaves.

◄ Zinc deficiency symptoms in corn.

000886

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1M-7-14

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Soybeans need 14 mineral nutrients: nitrogen (N), phosphorus (P), potassium (K), sulfur (S), calcium (Ca), magnesium (Mg), copper (Cu), iron (Fe), manganese (Mn), zinc (Zn), boron (B), chloride (Cl), molybdenum (Mo) and nickel (Ni).

Of these, North Dakota soils provide adequate amounts for soybean production of all of them except N, P, K, S and Fe.

Nitrogen

Nodulation

Although the atmosphere is 78 percent nitrogen gas, plants cannot use it directly. Plants can use only ammonium-N or nitrate-N. Soybean is a legume and normally should provide itself N through a symbiotic relationship with N-fixing bacteria of the species Bradyrhizobium japonicum. In this symbiotic relationship, carbohydrates and minerals are supplied to the bacteria by the plant, and the bacteria transform nitrogen gas from the atmosphere into ammonium-N for use by the plant.

Soybean infection by N-fixing bacteria and symbiotic N fixation is a complex process between the bacteria and the plant. The right species of N-fixing bacteria must be present in the soil through inoculation of the seed or the seed zone at planting.

N-fixing bacteria are attracted to soybean roots by chemical signals from the soybean root in the form of flavenoid compounds (1). Once in contact with the root hairs, a root compound binds the bacteria to the root hair cell wall. The bacteria releases a chemical that causes curling and cracking of the root hair, allowing the bacteria to invade the interior of the cells and begins to change the plant cell structure to form nodules (2)(3) **(Figure 1)**.

The bacteria, up to 10,000 in each nodule, live in compartments called bacteroids **(Figure 2)**. Each bacteroid is bathed in nutrients from the host plant. The bacteroid takes nitrogen gas from the soil air and converts it to ammonium-N using the enzyme nitrogenase, which consists of one Fe-Mo (iron-molybdenum)-based protein and two Fe (iron)-based proteins. In North Dakota, northwestern Minnesota and northern South Dakota, iron deficiency chlorosis (IDC) may result in poor nodulation and may contribute to N deficiency as well as iron deficiency (4).

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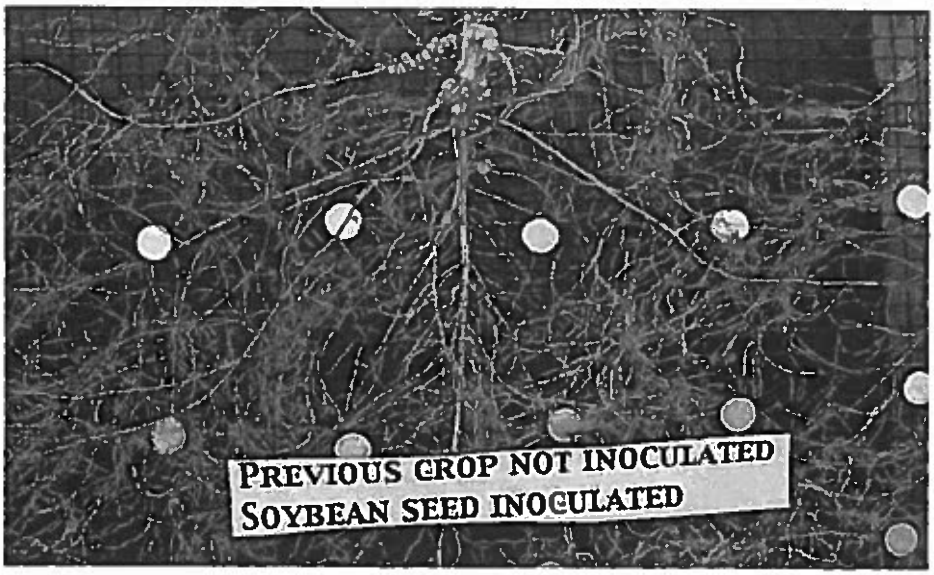

Figure 1. Nodules formed on soybean roots through infection by Bradyrhizobium japonicum inoculation in soils with no previous soybean inoculation history.

(R.J. Goos, NDSU)

Figure 2. Soybean nodule cross section micrograph showing individual bacteroids.

(Courtesy of Louisa Howard, Dartmouth College)

Inoculation

If soybean will be planted in a field for the first time, the seed will need to be inoculated with Bradyrhizobium japonicum (soybean inoculum). Several inoculum types can be used. They can be peat-based, liquid-based or granular. Of the three, granular appears to be the most foolproof for a first inoculation. The other two also can be used, but the frequency of mistakes is much higher. No formulation is free of error.

For the peat-based and liquid-based treatments, all seed should have inoculum attached to it when it enters the soil. Peat-based inoculants can vibrate off the seed if they are not applied with adequate sticking agent. Liquid applications could be calibrated poorly and may not stick to all of the seeds if the application is not made carefully. Even granular formulations that are applied near the seed in-furrow will have problems in performing if the seeder is poorly calibrated.

With proper care in handling and application, the success rate of all inoculation is very high. In the rare event that nodulation does not take place, supplemental N will have to be applied to reach yield potential. In-season foliar N application is not recommended, and slow-release liquid N sources have no higher foliar N efficiency compared with UAN (urea-ammonium nitrate solutions).

If a field has been seeded to soybeans previously and nodulation was effective, inoculating again has only a small chance of being economically effective. Studies in North Dakota have compared many inoculum brands in fields where soybeans were grown previously and successfully inoculated. Only very small yield benefits have been seen; most often inoculation results in no yield benefit. The six-year mean was 1.7 bushel per acre higher with inoculation (45 bushels per acre) vs. without (43.3 bushels per acre) **(Table 1)**.

Nitrogen is not required by soybean if adequate inoculation is present. In the north-central U.S. region, soybeans grown in soils that usually do not exhibit iron deficiency chlorosis symptoms sometimes responded to higher soil nitrate levels (4). However, higher soil nitrate levels in soils increase the severity of IDC in soils where IDC-supporting conditions prevail (5).

In North Dakota experiments, nearly all responses to supplemental N have been to first-year soybeans where initial inoculation resulted in poor nodulation (6). A three-year study of supplemental N at soybean growth stages R1 to R3 with a slow-release N source at about 25 pounds of N per acre showed no yield response compared with untreated check.

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Table 1. Frequency of soybean yield responses, grain yield and protein differences between experiments with or without a soybean history when seed is inoculated with *Bradyrhizobium japonicum* formulations at planting. (Carrington Research Extension Center, 2003-2007b and 2012; Oakes NDSU Experiment Farm, 2007a)

Site year*	Number of treatments	Soybean history	Number of treatments higher than check	Yield without inoculation	Mean yield with inoculation	Grain protein of the check	Mean grain protein inoculated
2003	38	No	38	32.8	38.8	31.5	35.0
2004	23	Yes	0	29.1	28.9	33.5	34.5 (NS)
2005	25	Yes	0	39.6	39.6	33.5	33.8 (NS)
2007a	7	Yes	0	55.9	55.9	35.1	35.1
2007b	11	No	11	46.1	50.7	32.0	34.1
2012	6	Yes	0	56.1	56.1	34.6	34.6

*All site years Carrington except 2007a treatment study at Oakes

Phosphorus

North Dakota soils are typically low in phosphorus (P). The soil test supported by NDSU recommendations is the Olsen sodium bicarbonate extraction method. The Olsen test best predicts crop response in the soils within state boundaries that range from below pH 5 to more than pH 8. More than one-half of soils in North Dakota have a pH higher than 7.

Soybeans have a great demand for P if soil tests are medium or below. Most soybean fields are seeded with grain drills and air-seeders to solid-seed soybeans. Historical use of these seeders for small-grain production has preconditioned most growers to apply their P with the seed.

Although up to 100 pounds/acre of 11-52-0 or equivalent P fertilizer can be applied with the seed row spacing through 12 inches in width, higher yields are achieved when the P is broadcast applied **(Table 2)**. Soybean, unlike small grain, canola, sugar beet and corn, usually does not benefit from banded P compared with broadcast P **(Table 2)**.

In some cases, phosphorus placed near the seed can reduce stand and yield **(Table 3)**. Experiments in Nebraska with broadcast compared with band resulted in almost a 5 bushel per acre advantage to broadcast. Similar experiments in Minnesota resulted in almost a 3 bushel advantage to broadcast vs. band.

In North Dakota, while seed-placed or near-seed-placed P application usually is profitable in small grains, canola, corn and sugar beet, profit is not assured in soybeans **(Table 3)**. No fertilizer P should be applied with the seed in 15-inch rows or wider because stand reduction can overwhelm any yield benefit of P application in wider rows **(Table 4)**.

In the central U.S. Corn Belt, P fertilizer commonly is applied to corn only in a corn-soybean rotation. This practice tends to provide good benefits to soybeans and corn because the soil P levels are most often in the "high" range. In North Dakota, the P test is

Table 2. Response of soybean to banded and broadcast fertilizer P, Nebraska, mean of three years. (G. Rehm).

	Placement Method	
	Broadcast	Band†
P_2O_5 lb/acre	Yield, bu/acre	
0	35.5	34.4
20	39.7	35.1
40	41.1	36.2
60	44.0	39.1
80	42.4	37.1

† Soil test P low. 2- by 2-inch band used.

Table 3. Seed-placed fertilizer effect on soybean stand, Carrington, three site-years, B. Schatz. Soybean seeded in 7-inch rows.

Rate of 11-52-0 with the seed	Final soybean stand	Yield bushels
lb/acre	plants per square foot	per acre
0	3.1	38.5
45	2.3	38.3
91	2.1	33.6
136	2.0	35.3

Table 4. Seed-placed 10-34-0 application to soybean stand and yield in 30-inch rows. Carrington, Endres and Hendrickson.

Application method	Stand	Yield
	1,000 plants/acre	bu/acre
Check	187.5	32.8
2 by 2, 4 gal/acre	188.6	33.5
In furrow 4 gal/acre	33.2	24.5
In furrow 8 gal/acre	20.6	18.9
LSD 5%	16.5	4.3

usually much lower, so P should be applied to soybean in a separate application. Fertilizing each crop is important until the field P test reaches the high availability range **(Table 5)**.

Phosphate "inoculants" sometimes are promoted to North Dakota soybean growers. The predominant inoculants are formulations of *Penicillium bilajii*, a fungus developed for commercial use in Canada about 20 years ago.

According to the developer, the fungus excretes acid from its hyphae. The acid can release trapped P from "occluded" P in the soil (P that is separated from the soil by a carbonate coating that can be present if the soils are high in free calcium carbonate). If, according to the developer, this P is present in soil, up to 10 pounds of P_2O_5 per acre may be made available during the course of the season with use of this inoculant.

The application of a P inoculant cannot be expected to act as a starter. The P inoculants will not release P in soil with a pH below 7 (7). Six site-years of work at Carrington found no significant soybean yield increase from the use of P inoculants (Endres, unpublished 2012). Recommendations for rates of P_2O_5 based on soil test can be found in **Table 7**.

Potassium

Potassium requirements for soybean are lower than they are for corn. However, in a corn and soybean rotation, fertilizing for higher nutrient levels is important.

Although the critical soil level for K using the 1-N ammonium acetate extraction method is only 100 ppm for soybean, the critical level for K in corn is closer to 200 ppm. Therefore, adding K to replace what the soybean crop may remove will make fertilizing corn less economically and logistically painful the next year corn is intended for the field.

In dry seasons, soybean has shown K deficiency symptoms even when soil test K is higher than 100 ppm. Recommendations for K fertilization of soybean based on soil test can be found in **Table 7**.

In-season Application of Foliar Sprays of N, P and K

Due to the observation of soybean plant physiologists that soybean nodule sustenance by the host plant is reduced soon after pod initiation, foliar fertilizer trials have been conducted in soybean-growing areas for the past 40 years.

Table 5. Effect of broadcast P application on low or very low soils in Minnesota (Rehm et al., 2001).

Application rate	Soybean yield
P_2O_5 lb/acre	bu/acre
0	23.0
23	37.0
46	39.5
69	41.3
92	40.2

Table 6. Soybean yield as affected by preplant N rate and seeding an oat cover crop at eight Minnesota IDC sites, 2006-2009. Lamb J., University of Minnesota (5).

N applied	Oats	C06	YM06	K07	YN07	C08	R08	C09	R09
lb/acre		bushels per acre							
0	No	42.1	52.0	3.7	51.7	34.3	30.4	51.0	42.0
100	No	28.6	32.2	0.3	46.5	—	—	—	—
200	No	25.3	19.1	0.1	40.2	—	—	—	—
0	Yes	42.5	52.4	40.2	50.7	41.7	28.1	50.0	44.0
100	Yes	20.5	42.6	24.5	43.4	—	—	—	—
200	Yes	18.9	25.9	7.2	33.7	—	—	—	—

Table 7. Phosphorus and potassium recommendation for soybeans based on soil test and yield potential.

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
bu/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/acre				
30	0		40	23	10	0	0	55	33	11	0	0
40	0		54	31	10	0	0	73	44	15	0	0
50	0		67	39	11	0	0	92	55	19	0	0
60	0		80	47	13	0	0	110	66	22	0	0

Bray-I P recommendation = (1.55-0.10 STP)YP
Olsen P recommendation = (1.55-0.14 STP)YP
Potassium recommendation = (2.2000-0.0183 STK)YP

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Yield responses to single nutrients or combinations of nutrients have not resulted in consistent yield responses to these applications (8)(9). Occasionally a yield response is recorded, but the great majority of experiments and on-farm trials have resulted in no yield increases and even yield decreases.

Some of the uncommon yield increases to foliar NPK applications have been related to low availability of soil nutrients. The rest of the yield increases are unexplained. The frequency of yield increases in all studies is so low and unpredictable that foliar application of NPK to soybean is not recommended.

Sulfur

Sulfur is as important to soybean as most other crops. The sulfur soil test poorly predicts the chance for S deficiency. Knowing the soils and considering the past precipitation is a better method of determining whether S is needed each season.

If the soils are loam or coarser in texture and the fall was wet, snowfall was normal to above normal and/or spring was wet prior to planting, the application of 10 pounds of S as a sulfate form (ammonium sulfate or gypsum) would be recommended.

Elemental sulfur of all formulations is not a recommended S source in North Dakota due to poor oxidation potential to sulfate.

Iron

North Dakota soils contain about 5 percent iron (Fe) by weight. However, only a tiny fraction ever is available to plants. Iron in well water is reduced iron (Fe++ or ferrous iron). Ferrous iron is very soluble in water.

The weight of a No. 2 carpenter nail can be dissolved in water if it were ferrous iron. Unfortunately, as soon as ferrous ion is exposed to oxygen, it oxidizes to oxidized Fe (Fe+++ or ferric iron). Ferric iron is a trillion times less soluble than ferrous iron. Plants, except for aquatic plants such as rice and pondweed, implement Fe uptake strategies to improve Fe nutrition and avoid deficiency.

In soybean, Fe is mobile in the plant from germination through the first monofoliate leaf. As the first trifoliate leaf emerges, Fe becomes immobile in the plant and must be taken up continually through the season to avoid deficiency.

The soybean strategy for Fe uptake begins by soybean roots acidifying the soil environment directly around the soybean root. The acidic soil environment is necessary for the activity of an Fe-reducing protein that is secreted by the soybean root (10). If the root rhizosphere remains acidic, the Fe-reducing protein contacts oxidized iron and reduces it to soluble ferrous iron, making it available to the plant.

Soybean plants exhibit iron deficiency as interveinal chlorosis **(Figure 3)**. In soils that are susceptible to iron deficiency chlorosis (IDC), the causal soil condition is the presence of carbonates (CO^{3-}) (11). As the soil becomes wetter, the solubility of carbonates increases, producing bicarbonate (HCO^{3-}) (12). Bicarbonate neutralizes the acidity around plant roots and makes the Fe-reducing protein secreted by the roots ineffective (13).

Iron foliar sprays generally are not effective in correcting a deficiency. The best application to reduce IDC is ortho-ortho-EDDHA Fe chelate applied

Figure 3. Soybean with IDC symptoms of interveinal chlorosis.

(D. Franzen, NDSU)

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with water in-furrow at seeding. The ortho-ortho-EDDHA not only succeeds in delivering Fe to the plant root early in the season, but after conveying its original Fe, it has the ability to return to the soil solution, capture additional Fe and deliver it to the plant root with the soil water stream (Goos and Lovas, unpublished data, 2012).

The amount of ortho-ortho EDDHA **(Figure 4, left)** in relation to ortho-para EDDHA **(Figure 4, right)** is very important in an iron chelate product. Both forms can be in a product, although the form effective in reducing IDC is only the ortho-ortho-EDDHA. Recent research at NDSU has shown that the response of soybeans to EDDHA fertilizer is directly proportional to the percentage of ortho-ortho EDDHA Fe in the product **(Figure 5)**.

An effective IDC prevention strategy should not rely on the application of ortho-ortho-EDDHA alone, but on a comprehensive approach to the condition. An IDC-tolerant variety should be selected.

A recent four-state study led by NDSU found that highest yield for a soybean field on soils with and without susceptibility to soybean IDC would be best managed by seeding a high-yielding IDC-intolerant cultivar in non-IDC soils and an IDC-tolerant cultivar in the IDC-susceptible soils (14).

To reduce IDC pressure, the soybean should be seeded in wider than 15-inch rows. Although the exact mechanism for the IDC benefit of denser stands is not known, many growers have seen this effect when the planter stops within the field and leaves a high density strip of seed behind when it resumes planting. Soybeans in densely seeded areas are taller and have less IDC symptoms, compared with the normally seeded fields.

Similar reductions in IDC symptoms are seen as soybeans are seeded closer to each other in wider row spacings or higher seeding rates (15). The causes of the denser seeding reducing IDC could be related to reduced soil moisture under the row, higher root-zone acidity that would favor activity of the Fe-reducing substance secreted by the soybean root, or other unidentified mechanisms.

A three-state study several years ago found that seeding a cover crop of 1 bushel per acre of oats or other easily killed small-grain cover crop about the day of soybean planting can reduce excess water and take up some excess soil N **(Figure 6)**. Depending on soil moisture, the oats may be killed with herbicide early if conditions are dry, or up to the five-leaf stage of oats if the season is wet.

The use of an oat cover crop resulted in as high as 40 bushels per acre more soybean, compared with where they were not used at a Minnesota site in a wet season (5) **(Table 6)**.

Because soil salinity aggravates and increases the severity of IDC, a comprehensive, rotation-based strategy should be imposed to reduce soil salinity as much as possible. That strategy should include selection of better salinity-tolerant crops; the use of alfalfa strips to reduce roadside salinity; the use of alfalfa above saline seeps to reduce the severity of the seep; the use of cover crops when possible before, during or after cropping to reduce the field water table; and possibly tile drainage if practical and socially and/or regulation-permissible.

Other Nutrients

Deficiencies of zinc, manganese, boron, molybdenum, nickel, chloride or copper have not been recorded in North Dakota.

Field experiments have not revealed any supplemental requirement for these nutrients above what our soils provide.

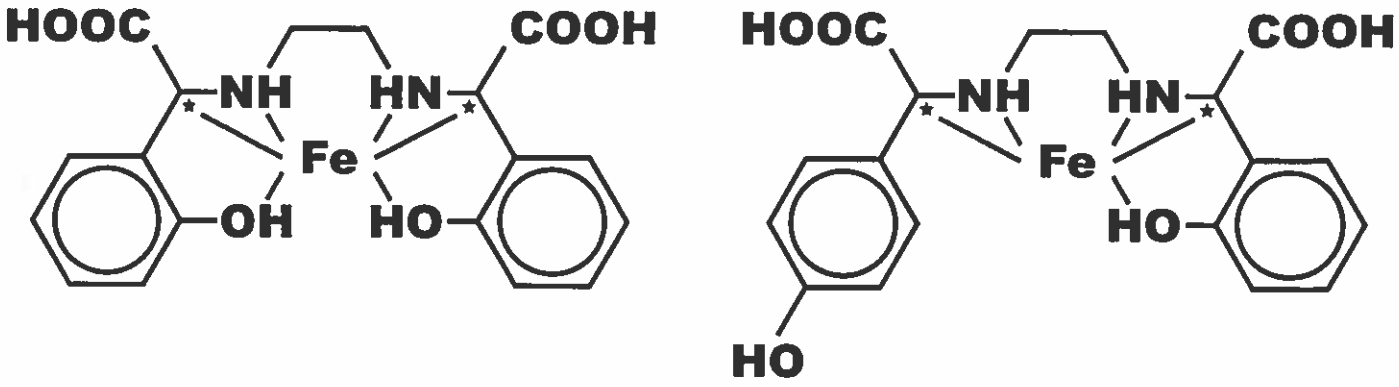

Figure 4. Ortho-ortho EDDHA (left); ortho-para EDDHA (right).

(Adapted by permission from Goos, 2012)

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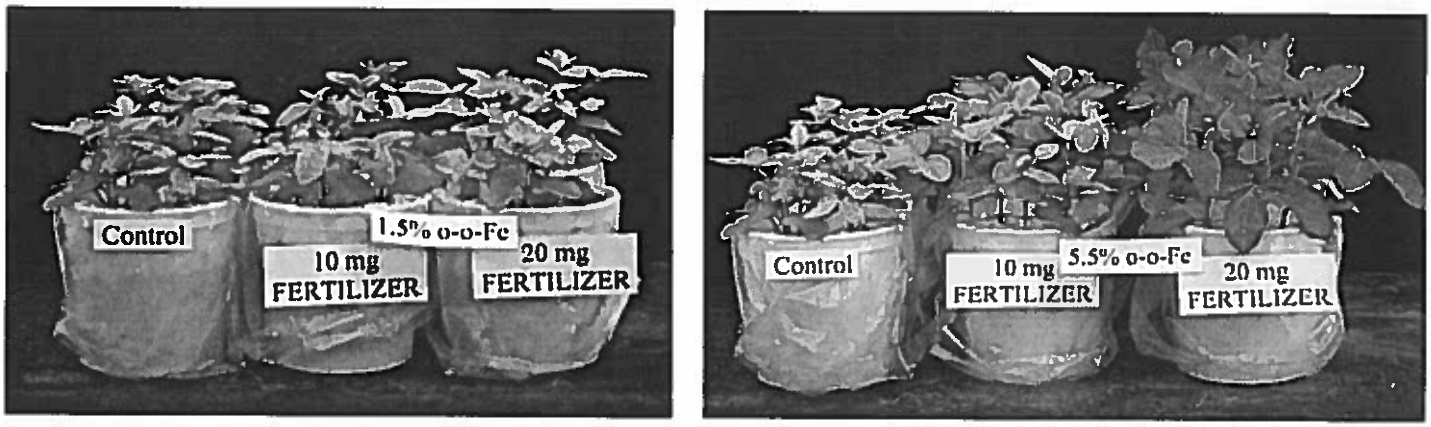

Figure 5. Effect of a 1.5 percent Fe as ortho-ortho EDDHA added to soil at different rates (left) compared with a 5.5 percent Fe as ortho-ortho EDDHA applied at the same rates (right).

(Goos and Lovas, unpublished, 2012)

Figure 6a. One hundred pounds of N/acre with no oat cover crop (left), compared with 100 pounds of N/acre with oat cover crop (right).

(J. Lamb, University of Minnesota)

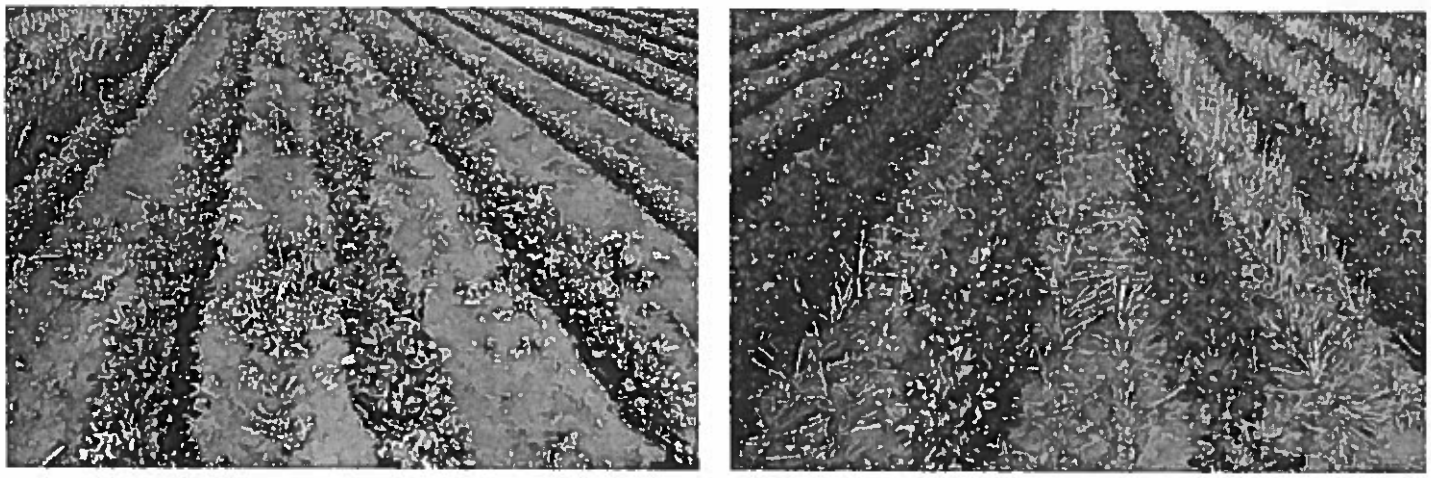

Figure 6b. No N applied and no oat cover crop (left). No N applied with oat cover crop (right).

(J. Lamb, University of Minnesota)

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SF720 (Revised)

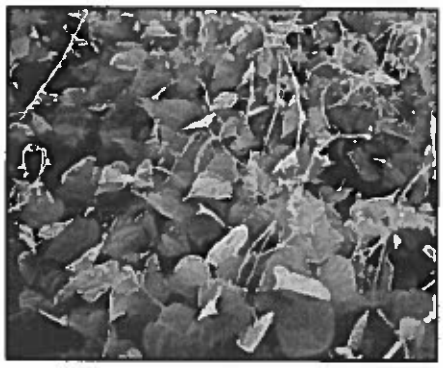
Fertilizing Pinto, Navy and Other Dry Edible Beans

David Franzen
NDSU Extension Soil Specialist

In the last 20 years, various researchers in North Dakota and northwestern Minnesota have conducted more than 30 site-years of trials.

NDSU EXTENSION SERVICE
April 2013

North Dakota is the leading producer of dry edible beans in the United States, with the greatest acreage of pinto beans of any state, and significant acres of navy, black and several other types of beans as well. Beans are a warm-season crop that prefers fertile, well-drained soils. Adequate, but not excessive, moisture during the growing season and a dry harvest result in high yield and quality.



NITROGEN

Dryland production

Nitrogen (N) nutrition is important to dry bean production, not only to sustain high yields, but also because of the quality concerns. Excessive N can delay maturity and encourage excessive leaf canopy growth, which may lead to increased disease incidence and severity in some years. Maturity delays and increased disease may result in reduced market price for growers due to reduced quality.

Dry bean growers usually do not go into and out of the business as do growers of other commodities in the state. For that reason, most growers know what N fertilization strategy works best for them in their area and in their soils. Growers effectively have used four main N fertilization strategies:

1. No inoculation or supplemental N
2. Inoculation with a nitrogen-fixing bacteria at seeding
3. Inoculation and supplemental N
4. Supplemental N only

Some soils with coarse to medium textures and higher organic matter levels (more than 3 percent) that have been in a dry bean rotation for many years do not require additional inoculation or supplemental N fertilization. These soils encourage the natural inoculation by N-fixing bacteria from previous years' bean production. The efficiency of the bacteria in this environment is so great that they are able to provide all the N requirements of the dry bean without additional assistance. In relation to the entire state dry bean acreage, these soils are in a minority, but for individual growers, they are important.

Inoculation is inexpensive, compared with supplemental N fertilizer. However, some soil and environmental conditions limit the effectiveness of the inoculants. Hot weather and wet soils can result in nodule abortion. Therefore, in areas that tend to be hot in June, such as west of Jamestown and along the Missouri River, inoculation may not result in consistent yields, compared with supplemental N. Likewise, if fields have significant areas of fine-textured soils,

inoculation may not result in adequate yields in wet years. Inoculation is, therefore, more effective in medium- to coarser-textured soils that are well-drained and in the northern half of the state. Seed for first-year dry bean fields always should be inoculated.

In the last 20 years, various researchers in North Dakota and northwestern Minnesota have conducted more than 30 site-years of trials. Using an N cost of 30 cents/pound and a dry bean price of 20 cents/pound, the return to N in inoculated and noninoculated trials was determined (Figure 1).

From these data, inoculated trials did not benefit from N rates greater than 40 pounds of N/acre, including residual soil nitrate from soil testing. Noninoculated trials peaked at about 100 pounds of N/acre, but N fertilization at rates more than 70 pounds of N/acre provided little additional economic advantage. Risks of later maturity, and increased incidence and severity of white mold disease, would favor the 70-pound N rate over the 100-pound rate.

The most economic rate was not related to yield potential or yield goal. Therefore, no scale of yield goal is made with N rate considerations in dryland production of dry beans. In years when environmental conditions favor higher yields, the conditions also stimulate greater mineralization of N from organic matter and crop residues, resulting in higher N availability to support higher yields.

N recommendations for dryland dry beans

Inoculated – 40 pounds N/acre less STN

Noninoculated – 70 pounds N/acre less STN

(STN = Soil test nitrate from 2-foot depth cores)

Irrigated production

Most irrigation will be on well-drained, coarser-textured soils. Inoculation has not been found to be adequate to support the very high yields often experienced in these fields, especially with high-yielding cultivars such as navy beans. Therefore, supplemental N is very important to achieving high yield potential of these irrigated fields. Not only is supplemental N encouraged, but split applications to increase efficiency and prevent nitrate leaching also are strongly recommended.

The formula for N recommendations under irrigation is:

N rec = YP X 0.05 – STN-PCC

Where N rec is the total supplemental N recommended through the growing season

YP is yield potential based on historic yield in the field

STN is available soil test nitrate from preplant soil test

PCC is previous crop credit/previous rotational crop or crops

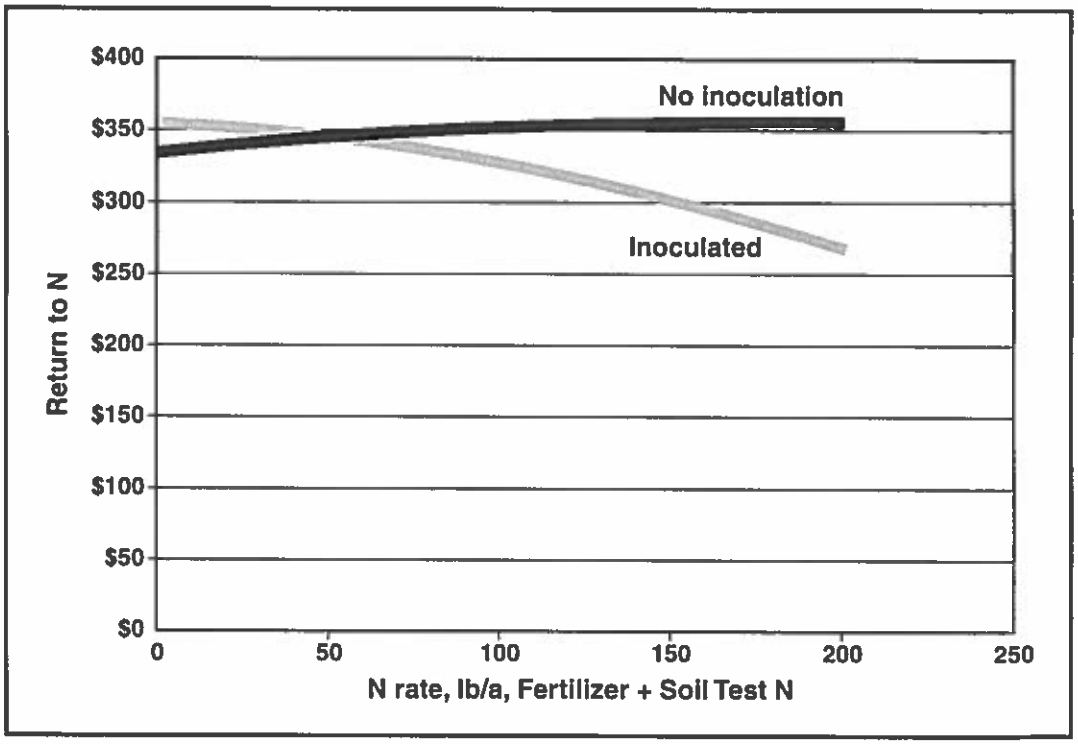


Figure 1. The economic return to supplemental N from more than 30 inoculated and noninoculated trials in North Dakota and northwestern Minnesota. Cost of N at 30 cents/pound, dry bean price of 20 cents/pound.

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A small preplant application is advised, usually under 40 pounds of N/acre.

The first supplemental N application can be side-dressed before vining.

Subsequent applications can be made through the irrigation system and completed before top pod fill begins.

PHOSPHORUS AND POTASSIUM

At phosphorus (P) soil tests of medium and lower, and potassium (K) soil tests that are very low to low, yield increases have been found with the application of supplemental fertilizer. The degree of response was not related to yield. Therefore, the P and K in these recommendations reflect one broadcast rate for each nutrient.

Banded P or K

Dry beans are sensitive to salts and ammonium-containing fertilizers when placed too close to the seed. The general recommendation is fertilizer should not be placed with the seed. An ideal planting band application is placement in a 2-by-2 arrangement: 2 inches to the side and 2 inches below the seed. With banded placement, P and K rates can be reduced about one-third from the recommended rate. Small rates of a product such as 10-34-0 (1 to 3 gallons/acre) have been successfully applied in some years with the seed, but in dry years, some stand injury has been reported, and therefore is not recommended as a standard practice.

ZINC

A soil test is a good guide for indicating the need for zinc (Zn). Soil tests below 1 part per million (ppm) suggest a good probability of dry bean response to zinc fertilizer. Broadcast rates of 3 to 5 pounds of actual Zn/acre as a soluble dry zinc product, such as zinc sulfate, usually are adequate to remedy a low Zn soil test. Zinc sulfate is an economic and effective zinc fertilizer, but intact granules of zinc sulfate are avoided by roots the first growing season, even in a band.

The first-year effectiveness of zinc sulfate can be improved by incorporation of finer granules of zinc sulfate, or fall incorporation of zinc sulfate granules. If a liquid starter is applied in a 2-by-2 band, rates of zinc chelate or ammoniated zinc complex as low as 1 pint/acre have been effective in preventing zinc deficiency.

Foliar applications of zinc chelate products when the plants are small also have been used effectively. Do not to apply foliar zinc products with herbicides or other plant protection products because of the chance of increased phytotoxicity to the crop or decreased efficacy to the pest.

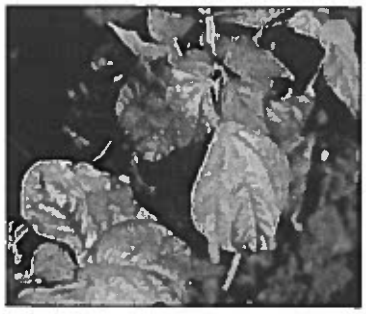

Figure 2. Zinc deficiency in pinto beans.

P and K recommendations for dry bean, dryland or irrigated.

	Soil test phosphorus, ppm					Soil test potassium, ppm		
Analysis	VL	L	M	H	VH	VL	L	M
Bray P1	0-5	6-10	11-15	16-20	21+	0-40	41-80	81-120+
Olsen	0-3	4-7	8-11	12-15	16+			
	lb P_2O_5 /acre					lb K_2O /acre		
Rate	45	30	20	10	0	50	20	0

IRON DEFICIENCY CHLOROSIS

Soils with carbonates near the surface, combined with wet soil conditions, and especially higher soluble salt levels, can result in iron deficiency chlorosis (Figure 3). This condition is seen as interveinal yellowing and should not be confused with N deficiency. Dry beans generally are more tolerant of the soil conditions that result in this problem. It usually is seen near ditch banks or edges of sloughs, where carbonates and salts are elevated.

Iron fertilizer sprays are available, but have not alleviated the problem consistently. The severity usually is caused by wet soil conditions that increase soil bicarbonate levels. As soil dries, bicarbonate levels drop and affected plants usually green up. If a field has a known susceptibility to iron deficiency chlorosis, selecting varieties that have shown more tolerance to the conditions is recommended.

Figure 3.
Iron deficiency chlorosis on a saline, calcareous soil near Arthur, N.D.

For more information on this and other topics, see www.ag.ndsu.edu

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NM-1629

North Dakota Manure Fertilizer Use Recommendations

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NDSU EXTENSION SERVICE

December 2012

Animal manure is a great source of nutrients for crop production.

It contains significant amounts of nitrogen (N), phosphorous (P), potassium (K) and lesser amounts of many micronutrients.

However, it must be managed differently than commercial fertilizers. Manure nutrients are primarily in an organic form and need to be made available to plants through microbial breakdown. This natural process is mediated by soil temperature, soil moisture, soil type and other biotic factors. These processes take time, making manure nutrients available more slowly during the growing season.

Because of the natural variability in the amount of nutrients in manure released to crops, many crop producers are hesitant to use manure as a fertilizer source. A research program was initiated at the NDSU Carrington Research Extension Center to address this concern and determine if manure can supply the needed nutrients to grow the crops typically grown in the upper Great Plains.

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Research Program Design

Field plot research projects were initiated following standard research protocols that included treatment randomization and replication to account for any field or treatment variations. The crops grown in the trials were corn, canola and hard red spring wheat.

Corn was chosen as a standard comparison crop because a significant amount of field research has been conducted on corn response to manure fertilizers in other parts of the country. Wheat and canola where chosen not only because they are popular in North Dakota but because they have a higher nutrient demand earlier in the growing season than corn.

Five trials were conducted with spring wheat to compare fall- and spring-applied manure with spring-applied commercial fertilizers. Two trials each of canola and corn were conducted to compare spring-applied manure with commercial fertilizer. All of the trials had a check treatment with no fertilizer.

To account for the P in manure, the commercial N fertilizer treatments were supplemented with commercial P equal to the amount in the manure treatments. Some of these trials also had soil investigation components, but this report will focus only on the crop response to the treatments. The trials were conducted during a five-year period (2007-2011), increasing the confidence in the numbers based on weather variation.

What We Learned

A previously published NDSU Extension publication stated that research has shown that 50 percent of the total N in manure is available to the crop in the first year of application. Varying levels of manure N availability were tested in some of the Carrington Research Extension Center trials, and a 50 percent availability rate was shown to be accurate (data not shown).

Table 1 shows the results of the Carrington Research Extension Center corn trials. Corn yields did not vary significantly when manure was used as the sole fertilizer. This was an expected outcome and similar to other research conducted in the Midwest. **Table 2** shows the results of the canola trials.

Canola yields were significantly lower when spring-applied manure was the fertilizer source, compared with spring-applied commercial fertilizer. Even though manure supplies the needed sulfur for canola, the release of N is too slow to allow canola to reach its yield potential.

Because crops such as canola and spring wheat have a high N demand early in the growing season, a fall-applied manure treatment was included in the wheat trials. According to the five trials conducted with wheat as shown in **Table 3**, fall manure-treated plots had statistically similar yields to commercial fertilizer but were, at times, a few bushels lower.

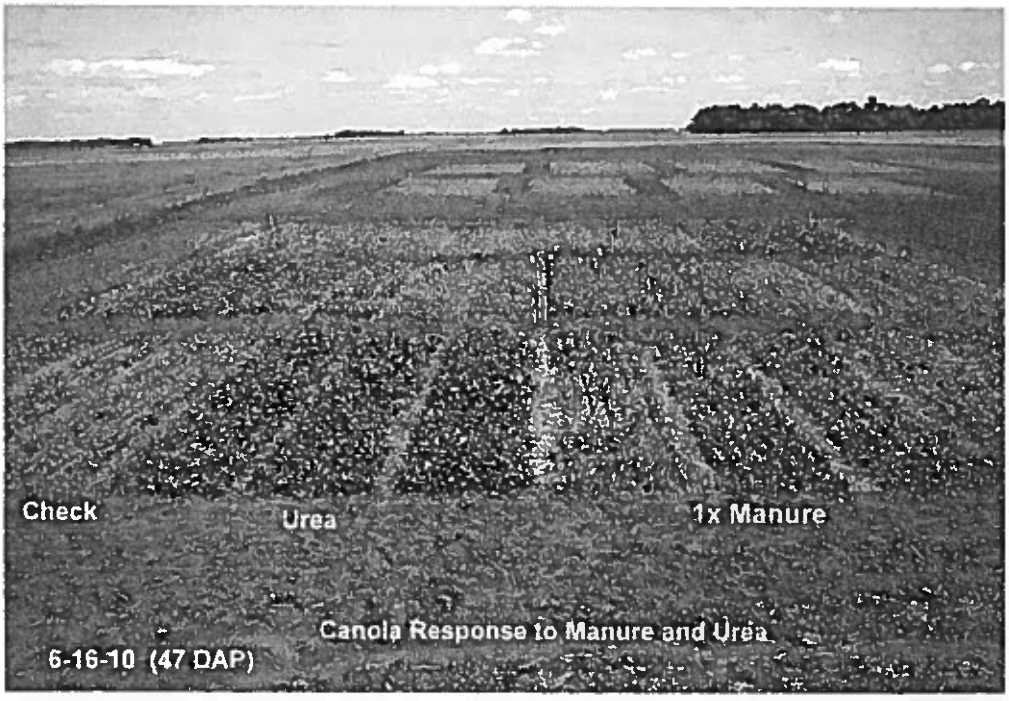

Figure 1.

Canola trial showing differences in crop growth based on fertility treatments.

All treatments were applied five days before planting.

Table 1. Corn yields in response to fertility treatments.

Treatment	Trial 1	Trial 2	Treatment Average
	(bu/acre)		
Check	136[b*]	98[b]	117
Commercial fertilizer	145[a]	111[a]	128
Spring-applied manure	144[a]	105[a]	125

[a,b,c] Numbers with similar letters are not statistically different at a 95 percent confidence level.

Table 2. Canola yields in response to fertility treatments.

Treatment	Trial 1	Trial 2	Treatment Average
	(lbs/acre)		
Check	1,240[c*]	1,503[c]	1,372
Commercial fertilizer	1,773[a]	2,671[a]	2,222
Spring-applied manure	1,733[b]	1,817[b]	1,775

*p = 0.05

[a,b,c] Numbers with similar letters are not statistically different at a 95 percent confidence level.

The yield from spring wheat and canola that received the spring-applied manure always was significantly lower than in crops with the commercial fertilizer or fall-applied manure treatments.

In all the trials, the yield for crops receiving the check treatment with no fertilizer always was significantly lower than in crops receiving the other treatments.

Table 3. Spring wheat yields in response to fertility treatments.

Treatment	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Treatment Average
	(bu/acre)					
Check	34[b*]	25[c]	26[c]	34[c]	30[c]	30
Commercial fertilizer	41[a]	45[a]	51[a]	46[a,b]	48[a]	46
Spring-applied manure	40[a]	32[b]	34[b]	47[a,b]	40[b]	39
Fall-applied manure			39[b]	50[a]	45[a,b]	45

[a,b,c] Numbers with similar letters are not statistically different at a 95 percent confidence level.

Recommendations for Using Manure as a Fertilizer Source

- Credit 50 percent of total N in the manure analysis as available the first year of application.
- Corn production: Manure nutrients are a complete substitute for commercial fertilizer and can be used as a sole source of nutrients for corn. Manure can be applied in the spring or fall.
- Wheat, canola and other short-season, high N-demand crops: If manure is applied in the spring, 20 to 40 pounds per acre of supplemental commercial N need to be applied at planting to supply early season N. If manure is applied in the fall, enough N should be available by spring, but a 20- to 40-pound-per-acre application of supplemental commercial N at planting may be beneficial.

Cover photo by Ron Wiederholt

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To Order

Clean Water- You Can Make the Difference

Fertilizing Cropland with Swine Manure

Michael Schmitt and George Rehm

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Manure management should be a top priority on hog farms as we approach the 21st century. Mismanagement of manure can have a substantial negative impact on our water, soil and air resources. When used appropriately, manure has nutritive, and thus economic value. Manure also improves biological activity, soil tilth, and soil chemical properties.

According to 1990 Minnesota Agricultural Statistic Service data, the swine industry in Minnesota generates approximately 11 million tons of manure annually. Hogs and pigs in Minnesota excrete almost 73,000 tons of nitrogen (N) per year that can serve as a nutrient source for crops. This manure also contains 55,000 tons of P_2O_5 (phosphorus fertilizer equivalent) and 58,000 tons of K_2O (potassium fertilizer equivalent). Although some losses of these nutrients are inevitable in handling and storage, manure can replace the need for commercial fertilizer on thousands of Minnesota's cropland acres.

Manure Inventory Assessment

A comprehensive manure management plan is essential for all hog operations. Knowing the amount of manure produced as well as its nutrient content will help a hog farmer plan for the number of acres that will be manured.

The best method to determine nutrient supply from manure is to analytically test it for nutrient content and multiply this by the storage volume. This method does not require numerous assumptions--yet it does require that representative manure samples be collected and storage volume calculations be made. Collecting a representative sample of liquid hog manure is difficult because of the constant settling of the solid portion of the manure. Because much of the phosphorus and the organic N is in this layer, the manure must be agitated enough to suspend the solids that can be resuspended. However, the sediment layer will never totally be removed by agitation.

An alternative method to determine nutrient quantities is to calculate storage capacities and multiply by the average nutrient content, based on the species and storage and handling methods **(Table 1)**. While Table 1 might be a good reference to begin developing application rates, these tabled values will vary

significantly among storage facilities and livestock operations. Research results for manure analyses in Minnesota range from 25-300% of the average values.

Table 1. Nutrient analysis of swine manure.
Livestock waste facilities handbook,
Midwest Plan Service, March 1985.

Form	Dry Matter	Total N	P_2O_5	K_2O
Solid:	**%**	**lbs/ton**		
No bedding	18	10	9	8
With bedding	18	8	7	7
Liquid:		**lbs/1000 gal**		
Anaerobic storage	4	36	27	22

A third alternative is relatively easy to calculate: Calculate the average amount of manure produced per animal, multiply by the number of hogs/pigs/sows and assume standard storage and handling losses. **Table 2** can be used to calculate the initial amount of manure produced by the hogs/pigs/sows. **Table 3** lists some average N losses that affect nutrient content from several storage and handling systems. This method may be a good one for planning cropland needs with proposed increases in livestock numbers.

Table 2. Daily swine manure production.
Livestock waste facilities handbook,
Midwest Plan Service, March 1985.

Animal Size	Manure Produced*		N	P_2O_5	K_2O
lbs	lbs	gal	lbs		
25	2.3	0.3	0.02	0.01	0.01
65	4.2	0.5	0.03	0.02	0.02
150	9.8	1.1	0.07	0.05	0.05
200	13.0	1.5	0.09	0.07	0.07
Gestating sow	8.9	1.1	0.06	0.05	0.05
Sow and litter	33.0	4.0	0.23	0.17	0.18
Boar	11.0	1.4	0.08	0.06	0.06
*Linear interpolations of manure production between weight categories is acceptable.					

Table 3. Storage losses of nitrogen.
Livestock waste facilities handbook,
Midwest Plan Service, March 1985.

System	N Lost
	%
Solid	

Daily scrape and haul	15-35
Manure pack	20-40
Open lot	40-60
Liquid	
Beneath barn pit	15-30
Above-ground storage	10-30
Earthen storage	20-40

Determining Application Rates

Next, manure application rates must be calculated. This requires knowing the nutrient content of the manure, nutrients required by the crop, and availability of nutrients in the applied manure to the crops.

The majority (70-90%) of the phosphorus and potassium applied in manure will be available to the crop the first year after application. The availability of N varies considerably. This variation is primarily a function of the method of application. **Table 4** provides an estimate of the amount of the total N that will be available in the application year and in the years after application.

Table 4. Nitrogen availability and loss as affected by method of application.

	Broadcast-Incorporate*			Injection	
	None	<12 hours	<4 days	Sweep	Knife
	% Total N				
Availability Year 1	30	65	45	65	50
Availability Years 2-3	30	25	30	30	35
Lost	40	10	25	5	15
*The categories refer to the length of time between manure application and incorporation.					

Often there is a sense of futility in trying to use manure analysis, application loss coefficients, and crop nutrient requirements to determine manure application rates. Here is a five-step process to get started:

1. Determine nutrient needs of each field's crop based on soil tests, previous crops, yield expectations, etc.
2. Make an initial manure rate selection. Use the crop needs and a tabled nutrient composition of the manure, or a previous year's test.
3. While applying the manure at the predetermined rate, collect a representative manure sample--either when loading the spreader in yard or unloading the spreader in the field. Send it to a laboratory for analysis.
4. After receiving the laboratory analysis (presumably the manure will have been applied), calculate the actual amount of nutrients applied based on data and the application rate.
5. In a record keeping system, record any possible overapplications or underapplications. If fewer nutrients were applied than planned and a fall application was made, starter or sidedressed programs can supply the deficiency. If spring manure applications were made and less N was applied than planned, a sidedressed application of N can be made. Overapplications should be credited for the next year.

Field Spreading Priority

Each livestock producer should determine the amount of manure generated on their farm and the nutrient requirements of the crops where the manure is to be applied. If the manure produced on a farm cannot supply all of the farm's crop nutrient needs, it is best to base the manure application rates on the phosphorus requirements. This strategy will use lower rates of manure and necessitate supplemental N fertilizer, which can be easily applied using starter N, weed-and-feed N, or sidedress-applied N.

If there is an excess of manure produced in relation to the crop's needs, manure rates should be based on the crop's N requirements. At no time should rates in excess of agronomic needs be used--this is both illegal (state rules, chapter 7020) and environmentally unsound. Rates will have to be based on P requirements if there is a potential phosphorus/surface water problem because of soil erosion, a very high soil test for phosphorus, and/or there is close proximity to water. Additional strategies such as applying manure onto legumes (see Special Use), hauling the manure off- farm, composting the manure and/or acquiring more cropland must also be considered in situations where excess manure is produced.

A field priority system should be developed to maximize the nutrient value of the manure. Priority should be given, in order, to those fields that: 1) require the greatest amount of N to grow the crop, 2) have the lowest phosphorus and potassium soil tests, and 3) will benefit most from adding the organic material to the soil.

Making a Multi-Year Plan

Thus far we have discussed annual manure management plans. For most planning processes, a three- to five-year forecast is often desirable. This may also be true with manure. In developing a multi- year plan, cropland nutrient needs often change due to crop rotations. The supply of nutrients should not change from year to year unless animal numbers change.

For each year in a rotation, the crop's needs must be determined and appropriate application rates determined. In an operation where cropland needs always exceed the manure's nutrient supply, shifting application rates and fields will occur. If there is a near balance in nutrient supply and needs, strategies that can correct for those "excess" and "deficient" years are needed. The primary strategies would be to apply/allow for multiple year needs.

Also, due to manure's residual properties, second and third year credits need to be accounted for in determining crop needs. Approximately 35-50% of the N in the organic fraction is available each year. Thus, second and third year N credits should be given for manure **(Table 4)**. After applying beef manure, approximately 20% of the total N is available to the crop in the second year; approximately 5-10% is available in the third year.

Calibrating Application Equipment

Correct application of manure to cropland is critical to maximize the value of manure to crop producers. For manure to replace commercial fertilizer and not create environmental problems, farmers must be confident about the application rate. All calculations involving calibration of manure must be done using manure on an "as is" basis. All analysis should be interpreted on an "as is" basis and the application rate should be as well. Do not worry about the moisture content or change to a dry matter basis.

Three conditions must be addressed to achieve this confidence in rates. First, the **analysis of the manure loaded into the application equipment must be known** and should not change. For liquid systems,

good agitation in the storage facility and in the transport tank are important. Loading procedures that do not separate the solids and the semi-solids can assure this for solid manure systems. Second, the **rate of manure being applied to the field must be known** and kept constant. Calibration must be conducted for all manure applications. And finally, the **application or spread pattern of the manure must be uniform throughout the field** so that all plants will have equal access to the nutrients. Having a predetermined travel plan for applying manure to a field and noting where loads stop and start will help ensure uniform applications.

Liquid systems

Calibration of liquid manure equipment requires that the manure be measured in gallons/acre (GPA). Getting a weight of the tank before and after spreading the manure and dividing by the density of the liquid manure (8.3 lb per gallon) is the best way to determine the volume. Combining this with the width of the spread pattern and the distance the tank takes to empty will provide the information to determine the application rate. *For example, Operator A takes a loaded manure tank across a scale and it reads 29000 lb. Then the operator applies manure to a field with four injector knives (2.5 ft centers); it takes 1200 ft to empty the tank. Driving the emptied tank across the scale gives a reading of 8500 lb. The rate is:*

> [(29000 lb - 8500 lb) divided by 8.3 lb/gal] divided by {[1200 ft x (2.5 ft/injector x 4 injectors)] divided by 43560 ft^2/acre} = 8965 GPA

Or, fill the tank to its predetermined volume to avoid needing a scale. However, the listed capacity is often different from what is hauled to the field with a "full" tank. Counting the number of loads needed on a given size field and assuming a set volume per load will allow calculation of a rate per acre, although this does not ensure uniform application within a field. *This example has Operator B filling a 3200-gal tank 90% full for each load, then spreading 29 loads on a 23-acre field. The solution is:*

> [(3200 gal/load x 0.90) x 29 loads]divided by 23 acres = 3630 GPA

Solid systems

Calibration of solid manure equipment is similar to liquid manure equipment. The weight of manure applied can be determined by any one of several ways. Weigh your manure spreader before and after going to the field and determine the weight of manure spread. Then determine the width the manure is being spread and the distance it took to unload the manure. Using the ratio of weight per portion of an acre, a per-acre application rate can be calculated. It is best not to unload the entire spreader because the spread pattern at the end of a load is not representative. *Example: Operator C weighs a loaded spreader; it is 9800 lb. After spreading a 12-ft width of manure a distance of 300 ft, the spreader is reweighed and it now measures 6200 lb. The rate calculation is:*

> [(9800 lb - 6200 lb) divided by 2000 lb/ton] divided by [(12 ft x 300 ft) divided by 43560 ft^2/acre] = 21.8 tons/acre

A practical method is to use a scale to determine the weight per load and then count the number of loads it takes to spread manure on a given field. Calculate the total tons per field and divide by the number of acres in the field to determine rate of application. *For example, if Operator D has previously calculated their spreader to hold 8.5 tons of manure when fully loaded, and uniformly applied 16 loads in a 13-acre field. The solution for rate is:*

> (16 loads x 8.5 tons/load) divided by 13 acres = 10.5 tons/acre

Another method is to lay a tarp or piece of heavy-duty plastic in a field. After the spreader has passed over, collect and weigh the manure from the tarp or plastic. Then determine the area of the plastic, and convert the weight measurement to a per-acre basis. This method generally has a large amount of variability unless several samples are collected and weighed. *In an example, Operator E places five 4 ft by 4 ft plastic sheets in their field and spreads manure across these sheets. The combined weight of the sheets is 38.5 lb. The solution for the rate is:*

> (38.5 lb divided by 2000 lb/ton) divided by {[5 x (4 ft x 4 ft)] divided by 43560 ft^2/acre} = 10.5 tons/acre

After determining the manure application rate, it is often necessary to adjust the rate to better match the recommended rate that you need. The most common method to change application rate is by changing the speed you drive across the field. Solid manure equipment may also have an adjustment that changes the chain speed in the box, thereby changing the manure rate. Liquid manure equipment may have valve opening adjustments to alter the rate. A concern with liquid manure systems is the difference in flow from the start to the end of the tank. Pressurized tanks, flow pumps, and new distributor designs are solving some of these problems in variable flows.

Special Concerns and Issues

Solid versus liquid manure

Nutrients voided by swine are the same whether the manure is to be handled as a liquid or a solid. It is the handling systems that create losses of nutrients or changes in the manure composition resulting in different nutrient analyses between solid and liquid manure.

The available plant nutrients in manure are often found in different fractions. Nitrogen, for example, is fairly evenly split between the feces portion, which contains the majority of organic N, and the urine, which contains most of the inorganic N. Therefore, it is essential to preserve and adequately mix these fractions before field application.

Phosphorus is found mainly in the feces component. Phosphorus is not lost by any chemical or biological process and the majority of this nutrient is available in the year of application. With a liquid storage system, the bulk of the phosphorus is in the settled solids at the bottom of the pit unless you agitate before spreading. Potassium is almost the opposite of phosphorus; almost all of it is in the urine.

Spring/winter/fall application times

Time of manure application can be extremely important if site- specific conditions create an environmental hazard. Fall applications allow for maximum time for the manure to break down before the crop uses the nutrients. While this is generally beneficial, it can also lead to environmental hazards if N loss from the soil is a concern. Fall applications of N are generally not recommended on coarse-textured soils.

With spring applications, there is less opportunity for N losses from a field. However, spring applications result in less time for organic decomposition of the manure, including the release of some nutrients. Spring application also generally delays fieldwork and planting, and could increase soil compaction.

Many producers use winter applications. While there will be significant losses of available N, the organic N fraction will still contribute to the plant-available N pool. The potential for nutrient runoff is an environmental concern for winter applications on frozen, sloping soils. If manure is applied to frozen

soils and there is runoff from snow melt or rain, nutrients in the manure will be lost with the runoff. This situation is not recommended.

Methods of application

Broadcasting is a way to apply solid or liquid swine manure. Sometimes this is followed by incorporation with a tillage operation. Other times, like with winter applications, the manure is left on the soil surface. Nitrogen loss is a concern with broadcast manure. The amount of loss depends mainly on the time between application and incorporation. Manure that is broadcast but never incorporated can lose about half of its total N. Incorporation within 12 hours is ideal for maximum N efficiency (See **Table 4**). Local ordinances and neighbors should be considered in determining where and when manure is broadcast due to odors.

With liquid manure systems, several more application options are available to crop producers. Injection methods place liquid manure below the soil surface, thus eliminating the majority of volatilization losses. Traditionally, injection knives placed the manure in a concentrated, vertical band about 6-8 inches below the soil surface with 30- to 60-inch spacings between knives. New injection systems such as sweep and disc injectors are being marketed that spread the manure in horizontal patterns under the soil surface. These systems allow for faster breakdown of the manure and places the manure in a more favorable position for early season plant uptake.

Another option for liquid manure handlers is to apply the manure with an irrigation system. Because this is an efficient method to apply large amounts of manure, excessive rates are often applied. Although application is often uniform, volatilization is still a major concern.

Special uses

Many pork producers grow soybeans and often consider spreading manure on these acres. Although soybeans do not necessarily benefit from the N in the manure, they can benefit from all other nutrients in the manure. The recommended rate should, therefore, be based on P or K requirements of the crop. The soil may also benefit from the organic material addition (soil tilth). When manure is applied to soybeans, the added N reduces the amount of N symbiotically fixed by the nodules. This has neither a consistent positive or negative effect on the soybean yields.

A recent trend with some hog/corn producers in Minnesota is to switch to ridge-till systems. Manure can be worked into this system in two ways. First, the manure can be injected in the ridge valleys as a sidedress application. This is a good method to prevent nutrient loss, yet the nutrients are not in the root-filled ridge and the soil disturbance counteracts some of the ridge-till philosophy. Manure can also be spread into the ridge valleys as a preplant or sidedress application; then incorporated into the ridge with subsequent cultivations. Take care not to broadcast manure onto the young plants because burning will take place. Nutrient movement into the ridges is limited in the year of application, but with several years of ridging, the nutrients will be well mixed into the ridge.

Conclusion

With the increased demand for pork, more manure will be generated. Recycling manure into the soil through a predetermined manure management plan is efficient and practical. This will optimize the nutrient value of the manure while minimizing potential environmental hazards. Manure is a valuable resource on a farm and should be treated as an asset.

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Chapter 4

Swine Manure Management

J.L. Hatfield, M.C. Brumm, and S.W. Melvin

Production of pork is a major agricultural enterprise in the United States, and a majority of the production occurs in the Midwest (Ohio to Nebraska and Minnesota to Missouri) and North Carolina. Seventy-nine percent of the hogs and pigs marketed in 1987 (96.6 million head) were produced in the north-central region of the United States (Bureau of the Census 1989). Iowa has ranked first in hog inventory since 1980, and in 1987 was estimated to have 25.6 percent of the December 1 inventory of 53,795,000 hogs and pigs on farms. Inventory on farms tends to fluctuate between 50 and 70 million swine in a 4- to 7-yr cycle.

In 1980, 21 percent of the growing-finishing pigs (pigs raised from 12 to 100 kg for meat production) and 45 to 50 percent of the nursing and nursery pigs in the United States were housed in confinement facilities (that is, liquid-manure systems; VanArsdall and Nelson 1984). With the large influx of new confinement construction, especially the construction associated with contract production units in North Carolina and Iowa, it is logical to predict a major increase in the percentage of manure captured and stored as a liquid or semiliquid.

The Corn Belt States are expected to remain the primary hog production area, although some shifts within the area will occur. Because of historically lower feed grain prices and lower human population densities, pork production is expected to expand west of the Mississippi River, especially in the western (Kansas, Colorado, and Wyoming) and southwestern fringe (Oklahoma) areas of the Corn Belt (Hurt et al. 1992).

Expansion will be governed in part by individual state laws or constitutional amendments regarding corporate ownership of livestock. These laws can vary tremendously from one state to the next. Currently, Nebraska has an amendment to its constitution restricting nonfarm corporate ownership of livestock destined for slaughter while Wyoming is using municipal bonds as a source of financing to attract corporate production units. Similar differences exist among other states.

One of the primary issues associated with the production of pork and expansion of production is the disposal of the animal manure and the odor associated with animals and manure storage facilities. Traditionally, swine manure has been returned to the land in some manner in the production areas; however, land application has come under attack in rural areas because of the odor problems during application. Estimates are that swine manure production accounts for 12 to 15 percent of the total livestock waste produced annually in the United States (VanDyne and Gilbertson 1978).

Today's swine production systems have become larger, more specialized, and more dependent on purchased feed supplies than in the past. Environmental problems associated with swine production during the 1950's and 1960's were often overlooked. However, swine production was characterized by small, individual systems that relied on recycling of animal manures back to the land as a major nutrient source for the farm. In the last 20 yr, many structural changes have occurred in the industry. These changes have caused concern over the environmental effects of swine manure management. The industry is rapidly consolidating. A recent University of Missouri study (Rhodes 1990) indicates that larger production systems are growing the fastest in terms of percent market share. This study shows that only the farms with annual sales of over 1,000 head are expanding. In 1988 large farms (those with more than 1,000 head) produced over 60 percent of the market hogs.

The environmental effects of swine manure storage systems and application methods are a concern, particularly with respect to surface water and groundwater quality and to air quality as affected by odors and gaseous emissions from large-scale swine production operations.

Manure Production and Composition

Swine manure composition may be estimated from various sources (Midwest Plan Service 1985, American Society of Agricultural Engineers (ASAE) 1990). Some estimates of swine manure's fertilizer components available to the plant are listed in table 15. In ASAE (1990), data are given for estimates of daily manure production for various species and means and standard deviations of physical and chemical characteristics of the manure. Swine are estimated to produce daily raw manure of as much as 8.4 percent of body

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Table 15. Mean (in parentheses) and range of values for composition of swine manure from various handling systems

Handling system	Dry matter (percent)	Nutrients available to the plant			
		Ammonium N	Total N	P	K
For solid manure		---------- g kg^{-1} ----------			
With bedding	15–20 (18)	2.7–4.0 (3.1)	4.0–4.9 (4.5)	1.4–2.6 (1.8)	2.2–3.7 (3.0)
Without bedding	17–20 (18)	2.2–3.6 (2.7)	3.1–4.5 (3.6)	1.0–2.0 (1.4)	2.2–3.3 (2.6)
For liquid manure		---------- g L^{-1} ----------			
Anaerobic storage	2–7 (4)	2.5–3.7 (3.1)	3.4–6.6 (4.3)	0.7–1.6 (1.4)	1.2–3.0 (2.2)
Lagoon	0.3–2.0 (1)	0.2–0.6 (0.5)	0.4–0.7 (0.5)	0.05–0.2(0.1)	0.2–0.6 (0.4)

Source: Adapted from Sutton et al. (1983).

weight (urine and feces). Sweeten (1992) estimated the total production and nutrient content of swine manure in the United States in December 1988 to be as follows:

Number of head	55,299,000
Annual manure production (solids)	14.1 million Mg
Annual N production	0.66 million Mg
Annual P production	0.42 million Mg
Annual K production	0.66 million Mg

More recent calculations indicate that the annual production of P and K should be about 0.23 and 0.37 million Mg, respectively.

Since much of the nation's swine manure can be collected, stored, and spread on the land surface, this manure could be used as a substantial nutrient source for crops. In fact, if all U.S. swine manure was recovered and applied without loss of nutrients, it could supply the nation's corn crop with one-eighth of its N needs and one-fourth of its P and K needs. It is estimated that over 80 percent of the manure is generated in systems where manure could be collected. Manure handling and storage systems may remove a significant amount of N, but P and K are not likely to be significantly affected by treatment.

As of yet, swine production units are not geared toward retaining nutrients in swine manure. One reason for this is that land for manure application is limited. Many units use anaerobic lagoons to digest manure solids and allow the manure to be handled as a liquid. Anaerobic lagoons may volatilize 70 to 90 percent of the N in the manure. Manure N is converted to ammonia in these lagoons and is lost to the atmosphere. By volatilizing this N, anaerobic lagoons allow land requirements to be decreased to 10 percent of the land required for application of slurry manure.

Swine manure tends to be a relatively homogeneous material from production unit to production unit, unlike manure collected from ruminant animals. The swine in the United States are fed diets similar to those fed to poultry. The swine diet is formulated with corn or grain sorghum and soybean meal, and vitamins and minerals are added to prevent deficiency. In addition to Ca and P additions, Zn is added at 50 to 100 ppm, Cu at 5 to 10 mg kg^{-1}, and Se at 0.3 mg kg^{-1} (National Research Council 1988). As a percentage of the total mineral content in the diet, excreted swine manure is estimated to contain 86 percent of the Cu, 100 percent of the Zn, 79 percent of the Mn, 40 percent of the Ca, 74 percent of the Mg, 59 percent of the K, and 66 percent of the Na offered to the pig (Overcash and Humenik 1976). The FDA held hearings on the environmental impact of selenium additions to all animal diets (Muirhead 1992), and there are current regulations on the additions of Se in animal feed.

The major differences in composition of the manure are dependent on the methods of collection, dilution, and storage and are not diet dependent. About 85 percent of the N in a typical corn and soybean diet is digested (McConnell et al. 1972). The majority of the

N excreted from the pig is as uric acid in the urine and organic N forms in the feces. Phosphorus is excreted as phytic acid (an organic matrix derived from the undigested P in cereal grains) and as other complexes that result from growth and digestion processes. Phosphorus is excreted in both the feces and urine. About 40 to 60 percent of the P in a corn and soybean diet is digested (National Research Council 1988).

It is estimated that corn and soybean diets supply sufficient K for swine of all sizes, and therefore supplemental K is not normally recommended (National Research Council 1988). However, K additions may improve swine growth rate (Mabudiuke et al. 1980, Coffey 1987). Little data exist on the digestibility and retention of increased K in the diet. Thus, no predictions can be made as to the impact of supplemental K additions (generally as KCl) on the composition of swine manure.

Swine nutritionists are evaluating the results of using phytase enzymes in diets to enhance the digestion and use of phytase P in cereal grains. In cereal grains the majority of the P is bound as phytate (National Research Council 1988). This form of P is not readily available to nonruminants because they lack phytase, which cleaves the orthophosphate groups from the phytate molecule (Cromwell et al. 1993). Nutritional P needs in pigs are met by adding inorganic P sources to diets because only 15 percent of the P in corn and 25 percent of the P in soybean are available (National Research Council 1988). The addition of the inorganic P sources leads to 65 to 75 percent of the P being excreted in the manure (Lei et al. 1993). Addition of dietary phytase to swine diets will lead to enhanced use of phytate P from the cereal grains and reduce the addition of inorganic P sources. Improved use of phytase P is generally associated with improved protein use, which will reduce the amount of excreted P. In the Netherlands, it is estimated that N and P excretion by pigs can be reduced by 33 percent and 40 percent respectively by the year 2000 through advances in swine nutrition (Jongbloed and Lenis 1992).

Sodium chloride additions to swine diets have decreased over the years, partially in response to concerns about the fate of Na in stored manure. Generally sodium chloride is added to swine diets at the rate of 0.25 to 0.5 percent to prevent Na deficiency symptoms, with 0.25 to 0.3 percent being the most common addition rate. In anaerobic storage pits, Na levels in manure range from 5,000 to 9,000 mg kg^{-1} on a dry matter basis for dietary additions of 0.2 to 0.5 percent (Sutton et al. 1976). On average for all phases of production, it is estimated that 40-kg pigs produce 182 g of volatile solids per day, and the ratio of volatile solids to total solids equals 0.81 (Overcash and Humenik 1976).

The United States industry is improving the overall conversion efficiency of feed to meat of the swine herd. Better use of nutrients leads to a lower rate of converting food to waste. Current estimates of manure production and composition are based on feed-conversion efficiencies of 3.7 to 3.8 kg of feed per kg of meat. However, many producers have made large advances in production efficiency and now report conversions of 3.3 kg of feed per kg of meat or better. Recent advances in reproductive efficiency also have led to less waste generated from sows and boars as a percent of the total waste stream. Thus, previous estimates of waste production and composition may prove to be inaccurate estimators and in many cases will overestimate both the total volume of production and the composition of the waste produced.

Manure Management Systems

A major change in the structure of the pork-producing industry is also impacting the animal waste issue. While total pork production remains relatively constant in the United States (about 92 to 93 million swine were slaughtered in 1992), the number of farms selling hogs or pigs has declined from 1,273,000 in 1959 to under 200,000 in 1990 (Rhodes 1990). By the turn of the century, the number of farms selling pigs is expected to decline to slightly more than 100,000 (Hurt et al. 1992). In 1988 about 69 percent of the commercial hog slaughter in the United States was from 28,700 operations.

While many swine farms have all their production at one site, an increasing number involve two or more sites, either through production contacts or expanded ownership. Thus, the issue of swine manure is becoming an issue of point source production, especially as it relates to livestock ownership and responsibility for the collected material.

Swine manure is handled as a solid, a semisolid slurry, or a liquid, depending on the type of housing and manure handling system used. Each of these systems has some unique features that add complexity to the

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problems of manure handling and use, and some of these features are discussed in the text that follows.

Systems for handling solid manure

No more than 15 percent of United States swine are raised on farms using systems designed to handle solid manure. These systems are most commonly used in the western Corn Belt. Smaller production systems may make use of extensive housing systems in which small, roofed buildings are used to handle solid manure. Other small production systems may involve the use of pastures or open feedlots for distributing and handling manure.

In pasture production, manure is generally spread "naturally" by the swine as they graze. Rotation grazing will allow manure to be somewhat uniformly distributed in the forage area except for in watering and feeding areas. In this system little manure is collected and spread on other land. Some overloading of manure in specific areas can be expected if feed and watering systems are not moved frequently, since these areas collect a majority of the manure excreted. Pasture production systems are most common in states where smaller swine farms are more common. Certain areas within states, such as Henry County, IL, have been producing swine on pastures for many years. Pasture production is most common in the mid and southern Corn Belt. However, it is estimated that no more than 5 percent of swine are now raised on pasture.

Open feedlot systems are also common with small- to moderate-sized production systems. These systems are not covered by a roof, and the feedlot surfaces commonly have an accumulated manure layer on them. Solid manure is scraped from the feedlot surface periodically. Scraping frequency may vary from once or twice weekly to once monthly. Some manure is lost from the feedlot surface through runoff from rainfall or snowmelt. Unless some runoff containment system is in place, surface water contamination is possible if the runoff from the feedlot can enter a body of water before manure solids are settled or infiltrated into soils during transport in the runoff.

Research has shown that 5 to 20 percent of the manure deposited on an open feedlot can be expected to be transported from the feedlot via water runoff. The fate of manure nutrients is affected by whether or not a solid settling system is built to contain solids. Runoff losses are highest for K and lowest for P, assuming solids are retained in a solids settling system below the feedlot. Solid storage systems are required to store manure between land disposal events. These storage facilities generally consist of an on-grade concrete pad with low walls surrounding the pad to allow manure to be pushed into storage and removed with a blade or a front-end loader. The overall nutrient value of manure from solid systems is quite variable, and N losses during storage of 20 to 40 percent have been reported for these manure systems. Typical concentrations of N on a dry-weight basis for solid manure applied to land range from 0.45 to 0.55 percent for manure containing no bedding and from 0.25 to 0.50 percent for manure containing bedding.

Other solid systems besides open feedlot systems may also use bedding. The most common bedding material is straw, but wood chips or shredded newspaper are sometimes used. These systems may have totally or partially roofed pens in which bedding is added to absorb urine and to provide insulation for the animals inside unheated buildings. Manure and bedding is periodically removed from the pens, and the pens are rebedded to keep animals clean and comfortable. Once removed, the mixture of manure and bedding can be stored on concrete pads with optional low outside walls to help contain the mixture. Stored manure can be stacked in a pile with a front-end loader or stacking elevator.

Solid manure can be applied to the field using regular box spreaders or side-discharge flail-type spreaders. Some box spreaders require an end gate to prevent leakage of the material from the rear of the spreader during transport.

Systems for handling slurries

Most large-scale swine production systems have totally roofed confinement systems. Bedding is purposely not used so that the manure can be handled as a slurry or as a liquid. Manure converted to a slurry is not diluted much, since little water is added in the conversion process. Liquid manure, however, has been diluted quite a bit since significant water is added to assist with manure transport, treatment, and land application. Slurry manure systems are most common in the north-central region, where manure can be recycled back to cropland and where cool temperatures are not as conducive for lagooning swine manure.

Slurry systems commonly use several types of storage structures. The most common system is the below-

floor pit covered with a slatted floor. Until recently, a high proportion of all swine confinement systems using slurry manure used a deep-pit storage system. However, in recent years, there has been more concern over air quality problems in buildings resulting from long-term manure storage in the building. Alternatives to an indoor storage system are in-ground storage tanks remote from the building, aboveground storage tanks, and earthen structures. In-ground tanks may be covered or uncovered, but if left uncovered, they must be isolated with a safety fencing to prevent accidents. Uncovered tanks unfortunately can collect significant snow during winter. Round tanks are becoming more popular as remote tanks, since the shape has structural advantages and these tanks are more easily agitated. Aboveground tanks can be constructed from various materials, but concrete and glass-fused steel are the most popular. Earthen structures provide the lowest cost storage system, but adequate soil investigation and construction controls are necessary to minimize groundwater pollution hazards.

Equipment for handling slurry manure is designed for agitation, pumping, transport, and spreading. Vacuum loading tankers are designed for several functions. However, some systems require more agitation and pumping capacity than available with vacuum loading equipment. Agitation equipment usually consists of a propeller or open impeller. Pumps must be able to chop and pass large-diameter solids in the manure. Tank-type manure spreaders can be mounted on trailers or trucks for field distribution of manure. Direct-injection equipment for immediate incorporation of manure is now common. Direct-injection allows immediate covering of the manure to prevent N loss by volatilization, reduces the potential of surface runoff of N and P, and significantly reduces odor potential.

Manure is most often applied to cropland near the swine production unit. A majority of slurry storage systems can store manure for 120 to 180 days, meaning that manure applications to fields are needed two or three times per year. This sometimes leads to problems with having land available for manure application in the middle of the growing season or during winter. It is estimated that 50 to 60 percent of producers use slurry manure handling systems. These units are most common in the Corn Belt. A slurry manure should be stored for at least 180 days before application in the Corn Belt. The longer storage period minimizes manure application problems, and full-year storage is becoming more popular.

Systems for handling liquid manures

Hydraulic flushing systems have been successfully used for 20 yr for quick, efficient removal of manure from swine confinement buildings. Flushing systems require the use of larger manure storage systems, since significant amounts of dilution water are added to the manure during flushing. Anaerobic lagoons are used extensively for storage and treatment and, in many cases, as a recycling system. Recycled treated lagoon water is often used to minimize storage requirements. In areas where lagoon water can be used for irrigation throughout the year and where adequate fresh water is available for flushing, recycling is not generally practiced. Anaerobic lagoons are also popular for swine production systems in areas with a limited land base, since high losses of N can be expected in anaerobic lagooning systems.

Anaerobic lagoons convert manure to a liquid that is low in solids, allowing easier transport and application. Conventional irrigation equipment can be used to apply anaerobic lagoon liquid to land. Even though higher volumes of waste are produced with these systems, the cost and labor requirements for application of liquid manure are lower than for slurries or solids.

Aerated lagoons can also be used as a storage and treatment system for flushing units. Odors are minimized and recycled water is safer in terms of disease prevention, but the cost of mechanically aerating a swine lagoon is relatively high. Capital requirements and energy and maintenance costs have been high enough to prevent this use of aerated lagoons from becoming common on swine farms, even though aerated lagoons are commonly used for this purpose in municipal and industrial sewage treatment systems.

Odors, potential leakage, overflow, and over application of lagoon effluent are the major environmental concerns associated with anaerobic lagoons. Proper design, loading, and management are required to minimize odor problems. Soil investigations and proper construction techniques are required for groundwater protection. Adequate irrigation equipment is needed to dewater lagoons on a regular basis and to distribute the water over farmland. Nutrient management plans should specify loading rates to properly use the manure product.

Anaerobic lagooning systems do lose significant amounts of N to the atmosphere, but P and K are not lost. It is estimated that 80 to 90 percent of the input N is lost to the atmosphere through ammonia volatilization. A high proportion of the P is contained in sludge from the lagoon. Periodic cleanout of this sludge is required for continued efficient operation of the lagoon. These P-rich sludges should be applied to land with caution so that high levels of P buildup will be prevented.

The majority of the systems using anaerobic and aerobic lagoons are used in warm climates. The majority of large operations (1,000 head per year) are using anaerobic lagoon systems to minimize land application areas. These operations are concentrated in the Southeast, the southern Corn Belt, and the southwest Plains. It is estimated that 20 to 30 percent of the manure from swine production is processed in liquid manure systems.

Manure Handling and Disposal

The major concerns associated with managing manure from swine are related to runoff control from open feedlots, storage requirements, and land application of manure collected from confinement facilities. The runoff control issues for handling this type of manure are very similar to those for handling other types of manure.

Storage and land application problems from confined production units occur due to the large volumes of water often associated with the material. Depending on method of collection and storage, the collected material can contain from 90 to 99.9 percent water at the time it goes into storage.

Generally, growing-finishing pigs weighing 21 to 100 kg can be expected to generate 0.39 to 0.45 kg of waste per day on a dry matter basis (Brumm et al. 1980). This manure contains 1.9 percent P, 7.2 percent N, and 3.2 percent K as byproducts of digestion. Depending on the phase of production and the specific production practices of the pork producing unit, the manure may also contain significant amounts of Cu, which is added to the diet as copper sulfate at up to 250 mg Cu kg^{-1} to promote growth. Swine manure may also contain antimicrobial drug residues, which are added to the diet to enhance growth and improve health (Brumm 1978).

Copper levels and drug residues in manure have in some instances limited the uses of the manure. For instance, manure high in Cu is undesirable for anaerobic storage because it reduces biological activity (Brumm 1978), and manure high in antimicrobial drug residues is undesirable for pilot anaerobic digesters designed to generate methane because of the limited biological activity in the methane generator (Fischer et al. 1978).

Refeeding of collected swine manure to swine has been researched and has been tried on several commercial swine units. However, the large volumes of water associated with typical manure collection has meant that dewatering of some type must be used to generate a material that is easily handled. Refeeding swine manure to a different species (generally beef cattle) has been successful on a limited scale. The possibilities of high concentrations of Cu or other potentially toxic elements or drug residues has limited refeeding to beef animals during their growing stage. This limitation has generally minimized the concern of residues entering the human food chain as a result of refeeding. In general, the primary safety concerns associated with using animal manure as animal feed involve potential harmful residues of pesticides, drugs, toxic minerals, and other toxins, and the hazard of disease transmission (American Society of Animal Science 1978).

Some sow herds are fed dewatered swine manure as a means of enhancing colostral immunity for newborn pigs. Refed manure, however, has been recognized as a possible source of internal parasite reinfestation and dysentery spread. Reuse of stored swine manure as either a source of water for flushing or as a nutrient source in the diet has caused concern regarding animal health. Anaerobic storage in either deep pits or lagoons does not affect the survival of roundworm eggs, *Treponema hvodvsenteriae,* and *Salmonella* spp.

Swine manure that contains small or no amounts of antimicrobial drug residues can be used to generate methane. In general, successful methane generation relies on thermophilic bacteria for the conversion of organic wastes to volatile fatty acids and then to methane. With much of the pork production in the United States occurring in the north-central regions, extensive investments in insulated and even heated facilities have been necessary for this bacterial process to be possible during winter weather.

During methane production only 40 to 60 percent of the volatile solids are converted to methane; 1 m^3 of methane is produced per 0.61 kg of volatile solids converted in the digestion process (Sweeten et al. 1981). The conversion of the organic wastes to methane does not decrease the need for disposal of byproducts. Removal of carbon as methane from the waste stream does not decrease the amount of N, P, K, or other significant elements in the digester effluent.

Land Application of Manure

Problems

Decisions on the best ways to apply swine manure to land are complicated by compromises between achieving best soil erosion control and best conservation of nutrients in manure and use of these nutrients by growing crops. For a long time, extension specialists have recommended that manure applied to the soil be incorporated into the soil surface within 24 hr after land application. This practice can significantly reduce odors and can minimize ammonia volatilization so that N in manure is conserved. Fall application of manure to cropland following harvest is often recommended because the risk of damage from soil compaction is minimized. Spring applications are usually accomplished prior to tillage and planting. Frequently in the spring, soils receiving the manure are close to saturation, resulting in significant compaction from spring application. Also, labor availability often favors fall application.

Many producers, as part of their approved conservation plan with the Natural Resource Conservation Service (formerly the Soil Conservation Service), have agreed to significantly restrict or stop any fall tillage practices as a means of maximizing residue cover at the time of spring planting. Thus, land application and tillage in the fall, long an accepted best management practice for manure application, may result in a violation of the NRCS plan and a reduction in government payments under provisions of the 1985 Food Security Act and the 1990 Food Agriculture Conservation and Trade Act. Direct injection by means of tanker wagons equipped with injection devices has become a common technique for land application in much of the Midwest. However, the injection process disturbs the soil as much as major tillage operations.

Limiting fall applications of manure in the future is likely to have an impact on the cost of storing manure. Currently, most regulations require 90 to 180 day storage capacity for collected animal manure. This requirement capacity generally is based on the growing season for the area or state, on the assumption that manure will be applied to land in the spring or fall. If fall application is no longer feasible due to soil conservation concerns or possible runoff concerns, the length of storage may need to be increased to 270 to 360 days. Longer storage not only increases cost but also increases the workload in the spring when many producers are already very busy.

Some farmers may be able to find use for swine manure in the summer. The traditional corn and soybean farmer who also raises pork may need to add some forage crop to provide a land base for summer applications. Forage crops, however, are generally not useful on swine farms, but producers may have to find a use for these crops in the future.

Impact of manure on the soil

Although manure can be used to supply adequate nutrients to grain crops, it is usually difficult to determine the exact nutrient content of the manure. Sutton (1992) stated that the potential fertilizer value of swine manure may range from $2.50 to $3.50 per market hog sold. He outlined some of the potential problems that need to be addressed concerning the use of swine manure as a fertilizer. Currently, there is no rapid, inexpensive method for testing manure before it is applied to land. Without knowledge of the nutrient content prior to application, it is difficult to apply proper rates to meet the soil fertility requirements. Even if proper rates could be determined, application methods can cause poor or inconsistent distribution of manure in a field.

Nitrogen is often thought to be the primary nutrient available in manure. However, there are proportionally larger amounts of P and K available than N because of the losses of N during storage. Little information exists regarding N losses during storage, but studies show that these losses range from 10 to 90 percent. Application of manure in quantities required to meet the N requirements of corn or other grain crops can lead to excessive supplies of both P and K in the soil. The manure value of a fertilizer must be based on the nutrient supply from all elements and therefore must be based on effective testing of the composition of the swine manure. Midwest Plan Service (1985) provided estimates for N losses during storage and land application, and some of these estimates are shown in tables 16 and 17.

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Table 16. Nitrogen loss during storage of manure from different manure handling systems

System	Type of manure	Nitrogen lost (percent)
Daily scrape and haul	Solid	15–35
Bedded manure pack	Solid	20–40
Anaerobic pit	Liquid	15–30
Aboveground storage	Liquid	10–30
Earth storage	Liquid	20–40
Lagoon	Liquid	70–80

Source: Midwest Plan Service (1985).

Table 17. Estimates for the amount of nitrogen that is lost within 4 days of applying swine manure

Application method	Type of manure	Nitrogen lost (percent)
Broadcast	Solid	15–30
	Liquid	10–25
Broadcast/immediate cultivation	Solid	1–5
	Liquid	1–5
Direct injection	Liquid	0–2
Sprinkler irrigation	Liquid	15–35

Source: Midwest Plan Service (1985).

There are various techniques for estimating the amount of available nutrients from manure applied during the year or during a previous year. This estimate will vary greatly with the type and form of manure applied to land. With solid manure or open-lot manure, little N is found in the ammonia or ammonium form, since much of the N in this form has been volatilized prior to land application. Slurry manures may have at least 50 percent of the total N in ammonium N form, which is readily available following application.

The key to estimating N availability after application rests on the mineralization decay rate expected from the breakdown of organic solids after land application. For swine manure, the estimated first-year contribution from organic N in manure can vary from 25 to 50 percent of the total organic N. This is a function of the breakdown rate of solids in the soil, which is a function of particle size, shape, temperature, moisture, and other environmental factors, including the level of antibiotics in the manure. However, with modern feeding systems, manure particle size is small, and mineralization rates approaching 50 percent of the organic N in the first year may be expected. The second-year rate is usually about half of the first-year rate (or approximately 25 percent), and the third-year rate is about half the second-year rate (12.5 percent). Little additional N contribution is expected from swine manure 3 yr after application.

In addition to providing nutrients for the crop, swine manure and other manures are an energy source for microbial activity that promotes soil structure and aggregation and therefore soil quality; however, the mechanism of the process and the ideal application rates have not been identified. The lower N contents reported in lagoon systems may be adequate for maintaining and promoting microbial action in the soil. Soil aggregation and a stable soil structure would improve the infiltration process, decrease surface runoff, and enhance the effect of other soil conservation practices. Manure application just for the purpose of enhancing the soil, however, may not provide sufficient economic incentive for the use of manure.

Management processes for preventing N loss from manure applied to soil are not well understood. Losses of N (as ammonia, nitrous oxide, or methane from the soil) diminish the value of the manure and also may add to the abundance of greenhouse gases in the lower atmosphere. Preliminary studies indicate that the amount of N lost after application is substantial.

Application rates to the soil are dependent upon the soil, crop, climate, manure composition, and mineralization rate. Proper manure application methods and rates should be incorporated into best management practices designed to manage both crop residue levels and soil quality. The amount of land area needed for the effective use of manure will depend upon the composition of the manure and the treatment of the manure after application. Nitrification inhibitors are sometimes used to arrest the rate of mineralization; however, they have not been fully evaluated under field conditions and the results have been variable

among different studies. More research is needed to fully understand the most effective manure application methods and rates for different crops and soil conditions.

Disposal of dead animal carcasses

Along with the usual manure problems associated with pork production, a new concern is the disposal of dead animal carcasses. In many states, the legal requirements for disposal call for incineration, burial, or pickup by a commercial rendering service. However, the number of dead-animal rendering services in the United States has declined significantly (Fats and Proteins Research Foundation 1992).

Because of decreased access to rendering services, increased charges for rendering services, frozen ground in winter months, and high fuel costs associated with incineration, many pork producers are evaluating composting of swine carcasses as a disposal alternative. Research information in support of this practice is limited, however, and it is unclear what the legal aspects of this practice are with regard to current state laws and local health regulations.

Effects of Manure on Environmental Quality

Water quality issues

Environmental water quality problems resulting from swine manure use on land have been related to excess manure generation relative to land available for application and to inadequate manure storage and handling facilities. Excess manure application rates, runoff and leachate from manure application sites, and leakage and overflow from manure storage sites represent major environmental concerns. The problem of a manure surplus on swine production farms is exacerbated by low-cost commercial fertilizers, concentration of large (greater than 10,000 head) production units, reduced availability of labor, narrow profit margins, and higher priced land. Low-cost commercial fertilizers contain the essential nutrients (N, P, K) in a uniform mix and in a form more easily transported and applied to the field. Manure application requires many trips to the same field because of the large volume of water in manure. Concentration of large production units creates a surplus of manure relative to the land area for application without incurring large transportation costs. Often these facilities are located in areas with little land base for application, and other disposal methods must be used. Manure application requires labor, and on-farm labor sources are becoming less available. A smaller labor force coupled with the problem of application during the part of the growing season that is already busy leads to problems of effectively using manure. Crop production is on a narrow profit margin, and grain farmers want to decrease the potential risk by applying a nutrient source that will ensure adequate nutrient supply. The narrow profit margin coupled with the high price of land for either purchase or rent creates a situation in which manure is not an attractive nutrient source.

Population equivalent concepts are sometimes used to evaluate the potential for animal production systems to create water pollution problems. However, it is incorrect to assume that a large amount of manure generated by animals is an indicator of actual water pollution, since manure handling systems should be designed to prevent discharge of manure into water bodies. Manure generation is only an indicator of the total *potential* pollution. Modern manure management systems can and should be designed and operated to meet strict discharge guidelines.

Swine manure has several components that can pollute water. These include oxygen-demanding materials (organic matter), plant nutrients, and infectious agents. Color and odor are potential pollutants of secondary importance. Organic matter serves as an energy source for aerobic bacteria in a receiving stream. Increased bacterial metabolism resulting from a discharge of organic waste into a stream increases the oxygen depletion rate of the stream. If the rate of oxygen depletion exceeds the aeration rate of the stream, oxygen depletion occurs. Decreased or depleted oxygen levels can result in fish kills and anaerobic conditions in the stream or other water body.

Organic matter in wastewater has historically been measured as biochemical oxygen demand (BOD). This is a measure of the amount of oxygen required to metabolize waste during a specified time, usually 5 days. BOD is a measure of the organic "strength" of a manure; strength is measured by the oxygen demand during the 5 days.

Another measure of organic strength of a waste is chemical oxygen demand (COD), which is based on chemical rather than biological oxidation. COD will exceed the BOD value for animal wastes, since animal manure and other waste products contain organic materials resistant to aerobic bacterial degradation. COD/BOD ratios vary from 3.5 to 6.5 depending on species and feed rations.

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Reduced organic substances such as ammoniacal N also increase oxygen demand. Relatively high ammonia concentrations are found in liquid manures, anaerobic lagoon effluent, and open feedlot runoff. Estimates of organic strength of different animal waste flows are available in many references (for example, Miner et al. 1966, Mielke and Mazurak 1976, Khaleel et al. 1978, and American Society of Agricultural Engineers 1990).

Figure 16 illustrates the relative strength of various types of waste. Note that raw manures have very high organic strengths compared to other common wastes. However, it should be noted that with the exceptions of accidental discharge or excessive precipitation, little, if any, waste should reach streams or other water bodies from animal production units that are environmentally safe.

Swine manures have high concentrations of plant nutrients. These nutrients are beneficial when properly recycled to land. These same nutrients, however, can pollute water bodies if manure is discharged into the water bodies. Nitrogen and P are the plant nutrients of primary concern. If they enter streams, these nutrients can stimulate the growth of aquatic plants, and these plants may have significant impacts on the acceptable water quality of that stream. In addition, high manure loading rates provide high levels of nitrogen, which can, in turn, increase nitrate concentrations of shallow groundwater.

Another potential water pollution hazard resulting from animal production is disease transmission of water-borne organisms. Several diseases can be transmitted in water from animal to animal and from animal to man (Hensler et al. 1970, Young 1974). Some examples include bacterial infections of *Salmonella, Listeria, Leptospiea, Vibrio, Brucella, Coxiella,* and *Chlamydia*. Other infectious agents such as *Mycoplasma*, fungi, and protozoa (*Cryptosporidium*) can also be transmitted in water. Managers of modern manure management systems must take into account the possibility of disease transmission through the environment and must therefore try to prevent improperly treated manure-laden runoff from reaching water bodies.

If swine manure is not handled and applied properly, it can be a threat to surface water and groundwater quality. Waste loading of swine manure discharges to groundwater or surface water is not well documented.

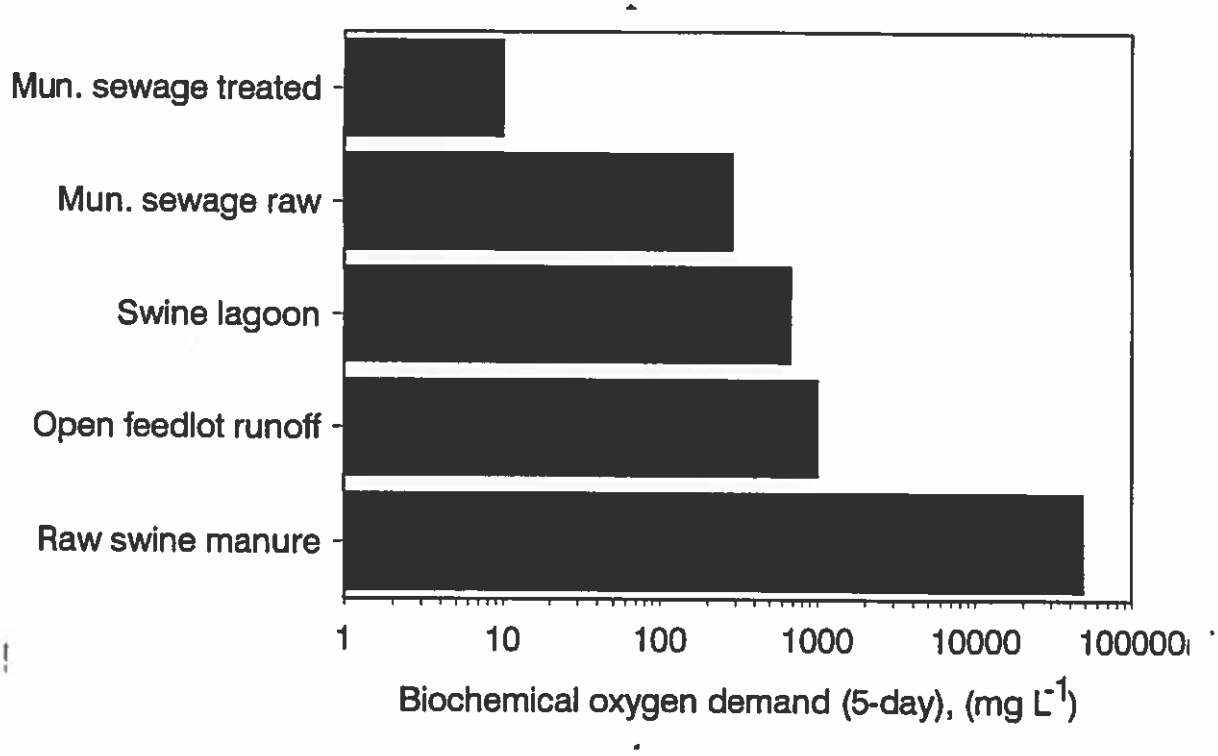

Figure 16. Biochemical oxygen demand of various wastes during a 5-day period

However, research indicates that little manure runs off land when the manure is applied properly. The worst-case scenarios for the incidence of surface runoff would be (1) rainfall occurring after manure is applied to frozen, snow-covered ground or (2) application of liquid manure by irrigation rates that exceed the infiltration rate of soil.

Environmental impacts of manure sites and application problems are just beginning to surface. Excess application rates in fields can lead to increased nitrate concentrations in shallow wells. In many areas, nitrate concentrations in wells often exceed 10 mg L^{-1}. The extent of these problems is not well known, and generally less than 20 percent of rural wells are expected to have nitrate problems; however, the soil above the well and the depth, aquifer material, and position of the well relative to any source will impact the nitrate concentrations.

Another water pollutant commonly associated with outdoor and unconfined animal production is increased sediment in surface water. Animal traffic in pastures, near and along streambanks, and on open feedlots can result in increased erosion in areas with animal production systems. Sediment is normally associated with cropland erosion, but in watersheds with significant permanent surface cover and high water quality, there is a potential impact for sediments from animal production systems to be a problem. Proper design and operation of feedlot runoff control systems and good pasture management can significantly reduce the problem.

Air quality issues

Odor control has become a major environmental concern of the swine industry. Swine producers have identified odor complaints as a major industry environmental issue. Because swine farms are larger and more concentrated, they have a larger potential odor problem. Neighboring residents have apparently become less tolerant of swine odors, since the frequency of lawsuits appears to be increasing. Fewer swine farms are in operation now than in the past, so now neighbors of swine farms are less likely to be associated with the swine industry.

Emission of gaseous wastes from production and manure storage systems has become a major environmental issue in Northern Europe during the past decade. Ammonia discharge from swine production systems is now being regulated in the Netherlands. Ammonia has been associated with acid rain problems in the region. Even though this has not yet been identified as a problem in the United States, there could be some future implications for the U.S. swine industry. Other gases, such as dinitrogen oxide (N_2O), methane (CH_4), and carbon dioxide (CO_2) are all associated with greenhouse effects. Production of these gases is increased through anaerobic treatment of swine manure.

Future Outlook on Swine Production and Research Needs

A study by the University of Missouri (Rhodes 1990) reports that over 50 percent of the nation's hogs and pigs since the mid 1980's have been marketed by farms producing more than 1,000 head per year. Nearly 70 percent of all market hogs in 1988 came from units producing greater than 1,000 head per year. In that year, 1,180 operations producing more than 10,000 pigs per year marketed nearly 19 percent of the nation's commercial slaughter of domestic origin, while a subgroup of larger firms marketing more than 50,000 head produced nearly 6.6 percent of the total. A survey of swine operations in early 1989 found that 30 percent of all operators were planning to expand their farms (Rhodes 1990). Plans to expand were more common among large farms, farms with multiple production units, farms outside the north-central region, and farms having new facilities. Therefore, the structure of the swine production industry continues to change. New, larger farms are expanding outside traditional production regions. Projections are that farms with less than 2,000 head may not be economically viable in the near future (Rhodes 1990).

If the trend of increasing farm size continues, problems with animal rights and animal welfare may arise. In most European countries, an increasing percentage of the breeding herd is being given access to straw bedding during a portion of the gestation and lactation phases of production in response to concerns for the welfare of the swine. If the United States follows the European lead at some future time, either through legislative or consumer pressure, an entirely new set of problems will be created since little information is available regarding the composition, storage, or land application of the resulting high-residue manure material (that is, the manure mixed with straw).

Although another general trend in United States swine production is towards increased confinement production, there is a growing minority of small and not-so-

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small producers who are intensively producing pigs outdoors. Outdoor pig production allows them to escape some of the high investment costs associated with confinement production units. In addition to the obvious concern regarding surface runoff from these outdoor production farms, there is the issue of nutrient leaching from the intensive production area, especially if stocking rates result in total removal of all vegetation. The United Kingdom now considers some outdoor farms as "nitrate-vulnerable zones" (Worthington and Danks 1992).

Future research on swine manure management must focus on several issues. Manure quality must be enhanced or at least preserved during storage and handling. As discussed previously, quality is affected more by treatment than by diet. Methods that can provide a rapid evaluation of the quality of the manure must be developed. An accurate evaluation of the nutrient content of a manure will be useful in avoiding potential negative environmental impacts to either water or air quality.

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Soil Facts

Hog Manure BMP's

The application of hog manure to farmland is an economical and environmentally sustainable mechanism for increasing crop production while providing a waste management service for the hog industry. Nutrients in hog manure can replace commercial fertilizers. However, the value of manure is more than the accumulated value of the individual nutrients. Hog manure is an excellent soil amendment capable of increasing soil quality. Manure can increase crop yields by providing large inputs of nutrients and organic material. Therefore, the value of the manure can best be thought of as the overall crop yield and quality response over several years.

Getting the maximum value out of liquid hog manure requires applying the manure at proper rates and using good application methods. Unique challenges arise with swine manure application. Over-application or improper application can lead to transport of nutrients into the groundwater through leaching or overland flow. As well, improper or over-application can lead to losses of ammonia and nitrous oxide into the atmosphere. Contamination of the soil can also occur in situ as excess quantities of nutrients, sodium and other soluble salts can reduce soil quality and productivity.

Best Management Practices

Adopting Best Management Practices for manure application requires:

1) knowing what is in the manure (manure nutrient analysis);

2) determining nutrients available in the soil (soil testing);

3) matching crop nutrient demand to total nutrients applied (in manure and commercial fertilizers);

Coulter injection systems have been developed to fit into existing direct seeding cropping systems.

4) strategy for application, and

5) record keeping and monitoring.

Hog Manure as a Fertilizer

Hog manure has most of the nutrients required for plant growth. The effluent can replace or reduce the need for commercial nutrients in crop production. However, the nutrient composition of manure varies considerably. The composition of manure differs with moisture content. It also varies with type of hogs, age, composition of feed, rations, climate, the presence of bedding, manure storage and manure handling. Without bedding material or the addition of other solid materials, hog manure is in the liquid state (about 95% water). Liquid hog manure can be composted and spread as

Table 1. Nutrient concentration in hog manure.

	Liquid Swine Manure (Lb/ 1000 gallons)	Commercial Fertilizer (Lb/ 1000 gallons)
Nitrogen (N)	15-50	2000
Phosphorus (P)	1-20	700
Potassium (K)	8-20	700
Sulphur (S)	0.1-3	600

Note: multiply P by 2.3 to get P_2O_5 and K by 1.2 to get K_2O
Adapted from Schoenau , 1997

www.soilcc.ca/gsmp-fact_sheets/pdf/Hogs%20Manure.pdf

Soil surface after 3000 gallons per acres was injected into standing stubble with a coulter injection system.

Soil surface after 6000 gallons per acres was injected into standing stubble with a coulter injection system.

a solid, but requires additional manure handling and processing.

Compared to commercial fertilizers, the relative nutrient concentration of liquid hog manure is quite low. This decreases the distance the manure can be economically transported. The low concentration of nutrients in hog manure requires large application rates to apply an equivalent amount of nutrients.

In addition to the quantity of nutrients in the manure, it is important to know the form of the nutrients. Animal manure has nutrients in the inorganic and the organic form. Liquid hog manure has a high portion of the nutrients in the immediately plant available inorganic form. The inorganic form of nitrogen in manure is found as ammonium nitrogen (NH_4-N). Lab tests will normally test for total N and ammonium nitrogen. Approximate organic N can be determined by subtracting ammonium-nitrogen (NH_4-N) from total N. Nutrients in the organic form must go through a decomposition process to be converted into the inorganic form. Between 50% to 90% of N in liquid hog manure is available for crop use in the year of application.

Phosphorus also exists in both the mineral (inorganic) and organic form. Phosphorus must be in the inorganic phosphate form to be plant available. Fall applied P *may be* less available than spring applied P. In the absence of lab results, applicators can assume 40% of P is available in year one.

The phosphorus content is found predominantly in the solid fraction of the liquid manure. An increased amount of solid material will typically be associated with increased amounts of total P. The phosphorus content of the effluent can be reduced through multi-phase storage systems as solids settle during each of the phases. By the latter stages a liquid virtually free of solids is created.

Soil surface after 9000 gallons per acres was injected into standing stubble with a coulter injection system. Note the effluent pooling on the surface.

Manure Sampling

The only way to determine the content and form of the nutrients in hog manure is to sample the manure. Manure samples should be collected and sent to an analytical lab for analysis. Instant analysis techniques may be limited to analyzing for only one or two elements and there could be shortcomings in accuracy and precision. The nutrient content of manure is highly variable, so sampling technique is important. Sampling requirements will vary with analytical

Table 2. Estimated nitrogen losses during application

Application Method	Retention Factor
Injected manure	1.0
Surface spread and incorporated (within 24 hrs)	0.85
Surface spread without incorporation	0.65

Saskatchewan Agriculture, Food and Rural Revitalization

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labs, however accurate sampling requires creating a slurry and taking a composite sample.

Analysis Results

Laboratory analysis of manure usually present the nutrient content as a "wet %" basis. This represents the percentage of that particular nutrient in the manure.

To calculate concentration in liquid manure:

- wet % x 100 = lbs/1000 gallons
- wet % x 10 = kg/1000 litres

To calculate equivalent pounds of P_2O_5

- total P x 2.3 = lbs of P_2O_5

Manure software recommendation packages have been developed by commercial testing laboratories and government agencies. The software simplifies the rate calculations and allows record keeping and provides applicator calibration information.

It is important to know the relative amounts of nitrogen, phosphorus and other nutrients in order to avoid the over or under application of another nutrient. Getting the crop fertility requirements from hog manure is different than the fertility requirements from commercial fertilizer. The nutrient requirement of crops doesn't often match the nutrient composition of hog manure. Crops require nitrogen and phosphorus in a ratio of 10:1, but if the N:P ratio in manure is around 3:1, this translates into an excess application of phosphorus when the nitrogen requirements are met.

Matching Nutrient Demand to Nutrients Supplied

On most prairie agricultural soils, applying hog manure to meet the crop requirements for N can be safely accomplished without P overload. Prairie soils have a high pH and sorption capacity that immobilizes the P to the soil. Sandy soils are the most susceptible to over application. Preventing soil erosion and overland water movement by maintaining soil cover through soil conservation practices such as direct seeding will prevent phosphorus from entering water systems.

Manure injection truck injecting 9000 gallons per acre. Note the pooling that occurs at higher injection rates.

Efficient, economic and environmentally sustainable manure application over the long term requires balance between manure nutrient application and crop nutrient demand. Determining application rates for the manure requires establishing target yields thereby determining the nutrient requirements of the crop. Required nutrients must be supplied either by the soil or the manure. Matching the nutrient requirements of the crop to nitrogen supplied by the manure and soil maximizes grain yield and protein without leaving

Table 3. Calculating manure application rates - Example

A - Soil test N recommendation	95 lbs/ac
B - Total manure nitrogen	30 lbs/1000 gal
C - Ammonium (NH4) in manure	21 lbs/1000 gal
D - Estimated loss factor after volatilization	1.0
E - NH4 available in growing season:	C x D 21 x 1.0 = 21 lbs/1000 gal
F - Organic nitrogen:	B - C 30 - 21 = 9 lbs/1000 gal
G - Organic nitrogen available in growing season:	F x 0.30 9 x 0.3 = 2.7 lbs/1000 gal
H - Total nitrogen available in growing season:	E + G 21 + 2.7 = 23.7 lbs/1000 gal

Source: Saskatchewan Agriculture, Food and Rural Revitalization

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excess nitrates in the soil.

Over application can occur by applying higher rates than the crop can take off over time. Since all nutrients aren't available in the year of application, repeated applications in excess of crop uptake are one method of over application. Over application can lead to nutrient saturation and losses. Excess nitrates in the soil are readily soluble in water and moves wherever water does. Phosphorus is not as mobile as nitrates and tends to accumulate in the top layer of soil. Therefore P is not susceptible to leaching, but can be lost with surface runoff.

Application Technique

Application technique is also a very important method of minimizing losses. Injecting the manure into the soil is an important step to reducing gaseous losses of ammonia. The application method greatly determines the agronomic response to the manure. Injected manure provides greater crop response and nutrient recovery compared to surface applied manure. Odour is also minimized. The injection of manure can be done with low disturbance coulters or knives. Row spacing of less than 18 inches should be used to get good distribution and minimize volume in each row.

Surface spread and incorporated manure requires increased rates to match the yield response of the injected manure. This reflects the nutrients lost through volatilization and runoff.

The soil landscape should be conducive to manure application. Since large quantities of liquid hog manure are applied, soils and landscapes susceptible to leaching or runoff should be avoided.

Ideally, the manure should be applied in spring prior to seeding, but late fall applications when the soil is cooled are also effective. As with commercial fertilizer, volatilization and denitrification losses can be greater with fall application. Spreading of manure on snow or frozen ground is not a recommended practice. Winter application can result in overland runoff and volatilization.

Application to Established Forages and Crop Stands

Application to established forages and crop stands is a viable option that extends the window of opportunity for application. With minimum disturbance coulters, the liquid manure can be added to grass pastures and as a post- emergent option for cereals to boost protein and yield. Damage to the stand can be minimized if coulters are used, soil moisture is good and the application to the cereal crop is made early.

Timing of application is similar to commercial fertilizer applications. Crop response and forage growth determines the optimal application time. Forage crops can be injected in the fall or early spring. **Forages that have received manure application should be tested for nitrate content.**

Record Keeping

Good records will maximize nutrient utilization, reduce risk of environmental damages and reduce liability. Records for manure application should include manure nutrient content, manure application rate, location of manure application, and the date of manure application. Crop records should include crop grown, commercial fertilizer added, yield, and nutrients removed with seed and straw.

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Determining Crop Available Nutrients from Manure

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This NebGuide discusses the availability and use of manure nutrients for field crop production.

When managed correctly, nutrients in livestock manure can be a valuable resource. When managed improperly, however, these same nutrients represent a potential environmental pollutant. Accurate crediting of manure nutrients within a total crop nutrient program is fundamental to utilizing manure as a resource. This NebGuide illustrates how to estimate the crop available manure nutrients *(part c, Figure 1)* and calculate an agronomically based manure application rate. To illustrate this process, example calculations are provided and a worksheet is included allowing you to complete the calculations as well.

To accurately credit crop available manure nutrients, a producer needs three pieces of information:

1. Manure nutrient of concentration at time of land application — the concentration of individual nutrients in manure measured as pounds of nutrient per unit of manure (ton, 1,000 gallons or acre-inch).
2. Manure application rate — the rate at which manure is applied to the land measured as tons, 1,000 gallons or acre-inches.
3. Manure nutrient availability factors — the percentage of nutrients in manure available to the crop in a given year.

Estimating Manure Nutrient Concentration

Knowing the concentration of nutrients in manure is as crucial as knowing those facts about commercial fertilizer. *Table I* provides estimates of typical manure nutrient concentrations. Because manure nutrient content can vary with livestock species, manure moisture, livestock diet and collection and storage losses, a manure analysis is preferable to using table values for an accurate estimate. Where manure is stored outdoors, sampling on a seasonal basis (when significant quantities of manure are land applied) is recommended.

A manure analysis should include:

- *Both ammonium-nitrogen and organic-nitrogen* (or total nitrogen). Knowing two of the three values means you can calculate the third.
  Total-N = Ammonium-N + Organic-N

  Nitrogen is excreted in two forms *(Figure 2)*. About one-half of the excreted nitrogen is a stable organic-nitrogen present in the feces. The other half is excreted as urea in urine, which decomposes rapidly to ammonium-N (NH_4^+).
- *Phosphorus and potassium as P_2O_5 and K_2O equivalents.*
- *Nutrients in the same units of measure as you calibrate your manure application system.* If manure application is measured by tons per acre, request the analysis be reported as pounds of nutrient per ton.
- *Nutrients on a "wet" or "as is" basis* since you are calibrating application equipment on a wet manure basis.

Additional information on manure sampling is available from *Sampling Manures for Nutrient Analysis* (NebGuide G1450) and *Manure Testing: What to Request?* (NebFact NF507).

Figure 1. Three key estimates needed to use manure nutrients as a resource.

Table I. Typical nutrient content of manure. Because of variability between farms, individual manure analysis is preferable to the estimates below.

	% Dry Matter	Nitrogen		P_2O_5	K_2O
		Ammonium-N	Organic-N		
Slurry Manure		(lbs. of nutrient per 1,000 gallons of manure)			
Dairy	8	12	13	25	40
Beef	29	5	9	9	13
Swine (finisher, wet-dry feeder)	9	42	17	40	24
Swine (slurry storage, dry feeder)	6	28	11	34	24
Swine (flish building)	2	12	5	13	17
Layer	11	37	20	51	33
Dairy (lagoon sludge)*	10	4	17	20	16
Swine (lagoon sludge)	10	6	16	48	7
Solid Manure		(lbs. of nutrient per ton of manure)			
Beef (dirt lot)	67	2	22	23	30
Beef (paved lot)*	29	5	9	9	13
Swine (hoop barns)	57	4	13	20	
Dairy (scraped earthen lots)	46	3	14	11	16
Broiler (litter from house)	70	15	60	27	33
Layer	40	18	19	55	31
Turkey (grower house litter)	70			15	30
Liquid Effluent from lagoon or holding pond		(lbs. of nutrient per acre-inch)			
Beef (runoff holding pond)	0.25	71	8	47	92
Swine (lagoon)	0.40	91	45	104	189
Dairy (lagoon)	2	317	362	674	1082

Value based upon ASAE, 2005, D384.2; Manure Production and Characteristics with exception of those "*".

Estimating Manure Application Rate

If manure nutrients are to be managed as a nutrient resource, the application equipment must be managed as a fertilizer applicator. Knowledge of manure application rate, like knowledge of fertilizer application rate, is key to managing nutrients applied to crops. Manure application rate can be estimated by one of the following:

1. Using one of the calibration methods detailed in *Nebraska CNMP Application Workbook* (EC720), pp. 87-88, available online at *http://cnmp.unl.edu/landapplication workbook.html.*
2. Maintaining a record of total manure applied to a field (i.e. total number of loads × average capacity ÷ the field's area).

Estimating Crop Available Nutrients

Manure application rate and a manure analysis provides the information needed to estimate total manure nutrients applied. The "total manure nutrients," however, is less important than "crop available nutrients." The process for estimating crop available nutrients is illustrated in *Figure 2.* A worksheet for completing the calculations *(Table II)* will assist in making this estimate.

Some manure nutrients become available slowly through mineralization in the soil. Mineralization is a process by which soil microorganisms decompose organic nutrients into a mineral inorganic, or plant available form. An estimate of crop available phosphorus and potassium is reasonably simple. Seventy percent of the phosphorus and 70 to 90 percent of the potassium is available to the crop during the year it is applied.

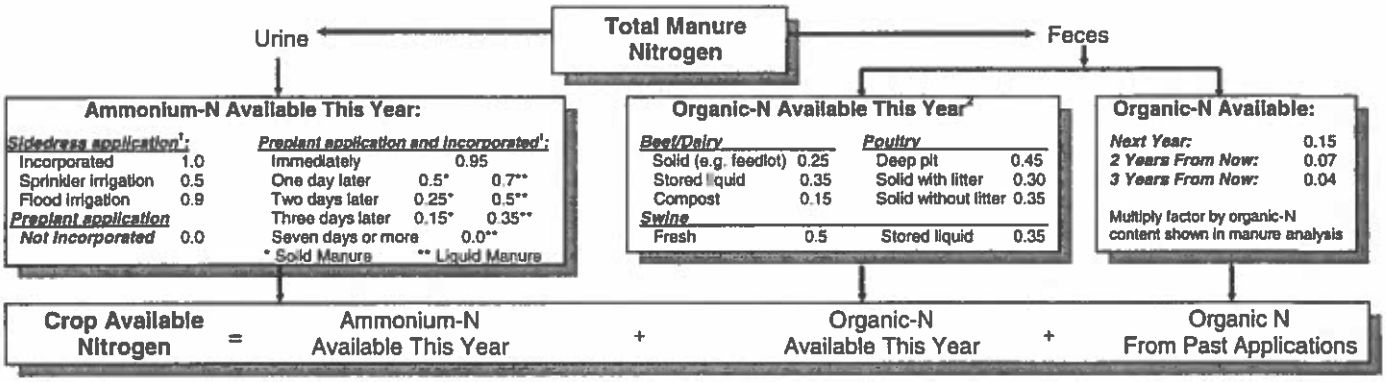
Determining nitrogen availability, however, is more complex. The availability of ammonium and organic-nitrogen for specific livestock species, application methods and other factors can be found in *Figure 2.* Ammonium and organic-nitrogen originate from the urine and feces respectively. The ammonium fraction's availability to the crop (left-hand box, *Figure 2*) depends upon both the time between manure application and incorporation into the soil and the environmental conditions. If manure is surface applied, ammonium (NH_4^+) is converted over several days to ammonia (NH_3) and lost by volatilization. Warmer temperatures accelerate this loss. If manure is mixed into the soil, the ammonium either is directly available to the plants or converts to another plant available form, nitrate-nitrogen (NO_3^-).

Organic-nitrogen is mineralized to ammonium over several years at a rate affected by soil temperature, soil moisture, the characteristics of the manure and other factors. During the cropping season following application, between 25 and 50 percent of the organic-nitrogen is available (middle box, *Figure 2*). Over the next several years, additional organic-nitrogen is mineralized to crop-available forms in decreasing amounts (right hand box, *Figure 2*). For example, mineralization of stored swine manure will be approximately 35 percent, 15 percent, 7 percent and 4 percent of the organic-nitrogen during the year manure is applied, one year later, two years later and three years later, respectively.

Calculating Crop Available Nutrients

At this point, information should have been collected for 1) nutrient concentration of the manure, 2) manure application rate for the current year and the past three years, and 3) availability of organic-nitrogen, ammonium-nitrogen, phosphorus, and potassium. *Table II* can now be used to complete a calculation for crop available nutrients. For determining crop available nitrogen in *Table II*, follow these steps:

1. Select the units used to measure manure application rate. Replace all "?" within the calculations with either tons, 1,000 gallons or acre-inches of manure or effluent.



[1]Incorporation can be accomplished by tillage or by a 0.50 inch or greater rainfall.
[2]Organic-N availability assumes spring seeded crops such as corn and soybeans. For winter or spring manure application prior to planting small grains, multiply organic-N availability factor by 0.7.

Figure 2. Availability factors for manure nitrogen.

2. Enter the manure application rate and nutrient concentration and calculate total nitrogen application.
3. Enter the total nitrogen application and manure nutrient fraction available, and calculate the available nitrogen for ammonium, organic-N and organic-N from past applications separately.
4. Sum the estimated available nitrogen from ammonium, organic-N, and organic-N from past applications.

An example is presented in *Table II* for cattle feedlot manure applied at a rate of 28 t/ac this year and two years ago. Manure is disked into the soil within 24 hours. The producer's manure analysis indicates nutrient concentrations of 5 lb. of NH_4^+/ton, 13 lb. of organic-N/ton, 12 lb. of P_2O_5/ton and 21 lb. of K_2O/ton.

A much simpler estimate of crop available phosphorus and potassium can also be completed in Step 5. The results of these calculations can be summarized in Step 6.

Soil Testing and Crop Monitoring

The previous procedures have provided a "calculated" estimate of nutrient availability from manure. Soil testing provides a "field measurement" of residual nutrients. For a producer who regularly soil tests, is this calculated estimate necessary?

A deep soil test measures soil nitrate-N at the time of sampling. The above calculations estimate organic and ammonium nitrogen accessible to the crop through the growing season. Although most manure nitrogen will eventually be converted to nitrate nitrogen, this has not happened at the time soil samples are typically taken (fall, winter, or early spring). A soil test for nitrate nitrogen will not account for the future nitrogen available from manure. Thus, the "field measured" and "calculated" values are independent sources of nitrogen and should be added together.

The amount of manure nitrogen credit is an estimate based on average conditions. An alternative strategy is the presidedress nitrate test (PSNT) which may be a more accurate predictor of when manure release is sufficient to produce maximum yields in corn. The PSNT test is a one-foot soil sample taken in early June or at the 6 to 8 leaf stage. The soil is analyzed for nitrates. By this time of the growing season, manure nitrogen is mineralizing to nitrate. In Iowa and other states a soil nitrate level of over 25 ppm is usually sufficient for maximum corn production.

Corn can be monitored to determine if a nitrogen deficiency is developing by use of a chlorophyll meter. Under irrigated conditions additional nitrogen can be applied when needed with the irrigation system. In the near future remote sensing may allow monitoring of nitrogen status without the need to sample individual plants.

Phosphorus and potassium application needs can be determined by soil testing. Regular soil testing of fields receiving manure will document phosphorus and potassium status.

Using any one of these techniques or a combination will allow more accurate crediting of manure nutrients with confidence. The "calculated" estimate of manure nitrogen will remain an important pre-growing season planning tool for manure nutrient sources.

Once the available nutrients are determined, the next step is to fit this information into a nutrient management plan. NebGuide G174, *Fertilizer Suggestions for Corn*, details how to determine the total nutrients needs based on soil tests and yield expectation. The *Nebraska CNMP Application Workbook* (EC720) provides reference tables for nutrient recommendations for many common crops.

Additional Resources

All University of Nebraska–Lincoln resources for nutrient management planning can be found online at *http://cnmp.unl.edu*. The Web site contains software tools, sample records, regulatory information, and other tools associated with nutrient management planning. Of particular value are two software tools, UNL's Manure Use Planner and Purdue's Manure Management Plan. These tools can be downloaded at no cost from the CNMP Web site.

NOTE: Use your Adobe Reader® to fill in the blanks in the following form and print out the results. Use the Tab key on the computer keyboard to move through the form. The form will automatically calculate equation solutions. The file cannot be saved to your computer, but can be completed and printed to create a record.

Table II. Planner for estimating crop available nutrients. An example is presented for cattle feedlot manure. Enter your own numbers in the boxes provided.

Step 1. Is manure measured in:

✓ ton (solid or semi solid manure)?
____ 1,000 gallons (slurry or liquid)?
____ acre-in (lagoon or holding pond effluent)?
(Replace "?" with appropriate unit of measure.)

Check one.

Step 2. Calculate total manure nitrogen applied.

Total Ammonium-N

Manure Rate (?/acre) (lb/acre)	X	NH_4 From Analysis (lb/?)	=	Total (lb/acre)
28 t/ac	X	5 lb/t	=	140
10		4		40

From Manure Analysis: 5 lb. NH_4 / ton

Total Organic-N from Present Application

Manure Rate (?/acre)	X	Organic-N From Analysis (lb/?)	=	Total (lb/acre)
28 t/ac	X	13 lb/t	=	364
10				0

From Manure Analysis:
13 lb. organic N/ton (this year)
11 lb. organic N/ton (2 years ago)

Total Organic-N from Past Applications

Manure Rate (?/acre)	X	Organic-N From Analysis (lb/?)	=	Total
1 year ago: 0	X		=	0
				0
2 years ago: 28 t/ac	X	11 lb/t	=	308
				0
3 years ago: 0	X		=	0
				0

Step 3. Calculate crop available nitrogen applied.

Part 2. Crop Available Ammonium-N

Total (lb/acre)	X	Fraction Available[a]	=	Available (lb/acre)
140	X	0.5	=	70
40				0

[a]Left box of *Figure 2*

Incorporated within 24 hours of application

Part 2. Crop Available Organic-N From Present Application

Total (lb/acre)	X	Fraction Available[b]	=	Available (lb/acre)
364	X	0.25	=	91
0				0

[b]Middle box of *Figure 2*

Beef feedlot manure

Part 2. Crop Available Organic-N From Past Applications

	Total (lb/acre)	X	Fraction Available[c]	=	Available (lb/acre)
1 year ago:	0	X	0.15	=	0
	0		0.15		0
2 years ago:	308	X	0.07	=	22
	0		0.07		0
3 years ago:	0	X	0.04	=	0
	0		0.04		0

[c]Right box of Figure 2

Step 4. Sum crop available nitrogen applied

Part 3. **Crop Available Manure Nitrogen Applied**

Ammonium	+	Organic-N	+	Residual Organic-N	=	Crop Available Nitrogen
70	+	91	+	22	=	183 lbs. N/acre
0		0		0		0 lbs. N/acre

Step 5. Calculate available phosphate and potash at known manure application rate.

P_2O_5 concentration in manure: 12 lb/t ____ lb/?

lb P_2O_5/?	X	?/acre	X	% available	=	lb P_2O_5/acre
12 lb/t	X	28 t/ac	X	0.7	=	235
		10		0.7		0

K_2O concentration in manure: 21 lb/t ____ lb/?

lb K_2O/?	X	?/acre	X	% available	=	lb K_2O/acre
21 lb/t	X	28 t/ac	X	0.8	=	470
		10		0.8		0

Step 6. Summarize crop available manure nutrients for selected application rate: 28 t/ac — 10 ?/ac.

Available Manure Nitrogen	Available Manure P_2O_5	Available Manure K_2O
183 lb/acre	235 lb/acre	470 lb/acre
0 lb/acre	0 lb/acre	0 lb/acre

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Index: Waste Management
Livestock Waste Systems
Revised March 2006

SWINE MANURE MANAGEMENT PLANNING

ID-205

Cooperative Extension Service
Purdue University
West Lafayette, IN 47907

SWINE MANURE MANAGEMENT PLANNING

Purdue University Cooperative Extension Service
and
Indiana Soil Conservation Service

SWINE MANURE MANAGEMENT PLANNING (MMP)

Many Indiana pork operations generate large volumes of manure. For example, 500 finishing pigs produce nearly 3,000 cubic feet of manure a month, which is over 265,000 gallons a year. Swine manure is an economical fertilizer. The plant nutrients in manure can reduce a producer's costs up to $50 per acre. If mishandled, however, swine manure can contaminate surface and ground waters. Proper storage, handling and application of manure from pork production operations can protect Indiana's water resources and increase profits for animal and crop enterprises.

A Manure Management Plan (MMP) brings together information about crops, livestock, and manure handling for your farm. This information will help you develop a better long-term plan for maximizing the value of your swine manure.

Preparing the MMP takes some effort, but the results are reduced costs to your crop program and environmental protection.

A MMP includes:

* Field slope and soil type, and soil test results.

* Crops and rotations for each field for about the next three years, or the time period for your specific rotation.

* Crop nutrient requirements.

* The types and amounts of manure expected each year.

* What needs to be done to:

- collect (slotted floors, gutters, scraped lots, runoff),

- transport (pipes, pumps, tanks, spreaders, ditches),

- store (pits, lagoons, earthen basins),

- and properly utilize manure for crop growth or other uses (fertilizer, livestock feed, garden soil conditioners).

* Data on stored manure, and analyses of its nutrients
* Planning manure applications to: meet crop needs, empty manure storages as required, and meet state environmental requirements.

Preparing the MMP takes some effort, but the results are reduced costs to your crop program and environmental protection.

Keep in mind:

* It takes time to collect and organize information. Fortunately, you collect information such as field sizes or building pig capacity only once.

* Enough land must be available for spreading the manure at environmentally sustainable application rates.

* If manure will be applied to land not owned by the operation, have Land Use Agreements signed by the property owners.

* You may want more storage capacity, to avoid spreading manure during the growing season because not enough land is available.

Many publications describe in detail the collection, transport, and storage alternatives for handling manure from animal to storage. Use them to develop those portions of your MMP. Others detail crop nutrient needs under various conditions and can help assure that your crop needs are being met. See References near the end of this publication.

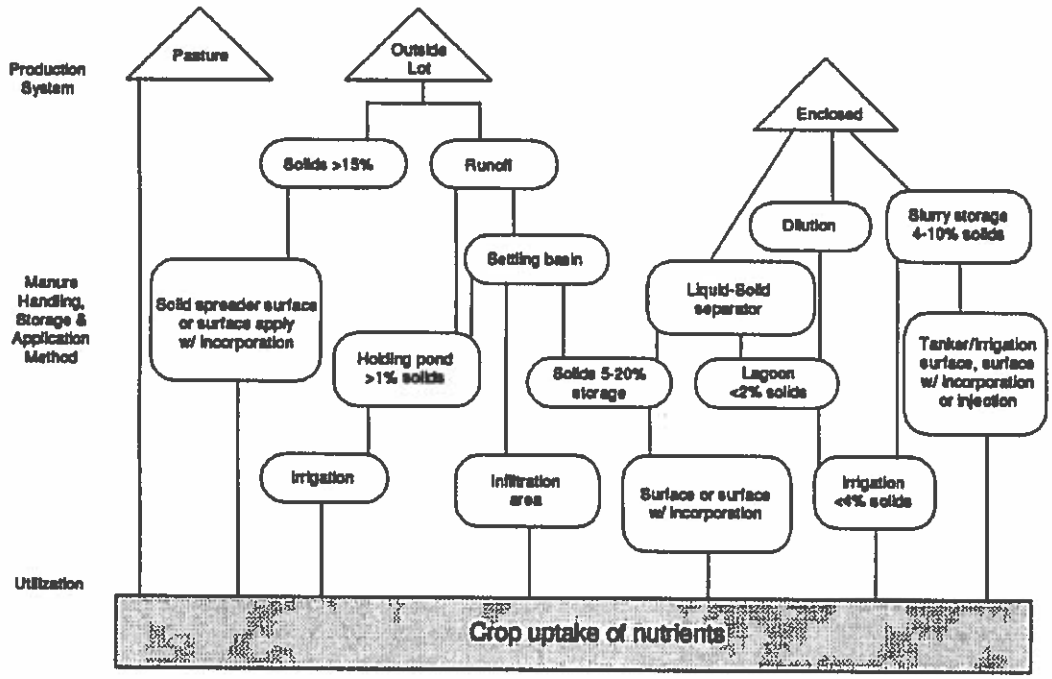
This publication concentrates on the timely application of manure nutrients to crops. It deals with the part of a Manure Management Plan that utilizes manure as a fertilizer. A summary of manure handling options is included, because they affect what is in storage. But, our purpose is to start with stored swine manure and include handling alternatives and descriptions of components needed by the system.

HOUSING AND MANURE HANDLING OPTIONS

Pork producers select a manure handling system based on factors such as location, the size, type and use of their cropland, the number of animals, and the type of animal housing. Many options relate to the type of housing system - pasture, drylot, and enclosed. Here is a brief discussion of each system with design and management hints to minimize manure storage and application problems.

With all systems, divert rain and snowmelt runoff away from the manure handling system. Install gutters to direct roof runoff to a ditch or other diversion. Keep uncontaminated surface water away from lots, settling facilities, infiltration channels, outdoor storages, and animal traffic lanes. Channel contaminated lot runoff to adequate treatment, storage, and application systems.

Figure 1. Swine Manure Management Alternatives



Pastures usually do not need separate manure management facilities. However, drylot and enclosed systems need specific facilities for handling manure as a solid, a liquid, or both. Figure 1 illustrates how the manure flows within each system. All systems return all manure to the land with no discharge into Indiana waters.

Pasture System

Pasture no more than 10 sows and litters, or 50 growing-finishing pigs, per acre in Indiana. Rotate pastures to prevent overgrazing. Reduce erosion by providing stabilized areas (for example, a gravelled slope around a waterer) for feeding, watering, and animal sorting and handling. Maintain vegetative cover on steep slopes near streams to minimize soil erosion and polluted runoff. See Purdue University's publication WQ-7, in References.

Drylot Systems

The drylot systems and their space requirements are:

* Concrete lot: Minimum total space is at least 12 sq ft/animal - 6 sq ft/animal inside the building and 6 sq ft outside. Producers seem to prefer 4 sq ft inside and 15 sq ft outside.

* Dirt lots: Allow at least 30 sq ft/animal in well drained lots with paved feeding and watering areas. Allow up to 200 sq ft/animal in lots with no paving, depending on animal size, soil type, and site slope and drainage.

Because of potential odor problems, select a site downwind and some distance from neighboring residences and businesses. Avoid potential ground water pollution: never put a drylot system near a sinkhole or abandoned well, or on a site known to be underlain with fractured limestone. A bedded mound can help reduce wallows and erosion, and makes removing some of the solid manure a little easier. Remove and renew bedded mounds frequently. (See PIH-33 for more information on odor control.)

Locate a drylot on a 4% to 6% slope for drain- age. (Earth-moving equipment can often create enough slope if necessary.) In addition, suggested slopes from feeders and waterers are 3/4" - 1 "/ft; from buildings, 1/2" - 3/4"7ft; and along drainage ways, 1/4" - 1/2"/ft. Slope building floors 1/4" - 3/4"7ft toward gutters or an open front.

Common manure handling equipment includes a tractor with scraper blade or bucket loader and a spreader. Solid manure from pens, including bedding, is usually hauled directly from the animal area to the field, or scraped to short-term storage when bad weather prevents field spreading. For a 10-day storage capacity, provide 2 cu ft/grow-finish pig. Scrape outdoor lots twice weekly.

Rain and snowmelt runoff from lots and solid manure storages is contaminated and must not flow directly into a watercourse. Scraping removes most of the solids from outdoor lot manure. To remove most of the remaining solids, channel runoff to a settling basin that has 1 cu ft of liquid capacity per 12 sq ft of lot area. Field spread solids periodically from the settling basin. See ID-114 in References.

Drain the liquids to an infiltration area where grass or other crops utilize the nutrients. The infiltration area is a low-slope channel where the liquids infiltrate the soil. Locate the area away from surface water and broken tile lines, but convenient for vegetation removal or harvest. Do not graze the infiltration area unless soil type and moisture conditions prevent soil compaction.

Lot runoff liquids also can be stored in a holding basin or treated in a lagoon. Although the required storage volumes are large, the liquids are a source of dilute nutrients and irrigation water.

Because of the wide variation in the concentration of nutrients in either solid or liquid manure from lots, no nutrient estimates are included here. Measure nutrients with chemical testing. Handle the nutrients just like the other solids and liquids discussed later in this publication.

Enclosed Systems

In enclosed housing systems, animals are under a roof at all times on solid, partly-slotted, or completely-slotted floors. When siting a housing unit, consider manure flowing by gravity from housing to storage.

Some housing systems generate manure handled as solids, such as solid-floor breeding and gestation units. Removal and handling equipment is about the same as suggested for drylot solids, especially with bedded pens. Mechanical scrapers also can be used.

Slats over below-floor gutters or storages are very common, and generally lead to handling manure as a liquid or slurry. Mechanical scrapers, run at least once and preferably twice daily, work well in gutters that are level so liquids do not run off. Flushed gutters or floors require large volumes of fresh or recycled water. Storages below slats tend to empty well by gravity drainage, especially if the manure is agitated.

Liquid Manure Handling Systems

Liquid manure is stored in concrete pits under slats or in an outdoor tank or earthen pit. Liquid manure can be put in a lagoon where it is both stored and treated. During the treatment, much of the nitrogen fertilizer value is lost. Equipment needed includes scraper blades or slotted-floors, manure pump and/or agitator, and liquid manure tanker or injection equipment. Liquid manure irrigating systems are also common.

Storages should be water-tight and at least 100 feet from any well or domestic water supply. Except for lot runoff, divert all surface drainage away from storage. Needed storage capacity depends on the number and size of the pigs, pen cleaning method, and the length of time between storage unloadings. For outdoor storage consider rain and snow.

Table 2 gives estimated manure production values for roofed animal housing with reasonable allowances for bedding and for spilled and cleaning water. An unroofed outdoor storage also stores rain and snow that fall on its surface between emptyings--typically the fraction of annual precipitation during the storage period, less normal evaporation, plus rain from a 25- year 24-hour storm.

Provide storage for at least 1.5 cu ft/sq ft of area in the drained lot and the channel leading to the storage to handle rainfall for 6 months.

Freeboard is clear space in the storage above the designed maximum liquid level. For pits under slats, leave room for adequate ventilating air and some reserve storage--perhaps one foot. For outdoor storages, freeboard is the guarantee that the storage will not overflow.

A lagoon is a treatment unit, and its design and location may be regulated because of potential leaching problems. It needs space for manure and rain plus a specified volume of dilution water. See ID-120, in References.

Keep long bedding and dry or frozen materials out of a liquid manure storage. Haul such material direct to the field. Frequent hauling of liquid manure reduces the size of storage and equipment needed, better distributes the labor load, and aids in reducing manure odors, as long as timing matches plant need and soil condition.

Agitate stored liquid manure before emptying the storage to reduce the sludge left in the storage and to make nutrient applications more uniform.

Gases escaping from agitated manure can be deadly for both humans and animals. Operate all ventilation fans and open doors and windows when agitating and removing manure stored in a building.

GETTING STARTED WITH A MMP

Organize information about your fields.

* Get U.S. Geological Survey (USGS) Quadrangle topographic maps (for surface slope information), Soil Survey maps (for soil types) and Plat maps for the townships where your fields are located. The USGS and Soil Survey maps are available at county offices of the USDA Soil Conservation Service (SCS) or the Purdue Cooperative Extension Service (CBS). Plat maps are available from County Recorders.

* Outline each field that may receive manure with its size and shape using a dark pencil or marker on all maps.

* Mark each field with an identification system that is easy for you to remember. Add acres if the map is large enough.
* Note on the map of each field areas protected by separation distances that prohibit or limit spreading manure. Do not apply manure closer than:

- 200 feet from a water well.

- 100 feet from a surface tile inlet, sinkhole, intermittent stream, drainage ditch, or other body of water without immediate incorporation. An intermittent stream is one that carries a water flow only during the wet season.

* Make copies of the field maps for each year.
* Start recording field data in Worksheet A.l.

Organize information about your crops.

* Start, if you haven't all ready, using a crop production record keeping system in which each field's planting and harvesting dates, soil test results, and manure and fertilizer application rates are recorded. Date the entries. See ID-l98 in References.

* Record crop plans, rotations, summarized soil test results, and crop nutrient requirements in Worksheets A.2. and A.3.

* For crop nutrient needs, use recommendations from your crop consultant or fertilizer dealer based on anticipated yield and on soil test results for each field--your data will fit your conditions best. Suggested data for Indiana are in Table 1, if you don't have data for your farm yet. More complete data are in Purdue publications AY-l71, AY-170, AY-244, and AY-268; see References.

Organize information about your manure production.

* Start tables like Worksheets B.1. and B.2. Measure swine manure storages, if necessary, to find the volumes. (See "Conversions" for useful formulas and data.)

* For manure nutrient values, use results from chemical tests of the manure in your storages. If you don't have recent analyses, the values in Table 2 can temporarily be used as general estimates for swine manure.

* Start taking swine manure samples in storage, or during unloading. Samples are best taken after agitating and during pit emptying. See reference CES-227 or AY-277 on manure sampling. xble

Note that much of the information will not change every year--field descriptions, manure storage data, crops, and rotations. You don't have all the work to do every year, just a review of your plan.

DEVELOPING A MMP--A WORKSHEET APPROACH

The following worksheets help you match crop nutrient needs with the nutrients in the manure storages of your swine units. Decisions to be made include: Where and when do I apply manure and how much? The worksheets help make the calculations and organize the planning.

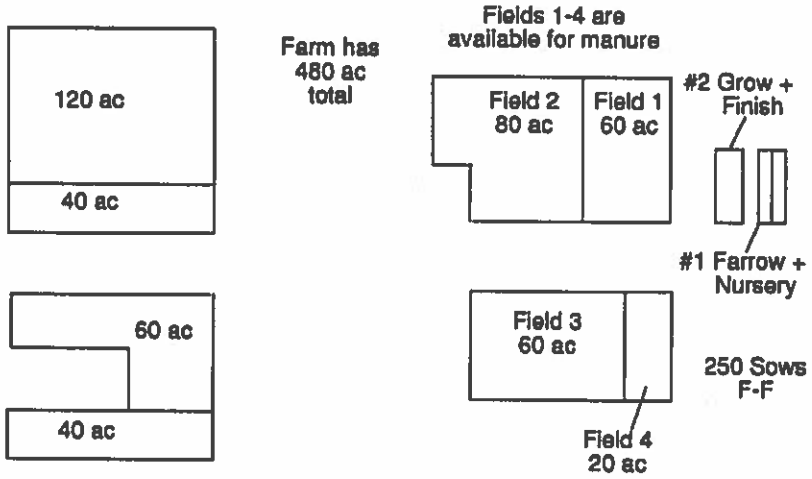
If you are expanding or developing a new operation, you may go through parts of the worksheets several times to consider alternatives.

Two inexpensive computer programs, AMANURE and MBUDGET, are available from Purdue University; see References. The programs help you rapidly change inputs and results to compare options.

Although the following example assumes under-floor manure pits, the worksheets (and the AMANURE and MBUDGET programs) can be used for open lots with runoff control, solid manure, and lagoons.

Example:

This example shows how to develop a MMP for a 250-sow farrow-to-finish operation with total slotted floors, deep pits, and all animals in enclosed buildings. A nitrification inhibitor will be added as the manure is injected from a 2750 gallon tanker wagon. There are four fields (220 acres) considered for manure application on this 480-acre farm. Cropping is based on a three-year rotation.



"A" Worksheets - Crop Data

List each field's basic information in Worksheet A.1. Enter the crops for three years' crop rotation in Worksheet A.2. Note: use longer rotations if they fit your operation.

In Worksheet A.3, list each crop's nutrient needs, based on anticipated yield and soil test results. Use data specific to your farm, if available, or the fertilizer recommendations for Indiana crops in Table 1. [Note: This table gives only some of the current fertilizer recommendation s for Indiana crops. Check AY-170, AY-171, AY-244, AY-268, or your local crop consultants for recommendations for your farm.] Note that N (nitrogen) depends on crop and average or expected yield; it is adjusted if the previous year's crop was soybeans (30 lb./a. carry over) or legume hay or pasture (40 lb./a. carry over). Recommended P (phosphorus) and K (potassium) fertilizer levels depend on the latest soil test results for the particular field - the P or K needed is the crop need at that field's P or K level.

Example:

Field #1, 160 bu corn. Soil test shows P = 20 ppm. Table 1 suggests that P205 needed for this crop is 60 lb./a.

In Worksheet A.3, the crop N, P, K needs for each field and for each year are from A.2. Where appropriate, deduct the legume carry over.

For Worksheet A.4, multiply the acres of each field, from A. 1, times the annual fertilizer recommendations for each field and crop, from A.3, to find the field nutrient needs for each field and each crop year.

Example:

Field #1, Year 1: 60 acres x 190 lb Avail. N needed per acre = 11,400 lb Available N needed for the whole field.

Note: "Available N" is the ammonia and organic nitrogen in the manure that is available to plants this year, after all losses have been accounted for.

To complete Worksheet A.4., total the nutrients (Avail. N, P205, and K2O) needed each year for all crops on fields that will receive manure. Note that the nitrogen amounts that legume s can use but do not require are not added into the column totals.

Example:

Nitrogen for Year 1: N required is 11,400 + 11,200 + 3,000 = 25,600. The legume in Field #3 can use an additional 8,400 lb N without causing excess N that might leach to ground water.

Even though, N applied to legumes is not required. P and K field values can be raised with manure to legumes.

Worksheet A.1. General field data

Field number	Acres	Miles from manure storage	Soil type	Soil slope	Soil test (ppm)	
		mi		%	P	K
1	60	1/8	silt clay loam	2	20	60
2	80	1/2	silt loam	2	10	60
3	60	1/4	loam	4	10	80
4	20	1/8	loam	6	50	95

Worksheet A.2. Crop rotation and expected yield

Year-1		Year-2		Year-3	
Crop	Expected yield/acre	Crop	Expected yield/acre	Crop	Expected yield/acre
Corn	160 bu	Corn	160 bu	Corn	160 bu
Corn	120 bu	Soybeans	40 bu	Corn	120 bu
Soybeans	40 bu	Corn	120 bu	Wheat	60 bu
Grass Pasture	6 tons	Grass Pasture	6 tons	Grass Pasture	6 tons

Worksheet A.3. Annual crop nutrient recommendations for 3-year rotations

Field #	Avail. N, lb/acre			P2O5, lb/acre			K2O, lb/acre		
	Yr-i	Yr-2	Yr-3	Yr-1	Yr-2	Yr-3	Yr-1	Yr-2	Yr-3
1	190	190	190	60	60	60	145	145	145
2	140	0(140)	110a	70	55	70	130	155	130
3	0(140)	110a	60	55	70	110	115	90	80
4	150	150	150	0	0	0	0	0	0

a Only 110 lb N is needed due to 30 lb N credit from last year's soybeans.
Transfer data from Table 1 in Appendix or use your own fertilizer data.

Worksheet A.4. Total field nutrient needs

Multiply field acres (A.1. above) x N, P2O5, or K2O per acre for the crop (A.3. above).

Field	Avail. N, lb/field			P2O5, lb/field			K2O, lb/field		
#	Yr-1	Yr-2	Yr-3	Yrli	Yr-2	Yr-3	Yr-1	Yr-2	Yr-3
1	11,400	11,400	11,400	3,600	3,600	3,600	8,700	8,700	8,700
2	11,200	0(11,200)	8,800	5,600	4,400	5,600	10,400	12,400	10,400
3	0(8,400)a	6,600	3,600a	3,300	4,200	6,600	6,900	5,400	4,800
4	3,000	3,000	3,000	0	0	0	0	0	0
TOTAL	25,600	21,000	26,800	12,500	12,200	15,800	26,000	26,500	23,900

Additional N that could be used by legumes if max. N given to them:

(8,400)	(11,200)

a 3,600 means legumes need no N, but 40 bu/ac soybeans will use 140 lb N/ac (Table 1) if it is applied: 140 x 60 acres = 8,400 lb N; 140 x 80 ac soybeans = 11,200 lb N.

"B" Worksheets - Manure Production

With an inventory of crop and field information completed, you are ready to inventory manure produced and its fertilizer value when applied to your crops. If you have laboratory analyses of manure in each of your storages, use those test results in the worksheets. Otherwise, Table 2 has good estimates for pork production. The table values are "as removed from storage" and include dilution, feed spillage, etc. They are averages of nutrient concentrations measured in many storages.

In Worksheet B.1, list the type of storage, type of animal, average number of animals that contribute manure to each storage (generally average pig capacity of building), portion of the year that the building is occupied, and annual manure production. Then, calculate monthly and daily average manure production and the total amount of manure you expect, using your own data or the estimates in Table 2.

Example:

```
Annual manure produced from farrowing, Storage #1:
       - Manure/year x No. of farrowing stalls x portion of year building is occupied (e.g., 47
         of 52 weeks/year)
       = 1,400 gal/year/sow & litter x 60 farrowing stalls x 0.90 weeks/year
       = 75,600 gal liquid manure/year
       =75,600/12 = 6,300 gal/month
       = 75,600/365=207 gal/day
```

In Worksheet B.2, enter the nutrient concentrations from your own test results or the averagel values in Table 2. Calculate the total of each nutrient in each storage.

Some application methods preserve more N for plant use than others. Nitrogen is lost largely to the atmosphere during manure handling unless it is injected or promptly incorporated. N is also lost in the soil before crops can use it by microbial immobilization, denitrification, and leaching, especially if no nitrification inhibitor is used. "Available nitrogen" is the amount of N available during the current crop season. Select an Application Factor from Table 3 to account for N losses between storage and plant uptake.

Examples:

```
  Pounds nutrients/year = (gal liquid manure/year) x (1/1,000) x (lb nutrient/1000-gal of manure).
For N, also multiply by the Application Factor, Table 3.

   75,600 gal/year =75.6 1000-gal/year

   Avail. N from farrowing (10.0 lb/1000 gal x 0.95 (Application Factor) = 9.5 lb avail. N/1000 gal):
   = 9.5 lb/1000-gal x 75.6 1000-gal/year
   = 718 lb/year in Storage #1

   lb P2O5 from farrowing:
   = 12 lb/1000-gal x 75.6 1000-gal/year
   =907 lb/year

  lb K2O from farrowing:
   = 11 lb/1000-gal x 75.600 1000-gal/year
   = 832 lb/year
```

Compute the other manure sources as in Worksheet B.2.

If a storage is filled with manure from more than one source, such as farrowing and nursery units illustrated in this example, calculate an average nutrient concentration for the storage. Divide the total P2O5 or K2O, lb nutrients/yr from Worksheet B.2. by the total volume (or weight) of manure added to the storage, gal/yr, from Worksheet B.1. For N concentration, multiply total weight of N by the Application Factor from Table 3 and then divide by the total manure volume (or weight).

Example:

```
Since farrowing and nursery manure are put into a single storage, what
are the Available N, P2O5, and K2O concentrations in the combined
storage?


  N concentration from combined storage:
     = (total lb available N from storage)/(total 1000-gal in storage)
     = (718 + 1194 lb Avail-N)/(75.6 + 70.2 1000-gal manure/year)
     =1,912 lb/145.8 1000-gal
     = 13.11 lb available N/1000-gal manure from combined storage

  P concentration from combined storage:
     =(907 + 1,334) / (75.6 + 70.2)
     =2241/145.8 1000-gal
     = 15.37 lb P2O-1000-gal manure from combined storage

  K concentration from combined storage:
     =(832 + 1,544) / (75.6 + 70.2)
```

```
=2376/145.8
= 16.30 lb K2O/1000-gal manure from combined storage
```

To find the potential dollar value of the manure resource, multiply the Total "lb nutrients/yr" for N, P2O5, and K2O (Worksheet B .2) times the fertilizer price in your area. The total dollar amount assumes you can use all of the N, P2O5, and K2O. After completing Worksheet E, the potential value can be adjusted for the amounts of each nutrient that this year's crops are expected to use.

Worksheet B.1. Annual manure production

Manure storage number	Storage type	Animal type	No.	Week	Portion of year facility occupied	Manure added gal/year	gal/	gal/day
1	Liquid pit	Farrow (S&L)	60	47/52	(0.90)	145,800	12,150	399
	Liquid pit	Nursery pigs	540	52/52	(1.00)			
2	Liquid pit	Grow-Fin pigs	1890	52/52	(1.00)	1,001,700	83,475	2,744
TOTAL						1,147,500	95,625	3,143

Worksheet B.2. Nutrient concentrations and annual nutrients from swine manure

Manure storage number	Concentrations Avail. N	P2O5	K2O	Pounds nutrients/year Avail. N	P2O5	K2O
	---lb/1000 gal---			---lb nutrients/year---		
1	13.16	15.31	16.30	1,918	2,241	2,376
2	22.60	26.40	25.40	22,638	26,445	25,443
TOTALS				24,556	28,686	27,819

Worksheet B.3. Balance sheet: Nutrients in manure and nutrients crops need (Year 1)

Total manure nutrients, lb/year, Worksheet B.2. Total crop nutrient needs, lb/year, Worksheet A.4.

	Pounds nutrients/year Avail. N	P2O5	K2O
	---lb nutrients/year---		
Total manure nutrients produced	24,556	28,686	27,816
Total crop needs	25,600	12,500	26,000
Surplus manure nutrients (or shortage)	(1,044)	16,186	1,816
Additional N used if N put on legumes.			
Year 1	(8,400)		
Year 2	(11,200)		
Year 3			

Before making decisions about which manure to apply where, see if you have more--or less--manure nutrients than your crops need. The total Avail. N, P2O5, and K2O needs of the crops from Worksheet A.3 and the animal nutrient production in Worksheet B.2 are shown together in Worksheet B.3.

In this example, the pork operation produces 24,556 lb Avail. N, 28,696 lb P2O5, and 27,816 lb K2O, per year. The 1,044 lb/year calculated as needed N (shortage of manure N) is about 4% of annual need or about 7 lb N/acre of corn land (1,044/140 acres). Such a small amount is generally negligible.

There is surplus P and K. When soybeans are growing in Fields #2 (year 2) or #3 (years 1 and 3), the soil tests in those fields for P and K could be substantially raised with manure. The legumes will use those elements. The legumes will also take up the N, even though it is not required.

There are two ways to handle excess P and K in certain fields, but still meet plant N needs:

* Fulfill plant N needs with manure one year (which will over-fertilize with P and K). For the next two or three years rotate fields by spreading manure on other fields to prevent P and K levels from becoming excessively high.

* Meet plant needs on the particular field by applying manure for the more limiting of P or K. Apply additional commercial N fertilizer to meet the crop's N needs. Apply a "starter" fertilizer at planting time, by sidedressing after planting or by adding nitrogen as needed to the manure ("enriching") prior to application.

Worksheet B.3 gives an overview of what manure utilization can offer your farming practices. If you do not have enough manure to fertilize all fields, save what nutrients you can by using manure carefully. If you have more manure than your crops and soils can safely use, consider contracting with neighbors for additional crop land. Another option is to put in a lagoon, which is a treatment unit that reduces the amount of nitrogen to about one third.

In the example, there is enough land to use the manure, based on crop nitrogen needs, but a surplus of phosphorus. The next step is to determine how much of which manure goes on which field.

"C", Worksheet - Manure Storage Capacity

The amount of manure storage needed depends on:

* Soil conditions - is it too muddy or too likely to compact for hauling during some months?

* Cropping patterns - when can the cropland accept manure and how much? * Type of storage - lagoon water can be irrigated on flat ground as long as temperatures are above freezing. Liquid manure injected on rolling ground can be applied only at certain times.

* Weather patterns.

* The availability of labor, equipment, and application rate.

In Worksheet C, transfer the daily and monthly manure accumulation for each storage from Worksheet B. 1. An example of computing storages is shown below. Compute storage capacity in cubic feet, gallons, or tons of manure. See "Conversions and Volumes" on page 27 for useful formulas. Assume at least 1 ft freeboard for deep pits, tanks, and earthen basins and lagoons.

The number of days of manure storage available is: (manure storage capacity) divided by (daily manure accumulation).

Example:

```
     Consider Storage #1, which includes liquid pits under the
farrowing and nursery room.

       Assume the usable pit volumes are 230' long, are 7' wide under
each side, and 4' deep.
       Allow 1' freeboard; maximum manure storage depth =3.0'.

     Storage pit volume = (230 x 14 x 3.0 ft) x 7.5 gal/cu ft
       = 72,450 gal
     Days of storage capacity = (Storage Capacity)/(Daily Manure Accumulation).
     Storage = 72,450/399 gal/day (Worksheet B.1.) = 182 days.
```

Worksheet C. Manure storage capacity

Manure storage	Daily manure accumulation (gal or tons)	Monthly manure accumulation (gal or tons)	Existing manure storage capacity (gal, tons)	Days storage
1	399 gal	12,150 gal	72,450 gal	182
2	2,744	83,475	430,000a	157
TOTAL	3,143	95,625	493,900	

a Assumed value for this example.

"D" Worksheet - Labor, Equipment and Cropping Time-Line

Worksheet D helps you schedule times to apply manure when soil and crop conditions are appropriate. Table 4 gives the average number of days available for land application on various crops based on typical Indiana weather and soil conditions. Adjust the "Suitable periods" and "Number of days" based on your experiences with each specific farm field.

Mark with "x" the times when labor, manure application equipment or land are not available for applying manure. While planning manure application, try to minimize compacting soils, ruts in fields, and interference with the crop program.

Worksheet D. Field availability for application

"X" indicates the field is unavailable.

Note:Fields 3 and 4 are too steep for spreading manure on frozen ground.

```
Field #  Crop    Oct Nov Dec  Jan  Feb Mar Apr May Jun  Jul  Aug Sep
-------------------------------------------------------------------
  1     Corn     xxx                          xxxxxxxxxxxxxxxxxxxx
  2     Corn     xxx                          xxxxxxxxxxxxxxxxxxxx
  3     Beans             xxxxxxxxxxxxxx            xxxxxxxxxxxxxxxxx
  4    Pasture            xxxxxxxxxxxxxx
-------------------------------------------------------------------
```

"E" Worksheets - Manure Budget

Several factors affect fertilizing crops with stored manure. The following guidelines are suggested:

* Empty storages often enough to avoid having to apply manure during poor weather or soil conditions when pollution potential is higher.

* Empty storages while soil and crop conditions are suitable.

* Because crops typically need a different N-P-K balance than is in manure, coordinate manure and commercial fertilizer applications to meet crop needs.

* Match total N application to what plants will use to avoid excess nitrates leaching into ground water.

* Avoid excess P and K applications and soil levels as much as possible.

Non-legumes generally need more manure to satisfy their N needs than for their P and K needs. Legumes can generate the N they need; but if N is applied, with manure or commercial fertilizers, the plants will use that N up to the amount listed in Table 1 as "N crop use/year."

Think of your manure storages as a checkbook for budgeting. Livestock deposit manure every day. You spend it seasonally to fertilize crops.

A "rich" operation

If your operation is "rich," it has animal manure nutrients filling up the "checkbook" as fast or faster than you can spend it on crops. You will, generally, apply manure to satisfy crop N needs, and will therefore over-apply P and K. Rotate fields receiving manure to avoid P and K build-up. It is best to apply P and K at about the rates based on results of your soil and manure testing, or in Table 1, if possible. Contract with neighbors to accept some of your manure on their fields if your manure nutrient supply exceeds what you can usefully put on your crops.

Soil P tests will increase about 4 ppm per year. Applying manure to fields 1, 2, and 3 will supply adequate P and build up soil levels. Over the course of 5-6 years, the P soil levels should be high enough that only maintenance rates are needed. Continued high applications could result in excessive soil tests.

A "poor" operation

If your operation is "poor" relative to crop needs, it needs more nutrients. The manure nutrients going into the checkbook and plant demands for nutrients exceed your supply each year. Commercial fertilizers make up the difference. Usually, manure is used to meet P and K needs, and supplemental N is added to meet N needs.

Even if you are manure "poor," if some fields are low in P and K, consider meeting plant N needs with manure on those fields; the extra nutrients will build up soil P and K levels for future crops. Since it is unlikely that both P and K are balanced exactly with crop needs, rotate fields with this option, too.

The following manure budget for our example illustrates the deposit/withdrawal system. The cropping year begins on October 1 with a certain amount of manure on hand (in storage). The animals increase the balance each month by a known amount of manure; withdrawals are made to apply manure to fields. Our example farmer can spread up to 82,500 gal/day (10 hr/day x 3 loads/hr x 2,750 gal/load).

To start Worksheet E: List the storages, copy the manure added/month (gal/mo) from Worksheet B .1, copy storage capacities (gal) from Worksheet C, and the amount of manure in the storages at the beginning of the manure/crop year. We have assumed the capacities shown. Manure in storage can be calculated or estimated from the manure depth, see Conversions and Volumes.

The manure in a storage at the end of a month is:

```
The balance on the first of the month
+ Manure added/month
- Amount removed and spread during the
   month.
```

Example.

Storage #1: Manure on hand at the beginning of month (October) - 52,500 gal. Manure added during month = 12,150 gal. If none is removed during the month, total is 64,650 gal, which does not leave enough room to complete storage for next month (maximum storage capacity for #1 is 72,450 gal).

Note that all the storages in the example, Worksheet E.1, will be at least nearly full by the end of October, which is to be expected. Almost half the year's manure will be spread in October-November. The storages must go into the winter essentially empty to have enough capacity before the spring spreading season. The other half of all the manure will be spread in April-May.

Which manure on which field?

Using Best Management Practices # AS, A10, B6, C1, D2, D8, and D10 (see Appendix):

* Field #2 has a high N demand (Worksheet A.4) and the lowest soil P and K levels (Worksheet A. 1).

* Field #1 also has a high N demand, but has a slightly higher soil P level, making this field the second priority for manure applications this year.

* Field #3, with soybeans this year, and the pasture (Field 4) if necessary, would receive the more dilute manure.

* The most concentrated manure, from storage #2 (Worksheet B .2), is spread first on Field #2 then field #1 because of its high nutrient demand.

* Storage #1, which holds the least concentrated manure, was applied onto the legumes in field #3 to supply P and K.

Example:

Storage #2 and Field #2: Empty the storage in October and November. Assume manure volume applied was 492,250 gal (407,000 + 85,250). Using concentrations from Worksheet B .2 calculations, N in manure was 492,250 x 22.6/1000 = 11,125 lb N; plant demand (A.4) is 11,200 lb N/year. This manure also held 12,995 lb P, over twice the annual 5,600 lb need, and 12,503 lb K2O, about 20% above the annual need of 10,400 lb.

Worksheet E.1 Nutrient budget. All volumes in gallons. Year 1 in rotation

Working Days from Table 4* Max. manure handled = (Working days x 10 hr x 3 loads/hr x 2750 gal/load)/1000

Storage #	Manure Add/ month	Storage capacity	on hand Sep30	Manure inventory at END of each month: Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	12,150	72,450	52,500	6,900	8,050	20,200	32,350	44,500	56,650	5,550	17,700	29,850	42,000	54,150	66,300
2	83,475	430,000	330,000	6,475	4,700	88,175	171,650	255,125	338,600	6,825	7,800	91,275	174,750	258,225	341,700
Working days available				20	17	7	2	3	5	11	16	21	23	24	19
*Max. manure handled/month (thous of gal)				1,650	1,402	577	165	247	412	907	1,320	1,732	1,897	1,980	1,567
Manure Applied															
Field #1 Storage#/Vol. Applied										2/415,250	2/33,000				
Field #2 Storage #/Vol. Applied				2/407,000	2/85,250										
Field #3 Storage #/Vol. Applied				1/57,750	1/11,000					1/63,250	2/49,500				
Field #4 Storage #/Vol. Applied															
Total Vol. hauled/month				464,750	96,250					478,500	82,500				

Worksheet E.2. Summary, by field, for year-1 in rotation

Example:

In Worksheet A.3., Avail. N for Yr-1 (second column in the table), Field #1 needs 190 lb/ac N. From Worksheet A.1., Field 1 is 60 acres (column 2). Total field needs, Worksheet A.4., = 190 lb/ac x 60 ac = 11,400 lb N for Field #1.

In Worksheet El., looking across from Field #1 for all 12 months, there was no manure put on Field #1 from Storage #1. On Field #1, manure from storage #2 was put on in April (415,250 gal) and May (33,000 gal).

In the Worksheet below, in the column headed "Vol.", the volume of manure put on Field #1 from Storage #1 = 0. The volume for Field #1, Storage #2 was 448,250 gal.

The nutrient concentrations for Storage #2 manure are listed in Worksheet B .2. The manure contains 22.6 lb N, 26.4 lb P, and 25.4 lb K per 1000 gal. Multiply the manure volume (448,250) times the concentrations to find 10,130 lb N, 11,834 lb P2O5, and 11,386 lb K2O.

After finding the total N applied to Field #1 from Storage #2, compare the total (10,130 lb) N with the required N (11,400 lb). Additional commercial fertilizer will be needed (1,270 lb N). This could be applied with a starter fertilizer.

Crop	Vol.	Field #1 (60 Ac) N	P2O5	K2O	Vol.	Field #2 (80 Ac) N	P2O5	K2O
		---lb/field---				---lb/field---		
Crop Needs (from Worksheet A.3)	----	11,400	3,600	8,700	----	11,200	5,600	10,400
Nutrient Applied, lb (from Worksheets B.2 & E.1)								
Storage #1	0	0	0	0	#1 0	0	0	0
Storage #2	448,250	10,130	11,834	11,386	#2 492,250	11,125	12,995	12,503
TOTAL		10,130	11,834	11,386	TOTAL	11,125	12,995	12,503
Fertilizer needed; Total lb		1,270	0	0		75	0	0
(Excess) Total lb.		----	(8,234)	(2,686)		----	(7,395)	(2,103)

Crop	Vol	Field #3 (60 Ac) N	P2O5	K2O	Vol.	Field #4 (20 Ac) N	P2O	K2O
Nutrient Applied								
Storage #1	132,000	1,737	2,038	2,152	#1			
Storage #2	49,500	1,119	1,307	1,257	#2 0	0	0	0
TOTAL		2,856	3,345	43,409	TOTAL			
Fertilizer needed; Total lb		5,544	0	3,494				
(Excess) Total lb.			(45)*					

* () indicates application m excess 0 crop needs.

THE YEARLY PLAN - MAKING DECISIONS

In our example, crops were selected for three-year rotations on fields expected to receive manure. Three major reasons suggest planning for at least three years or whatever your crop rotation is:

1. A three-year plan exposes trends in nutrient levels. Note in Worksheet A.4 that nitrogen needs for these fields were reduced the second year, but phosphorus and potassium levels were about constant.

2. If manure is applied to satisfy crop N needs, usually P and K are over applied. The calculations show where P and K are available for future crops without buying commercial fertilizer. Planning helps maximize the dollar value of the manure!

3. Planning (and calculating) three nutrient budgets at once takes less time than doing each one separately each year. You can readily modify the budgets or add more fields if necessary.

In our example, manure was added to fields needing the most crop nutrients. Field #2 received manure first, because of its lower P and K soil tests and need for nitrogen. The most concentrated manure (storage #2) was applied to Field #1 and Field #2. More dilute manures were applied to the bean field, Field #3, and, was not needed for the pasture (Field #4). Only the P and K credit can be assumed for fertilizer savings with legume crops.

It was necessary in this example to empty the manure pits by the end of November to have enough winter storage capacity (December through March). Some manure might be applied in March, but it is most desirable to apply in April and May when field conditions are optimal.

Caution: Limited storage and limited manure-spreading capacity make it very difficult to fulfill a manure application schedule on the fields unless ideal weather conditions exist. Greater storage capacity allows more scheduling flexibility. Field spreading may be impossible during abnormally wet weather if soil won't support application equipment.

Summarize the volumes of manure from each source applied on each field in Worksheet E.2. Based on manure analyses from your farm, or the averages listed in Appendix Table 2, list the total amount of nutrients (Avail. N, P2O5, and K2O) supplied by the manure and compare it with the total amount required by the field (from work-sheet Table A.3). Determine if commercial fertilizer nutrients are needed in the field.

In this example, P and K requirements were in excess for Fields #1 and #2 with N requirement met on Field #2 with manure application. In Field #3, additional K2O from commercial sources is needed and since no manure was applied to Field #4, additional N from commercial sources is required.

SUMMARY

This worksheet approach to developing a manure management plan can help you evaluate manure applications to cropland. It is not intended to "automate" decision making, to recommend specific practices, or to replace computer software or crop consultants. Rather, it is to help the conscientious producer better utilize the value of available maure resources. The specifics of each farm, crop rotation, and set of management objectives must still be weighed. Decisions by the producer will fit the farm's specifics into workable manure "budgets."

The following Best Management Practices (BMPs) give you valuable guidelines on utilizing manure nutrients efficiently in cropping programs without negatively impacting the environment. Refer to the extension publications listed on page 28 in this publication for more detail on additional aspects of swine manure management.

BEST MANAGEMENT PRACTICES

A. Nutrient Management

A1. Reduce chemical fertilizer applied to a field by the corresponding amount of manure nutrients applied.

A2. Keep a record on each field of manure and chemical fertilizer applications, crop information, and soil and manure test results.

A3. Test the soil in each field for P, K and other nutrient levels, pH and cation exchange capacity (CEC). Follow a soil testing routine recommended by the Cooperative Extension Service or a crop consultant or fertilizer dealer.

A4. Test manure for TKN, NH4-N, P, K, and dry matter initially while emptying a storage. Use an on-farm quick test for available N content every 10 or so loads and adjust application rate if necessary. After manure test results are generally stable, use quick tests on a few representative loads each year. Note: Available N in storage = NH4-N + 0.35 x (TKN - NH4); where 0.35 is a typical mineralization value for Indiana.

A5. Apply manure uniformly with calibrated equipment. Check calibration routinely. A6. Use the nutrients carried in runoff that has contacted manure.

* Treat runoff from feedlots, animal exercise or handling areas, etc., as manure. Provide a settling basin to greatly reduce the solids suspended in the water.

*Maintain grassed buffer areas to filter out solids and absorb nutrients at points where field runoff may occur.

A7. Nitrification Inhibitors in liquid manure-injection systems can reduce nitrogen losses. xblb

In coarse soils all year long. In all soils in fall and summer. In fine or medium texture soils with high water table in winter and spring. xble

A8. An economic and efficient nitrogen benefit from manure is to apply a nitrification inhibitor and manure at a rate to meet the N crop requirement.

A9. In general it takes 5 lb P2O5 to increase soil P test by 1 ppm and 1.75 lb K2O to increase soil K test by 1 ppm. Soils low in these nutrients can be "built up" to recommended levels with extra manure nutrients.

A10. To prevent excessive P and K build-up, rotate manure applications to other fields, or reduce manure application to meet the most limiting nutrient requirement (generally P) and supplement with commercial fertilizer.

B. Crop Factors

B1. Base crop fertilizer needs on realistic yield goals. Deduct nitrogen credit from last year's legume from this year's fertilizer requirements. For the current crop year, estimate N contributions from:

* Manure. See Worksheet B.2 or the computer programs, AMANURE, MBUDGET.

* Legumes. See Table 1.

B2. Use commercial fertilizer only when manure does not meet crop needs.

B3. Apply fertilizer with proper timing and placement for maximum plant utilization, i.e., in the spring about two weeks before planting.

B4. Add a nitrification inhibitor (e.g. N Serve) to stabilize N before: xblb * Injecting manure on poorly drained, fine-textured soils. * Injecting high-N manure in the summer or fall. xble

B5. Incorporate manure to reduce N loss and manure runoff.

B6. Put manure on non-legume crops as a first priority.

B7. When necessary, surface-apply manure over fall cover crops or surface residues rather than tilled soil to minimize runoff.

B8. During the summer, broadcast manure on pastures, where nutrients can be used immediately or inject on harvested wheat fields with an inhibitor.

C. Soil Factors

C1. Apply manure to fields with the lowest soil test.

C2. Avoid applying manure to wet soils to reduce compaction, runoff, denitrification and leaching.

C3. Apply manure in the fall (possibly with an inhibitor) if compaction appears to be a prevalent problem with the soil.

C4. Apply manure to sandy soil near planting time to minimize nitrate leaching. Applying smaller amounts of N more often rather than a large amount at one time minimizes leaching.

C5. Add N-enrichment (anhydrous ammonia or urea) when incorporating manure at lower application rates to balance nutrients and meet crop needs.

C6. Apply manure in the fall after the soil has cooled to 500F or less, or add a nitrification inhibitor.

D. Which Manure Where?

Dl. Apply manure with the highest N content in the spring or fall; apply the lowest N manure in summer.

D2. Haul the highest nutrient content manure to the farthest fields.

D3. Apply lowest nutrient content manure to closest fields. If possible, irrigate with runoff water and lagoon water.

D4. Apply the highest nutrient manure to corn silage or other crops with high nutrient demands.

D5. Apply the highest nutrient manure to legumes only if you have no better use for the N content, because legumes produce their own N if none is provided.

D6. To avoid N leaching to ground water, limit N applications on sandy soils, and avoid soils with high water tables.

D7. Do not apply more N than crop needs.

D8. Apply high-P manure to fields with lowest P soil test levels.

D9. If manure is applied to the same fields every year, alternate each year between high-nutrient and low-nutrient manures if possible.

Dl0. Apply most concentrated manures to fields with high nutrient demand.

E. Site and Environment Factors

E1. Inject manure, or incorporate solid manure, the same day as surface spreading to minimize nitrogen losses, odors, and runoff potential.

E2. Applying manure on erosive soils, delay application and tillage until spring.

E3. Incorporate liquid manure applied in karst areas.

E4. Incorporate manure on nonerosive soils in fall to retain nutrients.

E5. Apply manure on frozen or snow-covered soil only if:

* It is necessary to empty storage.
* The land is not subject to flooding.

* Land slope is less than 2% or erosion control practices are in place (examples: terraces, conservation tillage, cover crops, contour farming). Note: Increase manure-spreading separation distances by 100% where runoff may occur. E6. Surface apply manures in highly erodable land (HEL) to cover crops, res-idue cover or consistent with erosion control practices.

F. Additional Recommendations:

Fl. Check with local city and county officials for applicable regulations on zoning, health, building code, set back distances, etc.

F2. Unless manure is incorporated by the end of the working day (and before rainfall occurs), do not apply manure within:

* 50 ft of road ditches,

* 100 ft from a surface tile inlet, sinkhole, intermittent stream, drainage ditch, or other body of water.

Note: Increase manure-spreading separation distances by 100% where runoff may occur.

F3. Do not apply manure within 200 ft of a water well.

F4. Do not apply manure on a floodplain during high water periods and not at other times unless manure is incorporated by the end of the working day, or unless there is sufficient residue or crop cover to protect the soil from erosion.

F5. Do not surface-spread liquid manure on slopes steeper than 6% unless there is sufficient residue or crop cover to prevent runoff, or on frozen or snow-covered slopes steeper than 2%, because of the risk of runoff, unless incorporated into the soil by the end of the working day.

Table 1. Example crop nutrient requirement*

N, P2O5, and K2O; soil concentrations and application amounts are in pounds per acre. Soil-P and soil-K reduce the amount of fertilizer-P and fertilizer-K needed.

Crop	ID	Expected yield	N* credit N	Use for Soil P (ppm) equal to or greater than: 0-5 pounds P2O5 per acre	6-10	11-30	31-35	36-40	41-45	>46	Use for Soil K (ppm) equal to or greater than: 0-40 pounds K2O per acre	41-50	51-60	61-70	71-80	81-90	91-150	151-300 (CEC of 10)	>300
Corn/Gr_sorghum	C110	80 110bu	110	90	60	40	20	0	0	0	165	145	125	105	85	65	45	30	0
Corn/Gr_sorghum	C125	111 125bu	140	95	70	45	20	0	0	0	170	150	130	110	90	70	50	30	0
Corn/Gr_sorghum	C150	126 150bu	160	100	75	50	25	0	0	0	180	160	140	120	100	80	60	35	0
Corn/Gr_sorghum	C175	151 175bu	190	110	85	60	30	0	0	0	185	165	145	125	105	85	65	40	0
Corn/Gr_sorghum	C300	176 300bu	220	115	90	65	35	0	0	0	190	170	150	130	110	90	70	40	0
Corn_Silage	CS20	10 20tons	140	115	90	65	35	0	0	0	300	280	260	240	220	200	180	110	0
Corn_Silage	CS25	21 25 tons	180	135	110	85	45	0	0	0	300	300	300	290	270	250	230	140	0
Corn_Silage	CS30	26 30 tons	220	150	125	100	50	0	0	0	300	300	300	300	300	280	260	160	0
Soybeans	S40	30 40bu	140	30 80	55	30	15	0	0	0	195	175	155	135	115	95	75	40	0
Soybeans	S50	41 50bu	180	30 90	65	40	20	0	0	0	210	190	170	150	130	110	90	45	0
Soybeans	S60	51 60bu	220	30 100	75	50	25	0	0	0	225	205	185	165	145	125	105	50	0
Soybeans	S100	61 100bu	250	30 105	80	55	30	0	0	0	240	220	200	180	160	140	120	60	0
Wheat/Rye*	W45	30 45 bu	40	125	100	75	50	25	10	0	155	135	115	95	75	55	35	20	0
Wheat/Rye*	W55	46 55bu	40	130	105	80	55	30	15	0	160	140	120	100	80	60	40	25	0
Wheat/Rye*	W65	56 65bu	60	135	110	85	60	35	20	0	160	140	120	100	80	60	42	25	0
Wheat/Rye*	W100	66 100bu	75	145	120	95	70	45	20	0	165	145	125	105	85	65	45	30	0
Oats/Barley*	B85	70 85 bu	40	125	100	75	50	25	10	0	155	135	115	95	75	55	35	20	0
Oats/Barley*	B115	86 115 bu	40	130	105	80	55	30	15	0	160	140	120	100	80	60	40	25	0
Oats/Barle*	B150	116 150bu	60	135	110	85	60	35	20	0	160	140	120	100	80	60	45	30	0
Grass-Hay	GH2	1 2tons	75	125	100	70	25	25	15	0	60	55	50	45	40	35	30	15	0
Grass-Hay	GH4	3 4tons	140	150	125	100	50	50	25	0	120	110	100	90	80	70	60	50	0
Grass-Hay	GH6	5 6tons	210	180	155	130	80	80	40	0	180	165	150	135	120	105	90	75	0
Grass-Pasture	GP2	1 2tons	55	125	100	70	25	25	15	0	60	30	25	20	10	0	0	0	0
Grass-Pasture	GP4	3 4tons	100	150	125	100	50	50	25	0	120	55	50	45	20	0	0	0	0
Grass-Pasture	GP6	4 6tons	150	180	155	130	80	80	40	0	180	85	75	65	30	0	0	0	0
Grass/Legume_Hay	LH2	1 2tons	115	40 125	95	70	25	25	15	0	240	220	200	180	160	140	120	60	0
Grass/Legume_Hay	LH4	2 4tons	225	40 150	125	100	50	50	25	0	340	320	300	280	260	240	220	110	0
Grass/Legume_Hay	LH6	4 6tons	335	40 180	155	130	80	80	40	0	440	420	400	380	360	340	320	160	0
Grass/Legume_Hay	LH8	6 8tons	450	40 200	180	155	105	105	50	0	540	520	500	480	460	440	420	210	0
Grass/Leg_Pasture	LP2	1 2tons	100	40 125	100	70	25	25	15	0	120	110	100	90	80	70	60	30	0
Grass/Leg_Pasture	LP4	2 4tons	210	40 150	125	100	50	50	25	0	170	160	150	140	130	120	110	55	0
Grass/Leg_Pasture	LP6	4 6tons	320	40 180	155	130	80	80	40	0	220	210	200	190	180	170	160	80	0
Grass/Leg_Pasture	LP8	6 8tons	430	40 200	180	155	105	105	50	0	270	260	250	240	230	220	210	105	0
Tobacco	T1.5	0 1.5 tons	250	175	120	75	75	50	25	0	350	300	250	200	150	100	75	40	0
Summer_Ann_Forag	SF3	0 3tons	110	100	70	50	30	20	10	0	100	85	70	60	50	25	0	0	0
Summer_Ann_Forag	SF5	3 5 tons	165	120	90	60	40	20	10	0	150	135	120	95	70	35	0	0	0
Summer_Ann_Forag	SF7	5 7tons	190	130	100	70	50	30	10	0	180	160	140	115	90	45	0	0	0

Table 2. Swine Manure Storage Requirements and Nutrients Produced.

Values are based on building capacity, e.g. number of farrowing stalls, and include typical dilution and bedding. Data are from nutrient measurements in many storages. Additional N can be lost during transport, distribution, and application.

Storage type	Sow and litter	Nursery pig (35 lb)	Grow-Finish pig (160 lb)	Gestating sow (370 Lb)	Farrow-to-Finish per sow	per pig mkt'd	Feeder pigs sold
Daily Manure Storage Required							
Solid, lb/day	13.2	1.3	5.8	5.5	47.0	2.6	0.7
Liquid, gal/day	3.8	0.4	1.4	1.2	12.5	0.7	0.18
Lagoon, gal/day	5.8	0.6	2.6	2.5	21.2	1.2	0.3
Yearly Manure Storage Required							
Solid, ton/yr	2.4	0.24	1.1	1.0	8.6	0.5	0.13
Liquid, 1000 gal/yr	IA	0.13	0.53	0.53	4.5	0.25	0.07
Lagoon, 1000 gal/yr	2.1	0.22	0.95	0.9	7.7	0.43	0.11
Manure Nutrients							
Solid manure			Pounds of nutrient/ton of manure				
Avail N, lb	5.4	7.9	9.5	6A	8.7	8.7	6.6
P2O5	6.0	8.0	9.0	7.0	8.5	8.5	7.0
K2O	4.0	4.0	5.0	5.0	4.8	4.8	4.4
Liquid manure			Pounds of nutrient/1000 gal of manure				
Avail N, lb	10.0	18.0	23.8	16.6	20.5	20.5	14.8
P2O5	12.0	19.0	26A	25.0	23.3	20.0	18.4
K2O	11.0	22.0	25.4	24.0	22.6	20.0	18.7
Lagoon			Pounds of nutrients/1000 gal manure				
Avail N, lb	2.9	3.7	4.7	3.3	4.3	4.3	3.3
P2O5	1.5	3.0	3.0	3.5	2.9	2.7	2.7
K2O	1.5	3.0	4.0	4.0	3.7	2.9	2.9

Table 3. Application Factors - % Available N alter handling, spreading, field and soil losses.

Data on stored manure include losses during collection and storage. This table accounts for the losses between storage and plant nitrogen use. A nitrification inhibitor reduces N losses following injection of liquids or incorporation of solids.

Type of application	No inhibitor	With nitrification inhibitor
Irrigated	50%	Not recommended
Surface spread	60%	Not recommended
Injected or incorporated within 24 hours of spreading	80%	95%

Table 4. When to apply livestock manure to Indiana crops.*

		Periods to apply manure			Number of days for applying manure With spreading equipment North Indiana		South Indiana		
Months	Dates	Beans/ corn	Small grain	Legume/ or grass	biweekly	total	biweekly	total	With irrigation
Jan	1-14	d	b	d	1	2	1	2	--
	16-31	d	b	d	1		1		--
Feb	1-15	d	b	x	1	3	2	5	--
	16-28	d	b	x	2		3		--
Mar	1-15	x	x	--	2	5	3	7	--
	16-31	x	x	--	3	5	4		6
Apr	1-15	x	--	--	5	11	6	13	9
	16-30	--	--	--	6		7		10
May	1-15	a	--	--	8	16	7	16	10
	16-31	a	--	--	8		9		--
Jun	1-15	a	--	--	10	21	10	21	12
	16-30	--	--	c	11		11		
Jul	1-15	--	--	c	12	23	12	23	14
	16-31	--	--	c	11		11		15
Aug	1-15	--	x	c	12	24	11	24	15
	16-31	d	b	d	2		3		--

Key to table symbols:
x. Typical application period.
a. Apply with injection or irrigate until corn is 2' high.
b. Apply up to 25% of annual crop needs to dormant wheat in winter.
c. Apply up to 25% annual crop needs to grass immediately after harvest. If grass is pastured, light applications are suitable all year.
d. See BMP's for spreading on sloping or frozen ground and near water.
*These are long term averages from Indiana Annual Crop and Livestock Summary. 1975. Actual periods vary by soil type, topography, and annual weather.

CONVERSIONS AND VOLUMES

* Parts per million (ppm) X 2 = lb/acre
* .5 lb P2O5 increases soil P test value by 1 ppm
* lb P2O5 X 0.44 = lb P
* lb P x 2.29=lb P2O5

* 1.75 lb K2O increases soil K test value by 1 ppm
* lb K2O x 0.83=lb K
* lb K x 1.2=lb K2O
* Divide ppm by 10,000 =

* Divide lb/ton by 20 =
* Divide lb/1000-gal by 83 =
* Typical density of swine manure = 62 pounds per cubic foot
Tons x 32.26 = cu ft
Cu ft x 0.0310= tons
Tons x 241 S gal
Gal x 0.00414 =tons

Examples:

80 lb nitrogen per ton/20 =4% nitrogen. 100 tons manure occupies about 3226 cu ft. Manure in 3500 gal tank weighs about 14.5 tons.

Volumes

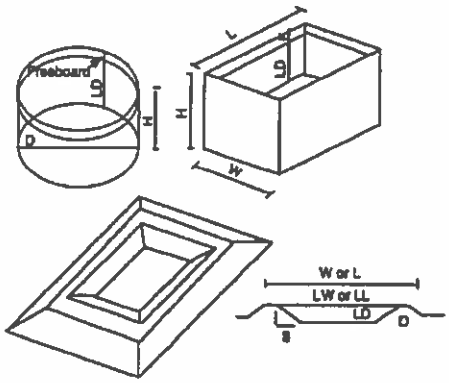
* "Freeboard" is space in a storage that is designed to not store manure. It is often one foot or two feet o f clear space between Liquid Depth, LD (maximum manure depth), and total height or earth depth, H, to prevent the storage from overflowing.

* if a rectangular tank is W ft wide, L ft long, and its sides are H ft high, and required free board is F ft:

Maximum manure depth =Liquid Depth = Height - Freeboard;

LD = H - F. Storage Volume=W x L x LD = W x L x (H-F) cu ft

```
*  if a circular tank has a diameter of D ft and sides that are H ft high,
and required freeboard is F ft

      Maximum manure depth = Liquid Depth = Height - Freeboard; LD = H - F.

      Storage Volume= 3.14 x D x D x LD/4 cu ft = 0.785 x D x D x LD. (3.14 is "Pi")

* If an earthen storage is W ft wide, L ft long, H ft inside depth,
freeboard is F ft and the sides slope S ft horizontal to 1 ft vertical
(manure surface is smaller than the top opening because of the sloping
sides):

      Liquid Width = LW = W-2 x F x S. Liquid depth= LD = H-F.

      Liquid Length= LL = L-2 x F x S.

      Storage volume = (LW x LL x LD) + (4 x S x S x LD x LD x LD/3) - (S x LD x LD) x (LW + LL).

Hint: a. Multiply: (LWxLLxLD).
      b. Multiply: (4xSxSxLDxLDxLD)
       and divide by 3.
      c.Add the second term, b,
       to the first term, a: c. =a. +b.
      d. Multiply (SxLDxLD).
      e. Add (LW+LL).
      f.Multiply the two terms,
        f.=d. x e.
      g. Volume = c. - f.
```



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MBUDGET, 1994; Essentially a compiled spreadsheet alternative to the worksheets in this publication; handles up to seven fields and up to seven manure sources; phone Purdue's Farm Building Plan Service at 317/494-1172. $15.

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GRID SOIL SAMPLING FOR MANURE APPLICATION
CASE STUDY #3

HOG FARM #1: LIQUID MANURE

Situation: This hog operation in southeast Minnesota has 1.0 million gallons of swine finishing liquid manure available annually, with an analysis of:

- Total N = 65 lbs/1000 gal
  - 31 lbs/1000 gal NH_4-N
  - 34 lbs/1000 gal organic N
- P_2O_5 = 35 lbs/1000 gal
- K_2O = 31 lbs/1000 gal

Photo: USDA-ARS

The field for this case study is 276 acres. The cropping system is two years of grain corn followed by one year of soybeans. Manure is knife injected the first and second years of corn after soybeans. This case analyzes alternative manure application strategies for the first year of corn.

CROP NUTRIENT NEEDS AND MANURE NUTRIENT AVAILABILITY

The crop nutrient needs for this field were from University of Minnesota guidelines in UM Extension bulletin 3790, **Fertilizing Corn in Minnesota**, 2006 or UM Extension bulletin 06240, **Fertilizer Guidelines for Agronomic Crops in Minnesota**, 2011. Use the most recent guidelines, since publications are updated with new research. Publications are available at: *http://www.extension.umn.edu/nutrient-management*

Nitrogen: The nitrogen (N) rate range is determined by the N price/crop value ratio. If we use the lowest N Price/Crop Value ratio (0.05), 120 lb N/acre falls near the center of the guideline range for corn after soybeans. For hog manure, knife injected, N availability is 70% the first year, so 172 lb manure N would be needed. For manure nutrient availability see **Manure Management in Minnesota**, UM Extension bulletin 03553 from 2007, and **Nitrogen Availability from Liquid Swine and Dairy Manure: Results of On-Farm Trials in Minnesota**, UM Bulletin 08583 from 2008, both available at *http://www.extension.umn.edu/nutrient-management*

Phosphorus (P): Crop P needs are determined from soil test values. A composite soil sample for the whole field (field average) is 27 ppm Bray 1-P, which is in the "Very High" range. In that range, no P applications are needed. However, since we have grid soil sample results mapped for this field (Figure 1), we can see that the P distribution is highly variable, ranging from Low to Very High (3-115 ppm Bray 1-P). A large portion (46%) of the field falls in the Medium to Low category where a P application would be recommended. No P application would likely result in a yield limitation in these Medium to Low testing areas of the field.

www.extension.umn.edu/.../manure.../manure.../

Potassium (K): Crop K needs are also determined from soil test values. The whole field average soil test K is 225 ppm, indicating no K would be needed. There is variability across the field, ranging from 132 to 494 ppm K_2O, following the trends of phosphorus.

COMPARING MANURE APPLICATION OPTIONS

Zonal Application

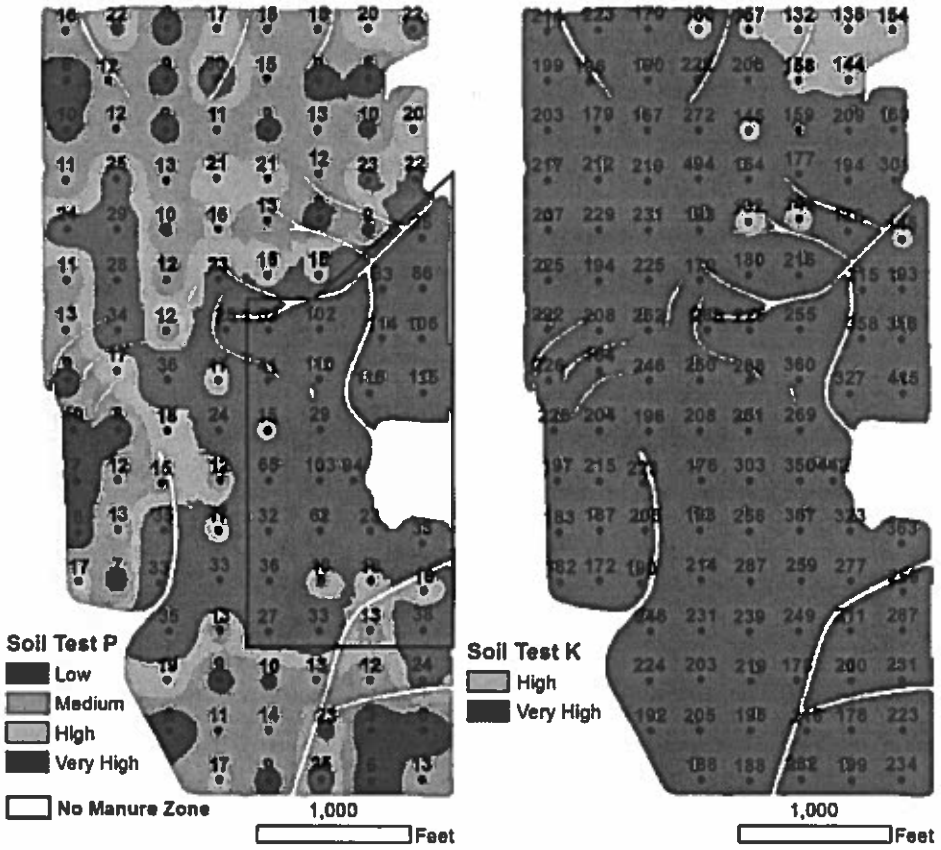

Figure 1. Soil Test P (Bray 1-P) and Soil Test K in ppm with University of Minnesota soil test classes.

Using a grid soil P map the operator can exclude one or more field zones from manure application because of already high P levels. This case study demonstrates the effects on economic returns of excluding a zone composed of 67 acres of high testing P & K grids from manure applications and supplementing with variable rate fertilizer application. Excluding the high P zone, the average P test for the remaining grids is slightly under 16 ppm. For these acres where manure would be applied, the average P need is 45 lb/acre P_2O_5 for broadcast application, or 56 lb/acre manure P_2O_5 equivalent with 80% availability. This manure rate is substantially higher than that determined by a whole-field P-based average, and would likely increase yields in the low P areas of the field while avoiding application in areas where P is not needed. The partial field average soil test K for the same grids is Very High due to past management, so little to no crop response would be expected in year 1 or 2 of corn. By avoiding continued high applications of K we will gradually bring levels down.

The manure exclusion zone in the example above is relatively regular in shape, making it easy to follow in the field. It does not, however, exclude all Very High P testing areas of the field. The producer would need to decide if the increased value of manure from avoiding a larger and more irregular area would be worth the increased management time required in manure application.

N-based vs. P-based Application

We have the option of basing manure application rates on either N or P needs of the crop if we do not exceed the crop N needs and do not over-apply P in sensitive areas. (See the bulletin "Applying Manure in Sensitive Areas", available on-line at *http://www.pca.state.mn.us/index.php/view-document.html?gid=3530*.)

We can compare the expected economic outcomes of the following three manure application rate and area alternatives. The P-based whole-field option is not available, since no P application would be recommended on a field average basis.

Whole-Field Application (no grid sampling)	Zonal Application (with grid sampling)
N-based manure rate	N-based manure rate in manure application zone. N and P fertilizer (variable rate P) in manure exclusion zone.
	P-based manure rate and supplemental N fertilizer in manure application zone. N and P fertilizer (variable rate P) in manure exclusion zone.

The economic comparisons are made using the spreadsheet "What's Manure Worth?" MANURWKST.XLS, available at http://z.umn.edu/manureworth. Data on the farm's manure type, amount, analysis, spreading method and spreading costs, application rates, and nutrient availability, as well as fertilizer costs, crop nutrient needs, acres for spreading, expected yield boost from use of manure instead of fertilizer, and second year nutrient credits are entered to determine the value of manure (total, per acre, and per gallon) under the a specific application rate and method. Additional data for the spreadsheet calculations are shown in Appendix 1.

Results

A comparison of results for the three rate alternatives is found in Table 1. The highest net values of manure per 1000 gallons are the P-based Zonal and N-based Zonal applications. Note that supplemental N would not be required for the Zonal N-based application, except for some starter if desired, and that the extra P would be used by the following year corn crop. Results of the Zonal N application analysis are highlighted in Table 1. The N-based whole-field uniform application would over-apply P in the Very High and High soil test areas of the field, reducing the value of the manure as a fertilizer replacement. Also, this would leave the least amount of manure for application to other fields where it might have more value by being placed where a yield response to P would be more likely and loss of P in runoff less likely.

TABLE 1. ECONOMIC ANALYSIS OF ALTERNATIVE MANURE APPLICATION STRATEGIES.

Manure Application Strategy	N-Based, Whole-Field	N-Based, Zonal	P-Based, Zonal
Manure Application (Acres)	276	209	209
Crop Nutrient Need N - P_2O_5 - K_2O (lbs/acre)	120-0-0	120-45-0	120-45-0
Manure Application Required/Acre (gal/acre)	2700	2700	1600
Manure to be Applied (gal/acre)	3000	3000	2000
Manure-Available Nutrients Applied (lbs/acre)	137-84-84	137-84-84	91-56-56
Net Value of Manure ($/acre)	72	108	82
Net Value of Manure ($/1000 gal)	24	36	41
Manure Remaining After Spreading (gal)	172,000	373,000	582,000

Value of Grid Soil Sampling

The spreadsheet analysis does not account for the increased cost of grid soil sampling. At $10.25 per acre for approximately 2 acre grids, the field-total cost is $2,829. Comparing the N-based whole-field with N-based zonal application shows an increase in the value of the manure by $12 per 1000 gal or $7524 for the 209 acres where manure is to be applied with the zonal application. This does not account for the higher value of the increased yield expected from targeted application of manure P, nor for the value of the remaining manure available for other fields where P and K need may be higher. One grid soil sampling every 3 to 5 years can serve multiple manure applications, reducing the cost substantially on a per-application basis.

Additional Application Considerations

A frequent approach to manure application when land is limiting, is to apply manure at crop P removal rates. This results in higher manure application rates in areas where soil test P would indicate low or no fertilizer P application would be needed but where the crop would remove the added P. This approach would not reduce the in-field P variability or reduce loss of P in runoff unless the highest P testing areas were excluded from manure application. Crop P removal rates are acceptable but may result in lower economic value of the manure. Another frequent approach is to apply manure once at P rates sufficient for two successive years of crops. This is also acceptable, however availability of P in the second year may differ among soil types and be more difficult to predict.

Photo: Stearns SWCD

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ADDITIONAL ENVIRONMENTAL CONSIDERATIONS

In addition to reducing areas of excessive soil test P, other strategies to reduce runoff loss of nutrients should be considered. Manure injection on this farm already reduces the risk of manure and dissolved P in surface runoff.

Nitrogen loss in the nitrate form can also be a risk with liquid swine manure because a high percentage is in the inorganic (ammonium) form. If applied in the fall before soil temperatures drop below 50 degrees F., ammonium can be converted to nitrate and subsequently lost to drainage tile or groundwater the following spring before crops are established. Delaying fall manure or N fertilizer application until soil temperatures fall below 50 degrees F. will conserve the N.

2' Contour Lines and Aerial Image

Most of the soils in this field are on slopes of 0-6%, however there are some slopes of 6-12% and 12-18%, and areas of concentrated flow (see contour map, left). The dominant source of total P reaching water on these slopes with a corn-corn-soybean rotation would be P attached to eroded soil particles. Crop rotations and tillage practices that minimize soil erosion are essential to reducing P pollution of water. Several strategies should be considered:

- Minimize tillage intensity as much as possible.
- Consider structural controls such as terraces, sediment control basins, and filter strips.

The local NRCS/SWCD office and some crop consultants can provide a predicted erosion rate for any combination of slope, crop rotation, and tillage practices using the RUSLE2 model. It is also part of the Minnesota Phosphorus Index available at http://www.mnpi.umn.edu

As an example with the steeper slopes in the northern part of the field, if tillage were fall chisel and spring field cultivate all three years of the corn-corn-soybean rotation, the predicted erosion rates would average 6.1 tons per acre per year assuming 8% slope and 200 foot slope length. Converting to no-till soybeans, spring field cultivate before first year corn, and fall chisel/spring field cultivate before second year corn would reduce rotation average erosion to 4.0 tons per acre per year while maintaining yields, reducing fuel use, and reducing P loss to water.

CONCLUSIONS:

1. Grid soil sampling allows the livestock producer to identify and treat zones of excess and deficiencies for P and K, which may have developed with a history of non-uniform manure applications.
2. Targeting manure and perhaps supplemental fertilizer P and K applications to lower soil test P and K areas of the field will likely result in higher average yields compared to uniform rate applications based on the average soil test value for the field.
3. Excluding zones of excess soil test P from manure application will allow more efficient use of manure on other fields and field areas, increasing the total value of the manure supply.
4. Excluding zones of excess soil test P from manure application will reduce P pollution in runoff, since P in runoff is proportional to soil test P.
5. The choice of crop rotation, manure application method, and tillage practices have a strong influence on loss of P to water.

Appendix 1: Additional information used to calculate the value of manure with the spreadsheet "What's Manure Worth?":

Fertilizer nutrient prices/lb.: N = $0.59, P_2O_5 = $0.54, K_2O = $0.54
Cost of purchased micronutrients/acre: $2.50
N fertilizer application cost avoided: $10.00 for the N-based application strategies.
Dry P_2O_5 and K_2O fertilizer application cost avoided/acre: $5.50 for all strategies where manure applied.
Additional value of micro-nutrients in manure: $0.00 assumed.
Second year nutrient credits/acre for valuation:

- **N-based, whole field = 29-0-0**
- **N-based, Zonal = 29-20-0**
- **P-based, Zonal = 20-5-0**

Manure yield boost value/acre over fertilizer alone: $20.00
Tillage effect of manure application: $0.00
Manure application cost/gallon: $0.015

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GRID SOIL SAMPLING FOR MANURE APPLICATION
CASE STUDY #4

HOG FARM #2: LIQUID MANURE

Situation: This hog operation in southeast Minnesota has 1.0 million gallons of Swine Finishing Liquid Manure available annually, with an analysis of:

- Total N = 46 lbs/1000 gal
  - 36 lbs/1000 gal NH_4-N
  - 10 lbs/1000 gal organic N
- P_2O_5 = 14 lbs/1000 gal
- K_2O = 25 lbs/1000 gal

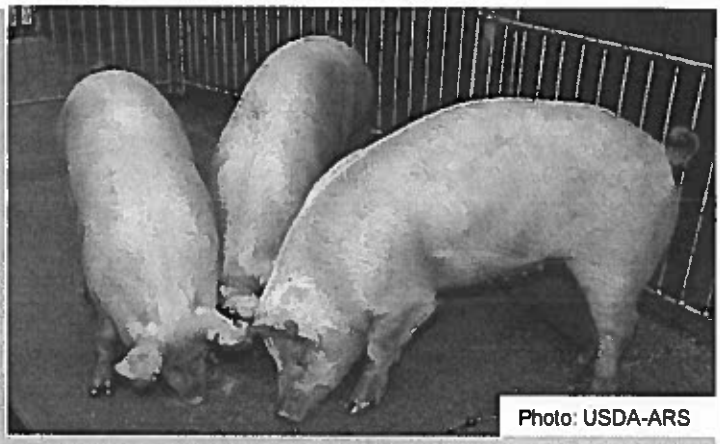

Photo: USDA-ARS

The field for this case study is 157 acres with 1-6% slopes. The cropping system is one year of soybeans followed by two years of grain corn. Manure is knife injected the first and second years of corn after soybeans. The value of manure spreadsheet is used to analyze the **first** year of corn.

CROP NUTRIENT NEEDS AND MANURE NUTRIENT AVAILAILABILITY

The crop nutrient needs for this field were from University of Minnesota guidelines in UM Extension bulletin 3790, **Fertilizing Corn in Minnesota**, 2006 or UM Extension bulletin 06240, **Fertilizer Guidelines for Agronomic Crops in Minnesota**, 2011. Use the most recent guidelines, since publications are updated with new research. Publications are available at: *http://www.extension.umn.edu/nutrient-management*

Nitrogen: The nitrogen (N) rate range is determined by the N price/crop value ratio. If we use the lowest N Price/Crop Value ratio (0.05), 140 lb N/acre falls near the maximum of the guideline range for corn after soybeans. For hog manure, knife injected, N availability is 70% the first year, so 200 lb manure N would be needed. For manure nutrient availability see **Manure Management in Minnesota**, UM Extension bulletin 03553 from 2007, and **Nitrogen Availability from Liquid Swine and Dairy Manure: Results of On-Farm Trials in Minnesota**, UM Bulletin 08583 from 2008.

Phosphorus (P): Crop P needs are determined from soil test values. A composite soil sample for the whole field (field average) is 33 ppm Bray 1-P, which is in the "Very High" range. In that range, no P applications are needed. However, since we have grid soil sample results mapped for this field (Figure 1), we can see that the P distribution is highly variable, ranging from Low to Very High (7-98 ppm Bray 1-P). For the acres falling in the Medium to Low P category a P application would be recommended.

Potassium (K): Crop K needs are also determined from soil test values. The whole field average soil test K is 194 ppm, also in the Very High range, indicating no need for additional K. There is variability across the field, ranging from 121 to 360 ppm K following the trends of P, but with no areas below the High category.

COMPARING MANURE APPLICATION OPTIONS

Zonal Application

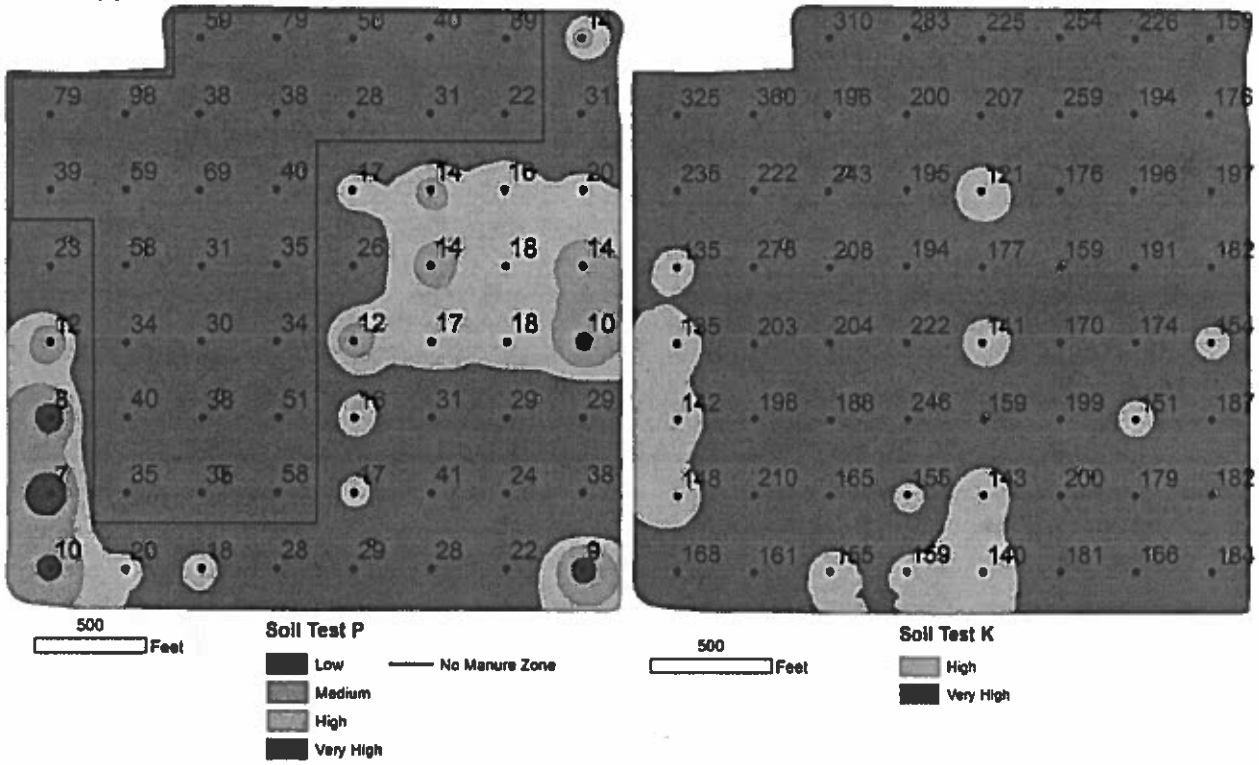

Figure 1. Soil Test P (Bray 1-P) and Soil Test K in ppm with University of Minnesota soil test classes.

Using a grid soil P map the operator can exclude one or more field zones from manure application because of already high P levels. In this case we demonstrate the effects on economic returns of excluding a contiguous zone composed of 71 acres of soil test values ranging from 22-98 ppm Bray 1-P (see Figure 1). The average P test for the remaining grids is less than 21 ppm, putting it in the High category. For these acres where manure would be applied, the average P need is 15 lb/acre P_2O_5 for broadcast application, or 19 lb/acre manure P_2O_5 equivalent with 80% availability. The lowest P testing areas in that zone would benefit from a yet higher P application rate. The partial field average soil test K for the same grids is 166 ppm, still in the Very High category and calling for no added K.

N-based vs. P-based Application
We have the option of basing manure application rates on either N or P needs of the crop if we do not exceed the crop N needs and do not over-apply P in sensitive areas. (See the bulletin "Applying Manure in Sensitive Areas", available on-line at http://www.pca.state.mn.us/index.php/view-document.html?gid=3530.)

We can compare the expected economic outcomes of the following three manure application rate and area alternatives. P-based whole field application is not an option because the field-average P test results in a guideline of no P needed.

Whole-Field Application (no grid sampling)	Zonal Application (with grid sampling)
N-based manure rate	N-based manure and precision P&K fertilizer in manure application zone. N fertilizer in manure exclusion zone.
	P-based manure rate plus supplemental N in manure application zone. N fertilizer in manure exclusion zone.

The economic comparisons are made using the spreadsheet "What's Manure Worth?" MANURWKST.XLS, available at: http://z.umn.edu/manureworth. A comparison of results for the three rate alternatives is found in Table 1. For the remaining data needed to complete the spreadsheet, see Appendix 1.

The liquid swine manure on this farm is high in available N relative to P and can meet the N needs of the crop at less than 5,000 gallons per acre.

Our three options are:

1. N-Based Whole Field for a maximum amount of manure to be applied. It produces the lowest net value of manure per acre because manure P & K is being applied in large areas where it is not needed.

2. N-Based Zonal where we have a crop nutrient need for P. There are smaller areas within the application zone where the N-based application level of P exceeds the recommended rate. However, crop removal (63 lb/acre P_2O_5 for 175 bu./acre corn) will exceed the N-Based manure application rate of P with this high N analysis manure and the soil test P values will decline gradually over years. If there is an increased application cost with lower manure application rates, the producer might choose this N-Based Zonal rate.

3. P-Based Zonal where less manure is applied per acre compared to N-Based applications. The Net Value of manure per 1000 gallons is highest for this alternative, and the recommended amount of P is applied for the average of the manure application zone. This alternative would leave the most amount of manure for application to other fields where it would have more value if placed in lower soil nutrient testing areas. Equipment capabilities will have to be considered since 1400 gallons per acre may be too low for older application equipment to reliably apply. If this alternative is chosen, the producer should consider variable rate P fertilizer supplement for the Medium and Low testing areas of the field, as well as the necessary N supplemental fertilizer.

TABLE 1. ECONOMIC ANALYSIS OF ALTERNATIVE MANURE APPLICATION STRATEGIES.

Manure Application Strategy	N-Based, Whole-Field	N-Based, Zonal	P-Based, Zonal
Manure Application (Acres)	157	86	86
Crop Nutrient Need N - P_2O_5 - K_2O (lbs/acre)	140-0-0	140-15-0	140-15-0
Manure Application Required/Acre (gal/acre)	4350	4350	1350
Manure to be Applied (gal/acre)	4400	4400	1400
Manure-Available Nutrients Applied (lbs/acre)	142-49-99	142-49-99	45-16-32
Net Value of Manure ($/acre)	77	91	40
Net Value of Manure ($/1000 gal)	18	21	28
Manure Remaining After Spreading (gal)	309,000	622,000	880,000

Value of Grid Soil Sampling

The spreadsheet analysis does not account for the increased cost of grid soil sampling. At $10.25 per acre for approximately two- acre grids, the field-total cost is $1609. Comparing the N-based whole-field with the N-Based Zonal application shows an increase in the value of the manure by $3 per 1000 gal or $1134 for the 86 acres where manure is to be applied with the zonal application. This appears to be a loss until we consider:

- It does not account for the higher value of the increased yield expected from precision application rates of manure and fertilizer P that would occur with the zonal strategies in the Low and Medium P testing areas.
- The value of the manure conserved in using the zonal strategies and available for other fields with greater P and K need is not calculated.
- One grid soil sampling every 3 to 5 years can serve multiple manure applications, reducing the cost substantially on a per-application basis.

ADDITIONAL ENVIRONMENTAL CONSIDERATIONS:

Preventing loss of P and N to surface water requires management of the sources of P and N, as well as transport to a water body. Management to reduce sources on this farm would include:

- Zonal manure management to gradually reduce excessively high P in soil.
- Subsurface injection to avoid manure on the soil surface susceptible to runoff (existing practice on this farm).
- Timing of application to reduce loss of N. If fall application is delayed until the soil temperature is below 50 degrees F, the ammonium in the injected manure will not be converted to nitrate and will not be leached to tile or groundwater.

2' Contour Lines and Aerial Image

Erosion and transport of soil particles with attached P is the remaining risk. There are two primary ranges of slopes in this field based on soil types, specifically, 2 to 6% and 1 to 4% slopes. See the 2' contour map (left). There is a stream touching the southwest corner of the field and running 400-700 feet from the south field edge. The aerial image and contours indicate possible runoff in two areas of concentrated flow from the field to the stream. To minimize soil and P loss several strategies should be considered:

- Minimize tillage intensity as much as possible.
- Consider structural controls such as terraces, sediment control basins, filter strips and waterways where appropriate.

The local NRCS/SWCD office and some crop consultants can provide a predicted erosion rate for any combination of slope, crop rotation, and tillage practices using the RUSLE2 model. It is also part of the Minnesota Phosphorus Index available at http://www.mnpi.umn.edu/

As an example, if tillage on this field was fall chisel and spring field cultivate all three years of the corn-corn-soybean rotation, the predicted erosion rates would average 1.8 tons per acre per year assuming 4% slope and 300 foot slope length. Converting to no-till soybeans, spring field cultivate before first year corn, and fall chisel/spring field cultivate before second year corn would reduce rotation average erosion to 1.3 tons per acre per year while maintaining yields. The predicted erosion reduction in the first corn year would be 1.0 ton per acre because of the soybean residue conserved with the reduced tillage.

CONCLUSIONS:

1. Grid soil sampling allows the livestock producer to identify and treat zones of excess and deficiencies for P and K, which may have developed with a history of non-uniform manure applications.

2. Targeting manure and perhaps supplemental fertilizer P and K applications to lower soil test P and K areas of the field will likely result in higher average and more uniform yields compared to blanketed rate applications based on the average soil test value for the entire field.

3. Excluding zones of excess soil test P from manure application will:
   a. Allow more efficient use of manure on other fields and field areas, increasing the total value of the manure supply if other acres of need have been identified or the manure is marketable.
   b. Reduce P pollution in runoff, since P in runoff is proportional to soil test P.

4. The crop rotation and the manure application method have a strong influence on the potential loss of P to water.

5. Tillage practices, both type and intensity over the duration of a crop rotation, have direct impact on trends related to soil erosion-conservation goals, thus an additional key management decision that can reduce the loss of P from productive soils.

Appendix 1: Additional information used to calculate the value of manure with the spreadsheet "What's Manure Worth?":

Fertilizer nutrient prices/lb.: N = $0.59, P_2O_5 = $0.54, K_2O = $0.54
Cost of purchased micronutrients/acre: $2.50
N fertilizer application cost avoided: $10.00 for the N-based application strategies.
Dry P_2O_5 and K_2O fertilizer application cost avoided/acre: $0.00 for all strategies where manure applied.
Additional value of micro-nutrients in manure: $0.00 assumed.
Second year nutrient credits/acre for valuation:

- **N-based, whole field = 30-25-0**
- **N-based, zonal = 30-17-0**
- **P-based, zonal = 10-0-0**

Manure yield boost value/acre over fertilizer alone: $20.00
Tillage effect of manure application: $0.00
Manure application cost/gallon: $0.015

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Swine Manure as a Fertilizer Source

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Swine manure can be an excellent source of nutrients for crop production. The key to proper management is determining the nutrient content of the manure, the percentages of those nutrients that are available to the plant, and the nutrient requirements of the plant. Considered together, these three factors will help you apply the proper amount.

Nutrient Content of the Manure

Because the nutrient content of swine manure varies among operations and over time, the manure must be analyzed before you apply it to the land. Waste samples, from North Carolina, can be analyzed for $4.00 by contacting the North Carolina Department of Agriculture (NCDA), Agronomic Division , Plant and Waste Analysis Lab, 4300 Reedy Creek Road, Raleigh, NC 27607-6465. Other qualified private laboratories are also available (fees vary).

Samples collected for analysis should be representative of the pit or lagoon. If the waste is to be applied as a slurry, the storage pit or basin should be agitated before sampling. Collect approximately 3/4 of a pint of material in an expandable container, being sure to leave air space.

If you cannot have a sample analyzed, determine the application rate by using the average nutrient values for different swine manure systems shown in Table 1. Table 2 shows the average amounts of secondary and micronutrients present in swine manures. These values can be used as planning guidelines, as long as you realize that they are not as accurate as a sample analysis.

Table 1. Nutrient Composition of Swine Manure

Manure Type	Total N	Ammonium NH_4- N	Phosphorus P_2O_5	Potassium K_2O
	lb/ton			
Fresh	12	7	9	9
Scraped[1]	13	7	12	9
	lb/1,000 gallons			
Liquid slurry[2]	31	19	22	17
Anaerobic lagoon sludge	22	6	49	7
	lb/acre-inch			
Anaerobic lagoon liquid	136	111	53	133

[1]Collected within 1 week.
[2]Six to 12 months accumulation of manure, urine, and excess water usage; does not include fresh water for flushing or lot runoff.

Source: Abridged from North Carolina Agricultural Chemicals Manual.

Table 2. Secondary and Micronutrient Content of Swine Manures

ManureType	Ca	Mg	S	Na	Fe	Mn	B	Mo	Zn	Cu
	lb/ton									
Fresh	7.9	1.7	1.8	1.6	0.39	0.04	0.074	0.00066	0.12	0.029
Paved lot scraped	12.0	2.3	2.2	1.6	1.03	0.19	0.015	0.00007	0.35	0.15
	lb/1,000 gallons									
Liquid slurry	8.6	2.9	4.7	3.7	0.69	0.15	0.069	0.0011	0.39	0.11
Lagoon sludge	15.8	4.5	8.3	2.9	1.8	0.28	0.023	0.0095	0.67	0.23

	lb/acre-inch									
Lagoon liquid	25.5	8.3	10.0	57.7	2.4	0.34	0.18	0.0045	1.5	0.3

Source: Biological and Agricultural Engineering Department, NCSU.

Nutrient Availabilities

The total nutrient content reported on a manure analysis report (or the levels shown in Tables 1 and 2) is not immediately available to the crops when the manure is applied. Some elements are released when the organic matter is decomposed by soil microorganisms. Other elements can combine with soil constituents and be made unavailable. Nitrogen may also be lost to the atmosphere through volatilization or denitrification, depending on the application method and soil moisture levels.

Table 3 lists the proportion of nutrients available for crop use during the first year of application for given application methods. When determining the application rate, refer to the availability coefficient for the appropriate application method, and then multiply that number by the corresponding nutrient value on the waste analysis report (or by the values shown in Tables 1and 2). Waste analysis reports from the NCDA's Agronomic Division show the nutrient availabilities for the first crop.

Table 3. First-Year Availability Coefficients for Swine Manure

Manure Type	Injection[1]	Soil Incorporation[2]	Broadcast[3]	Irrigation[4]
	P_2O_5 and K_2O availability coefficients			
All manure types	0.8	0.8	0.7	0.7
	N availability coefficient			
Scraped paved surface	—	0.6	0.4	—
Liquid manure slurry	0.8	0.7	0.4	0.3
Anaerobic lagoon liquid	0.9	0.8	0.5	0.5
Anaerobic lagoon sludge	0.6	0.6	0.4	0.4

[1]Manure injected directly into soil and immediately covered.
[2]Surface-spread manure plowed or disked into soil within two days.
[3]Surface-spread manure uncovered for one month or longer.
[4]Sprinkler-irrigated liquid uncovered for one month or longer.

The most recently applied waste is not the only source of nutrients; they are also available from previous applications of manures or from legumes crops. With the exception of nitrogen, updated soil tests are the best means of determining nutrient reserves from manure applications. Table 4 can be used to estimate available nitrogen carryover from legumes.

Table 4. Estimated Residual Nitrogen Provided by Legumes Grown in Rotation

Legume	Residual Nitrogen Available
	lb/acre
Alfalfa[1]	80 to 100
Hairy vetch[1]	80 to 100
Crimson clover[1]	60 to 75
Austrian winter pea[1]	50 to 60
Soybeans[2]	15 to 30
Peanuts[2]	20 to 40

[1]Killed before planting current spring crop.
[2]Legume planted in previous year or season. More nitrogen available if the fall-planted crop immediately follows legume; less nitrogen available with spring-planted crop. On sandy soils and in years with normally high precipitation, less nitrogen will be available to spring-planted crops.

Application Rates

Land application rates of manure are generally determined by matching the available nitrogen or phosphorus content of the wastes to the nutrient requirements of the crops. In most cases, nitrogen determines the application rate unless the area is designated "nutrient sensitive" and indicates that phosphorus movement off-site could contaminate surface waters. In areas not designated as nutrient sensitive, phosphorus movement can be adequately controlled with conservation methods that minimize soil and nutrient runoff. The conservation methods include grass field borders, grassed waterways, contour planting, and reduced tillage. Leaching of phosphorus is extremely limited on mineral soils and should not contribute to groundwater contamination.

Nitrogen recommendations for various crops are listed in Table 5. Use these rates as guidelines with the realistic yield capabilities for each crop and field. With feed and forage crops, excessive manure application can produce high nitrate concentrations, which can harm livestock (through nitrate poisoning) and promote nutrient imbalances that may lead to grass tetany. If loading rates are based on phosphorus, apply the amount suggested by soil test recommendations. Other nutrients such as potassium, magnesium, and the micronutrients manganese, zinc, and copper may not be supplied in sufficient quantities for normal crop production. In such cases, apply the supplemental nutrients with a commercial fertilizer as recommended by a current soil test.

Table 5. Nitrogen Fertilization Guidelines	
Commodity	**lb N/RYE[1]**
Corn (grain)	1.0 to 1.25 lb N/bu
Corn (silage)	10 to 12 lb N/ton
Cotton	0.06 to 0.12 lb N/lb lint
Sorghum (grain)	2.0 to 2.5 lb N/cwt
Wheat (grain)	1.7 to 2.4 lb N/bu
Rye (grain)	1.7 to 2.4 lb N/bu
Barley (grain)	1.4 to 1.6 lb N/bu
Triticale (grain)	1.4 to 1.6 lb N/bu
Oats	1.0 to 1.3 lb N/bu
Bermudagrass (hay[2,3])	40 to 50 lb N/dry ton
Tall fescue (hay[2,3])	40 to 50 lb N/dry ton
Orchardgrass (hay[2,3])	40 to 50 lb N/dry ton
Small grain(hay[2,3])	50 to 60 lb N/dry ton
Sorghum-sudangrass (hay[2,3])	45 to 55 lb N/dry ton
Millet (hay[2,3])	45 to 55 lb N/dry ton
Pine trees[4]	40 to 60 lb N/acre/year
Hardwood trees[4]	70 to 100 lb N/acre/year

[1]RYE = Realistic Yield Expectation
[2]Annual maintenance guidelines
[3]Reduce N rate by 25 percent when grazing.
[4]On trees less than 5 feet tall, N will stimulate undergrowth competition.

In addition to the supply of nutrients, proper soil pH is required to promote organic matter decomposition, improve crop yields, and ensure nutrient availability. The biological conversion of organic matter to nitrate is an

acid-forming process that will continue to reduce soil pH unless you follow an adequate sampling and liming program.

To help you determine land application rates, a worksheet is provided at the end of this publication.

Timing of Manure Applications

In addition to carefully calculating the application rate, you must also minimize the delay between applying the manure and planting the crop. Precise timing increases the amount of nitrogen used by the crop and thus reduces leaching. The risk of surface water and groundwater contamination is greater in areas of high rainfall and where manures are applied in the fall or winter for spring crops. On sandy-textured soils, apply manures at low rates throughout the growing season, wherever possible, to reduce nitrogen leaching caused by the soil's low nutrient-holding capacity.

Exercise caution when applying lagoon liquid through irrigation onto standing crops that are undergoing stresses.

Acreage Requirements for New Facilities

Whenever samples of manure or lagoon liquid are available for analysis, the specific results should be used to determine application rates and acreage requirements. However, when you are planning new facilities, average values can help determine the approximate acreage requirements for a given size swine operation. Table 6 can be used to determine the minimum acreage a new unit will need for manure use.

Table 6. Minimum Amount of Land Needed to Apply Swine Manure as a Nitrogen Fertilizer Based on the Nitrogen Rate Required by the Crop.

	Soil Incorporated[1]				Surface Broadcast[2]			
	lb N/acre/year							
	100	200	300	400	100	200	300	400
Manure Handling and Production Unit	Acres/animal unit capacity							
Paved Lot Scraped Manure								
Weanling-to-feeder per head	0.025	0.012	0.0082	0.0062	0.0158	0.0074	0.0049	0.0037
Feeder-to-finish per head	0.12	0.061	0.041	0.030	0.073	0.036	0.024	0.018
Farrow-to-weanling per sow	0.29	0.14	0.095	0.071	0.17	0.085	0.057	0.043

Farrow-to-feeder per sow	0.34	0.17	0.11	0.086	0.21	0.10	0.069	0.051
Farrow-to-finish per sow	1.4	0.70	0.47	0.35	0.84	0.42	0.28	0.21
Liquid Manure Slurry								
Weanling-to-feeder per head	0.031	0.015	0.010	0.0077	0.019	0.0095	0.0063	0.0047
Feeder-to-finish per head	0.15	0.076	0.051	0.038	0.094	0.0470	0.031	0.023
Farrow-to-weanling per sow	0.36	0.18	0.12	0.089	0.22	0.11	0.073	0.055
Farrow-to-feeder per sow	0.43	0.21	0.14	0.11	0.26	0.13	0.088	0.066
Farrow-to-finish per sow	1.7	0.87	0.58	0.44	1.1	0.54	0.36	0.27
Anaerobic Lagoon Sludge								
Weanling-to-feeder per head	0.0019	0.0010	0.0006	0.0005	0.0016	0.0008	0.0005	0.0004
Feeder-to-finish per head	0.0094	0.0047	0.0031	0.0024	0.0078	0.0039	0.0026	0.0019
Farrow-to-weanling per sow	0.018	0.0091	0.0061	0.0046	0.015	0.0074	0.0049	0.0037
Farrow-to-feeder per sow	0.022	0.011	0.0073	0.0055	0.018	0.0089	0.0059	0.0044
Farrow-to-finish per sow	0.11	0.054	0.036	0.027	0.089	0.045	0.030	0.022
Anaerobic Lagoon Liquid								
Weanling-to-feeder per head	0.0075	0.0038	0.0025	0.0019	0.0048	0.0024	0.0016	0.0012
Feeder-to-finish per head	0.037	0.018	0.012	0.0092	0.023	0.012	0.0078	0.0058
Farrow-to-weanling per sow	0.084	0.042	0.028	0.021	0.054	0.027	0.018	0.013
Farrow-to-feeder per sow	0.10	0.051	0.034	0.025	0.065	0.032	0.022	0.016
Farrow-to-finish per sow	0.41	0.21	0.14	0.10	0.26	0.13	0.088	0.066

[1]Incorporated within 2 days
[2]Not incorporated for 1 month or longer; lagoon liquid irrigated.

An example will make these methods clear. A producer is interested in starting a 500-sow farrow-to-finish operation using an anaerobic lagoon collection system. The producer is considering spraying the lagoon liquid effluent on bermudagrass being grown for hay. The realistic yield expected for this field is 6 dry tons per acre. How many acres of bermudagrass would be needed?

Using Table 5, the maximum nitrogen (N) rate required is 300 lb per acre (6 tons x 50 lb N/ton). Go now to Table 6 under surface broadcast column 300, and you will find that each sow would require 0.088 acres to utilize its waste. A 500-sow operation would thus require 44 acres (0.088 x 500 = 44).

Value of Manure

To compare the value of manure to commercial fertilizer, convert the manure nutrients to available nutrients by using their availability coefficients. In the example that follows, the amount of available nitrogen (N), phosphorus (P_2O_5), and potassium (K_2O) in each inch of lagoon liquid is approximately 68, 37, and 93 pounds per acre, respectively. At $0.225 per pound of nitrogen, $0.22 per pound of phosphate, and $0.12 per pound of potash, the manure's gross worth is

(68 x $0.225) + (37 x $0.22) + (93 x $0.12)

or

$15.30 + $8.14 + $11.16 = $34.60 per acre for each inch of lagoon liquid.

This value does not include labor or irrigation equipment costs, nor does it include the value of any secondary or micronutrients available in the manure. In addition, it assumes that the soil test has indicated a need for each nutrient, when, in fact, many nutrients may not be needed. Nutrients not needed should not be considered in assessing the financial value of the manure.

Land Application Worksheet

Farmer Jones has a swine operation in which lagoon liquid is applied through a travel gun to fertigate a field for corn. His yield goal is about 120 bushels per acre, and he decides to apply the equivalent of 120 pounds of nitrogen per acre (Table 5). His land is not subject to erosion, nor is it in a nutrient sensitive watershed. The corn crop will be planted in the same field that had soybeans last year. He has grass borders on his field to further reduce the potential of nutrient or pesticide runoff.

Farmer Jones uses a starter fertilizer on his corn crop at a rate to supply 10 pounds of nitrogen per acre and 34 pounds of P_2O_5 per acre. He intends to supply the remainder of nitrogen from liquid swine lagoon effluent. How much effluent does he need to apply to meet the nitrogen needs of his corn crop? How much will be needed to supplement the crop with additional K_2O or P_2O_5 to satisfy his soil test recommendations of 50 pounds of each nutrient per acre? The answers are given in the worksheet.

Worksheet: Determining the Nutrient Needs of Your Crop		
	Example	**Your Farm**

1. Crop to be grown	corn	_____
2. Total nutrients required		
a. N (Table 5) (lb/acre)	120	_____
b. P_2O_5 (soil test) (lb/acre)	50	_____
c. K_2O (soil test) (lb/acre)	50	_____
3. Pounds of starter or preplant fertilizer used		
a. N (lb/acre)	10	_____
b. P_2O_5 (lb/acre)	34	_____
c. K_2O (lb/acre)	0	_____
4. Residual N credit from legumes (Table 4) (lb/acre)	20	_____
5. Net nutrient needs of crop (lb/acre)		
Nitrogen: total need (item 2a) minus additional N from starter (item 3a) minus legume residual (item 4) a. N: 120 -10 - 20 (lb/acre)	90	_____
Phosphorus: total need (item 2b) minus additional nutrients from starter (item 3b) b. P_2O_5: 50 - 34 (lb/acre)	16	_____
Potassium: total need (item 2c) minus additional nutrients from starter (item 3c) c. K_2O: 50 - 0 (lb/acre)	50	_____

6. Nutrient totals in manure (from Table 1 or waste samples). If analysis report already gives available nutrients, skip this item.		
a. Total N (lb/acre-inch)	136	_____
b. P_2O_5 (lb/acre-inch)	53	_____
c. K_2O (lb/acre-inch)	133	_____
7. Nutrients available to crop (items 6a, 6b, and 6c) times availability coefficients (Table 6). If analysis report already gives available nutrients, fill in those numbers.		
a. Available N: 136 x 0.5 (lb/acre-inch)	68	_____
b. Available P_2O_5: 53 x 0.7 (lb/acre-inch)	37	_____
c. Available K_2O: 133 x 0.7 (lb/acre-inch)	93	_____

Worksheet: Rate of Manure to Apply		
8. Application rate to supply priority nutrient		
a. Priority nutrient	Nitrogen	_____
b. Amount of priority nutrient needed (lb/acre from item 5a)	90	_____
c. Rate of manure needed to supply priority nutrient (item 8b) divided by (item 7a): 90/68(lb/acre-inch)	1.32	_____
9. Pounds per acre of all nutrients supplied at the application rate required to meet the needs for the priority nutrient. For each nutrient, enter the available nutrients (items 7a, 7b, and 7c) times manure rate (item 8c)		
a. N supplied: 68 x 1.32 (lb/acre-inch)	90	_____

b. P_2O_5 supplied: 37 x 1.32 (lb/acre-inch)	49	
c. K_2O supplied: 93 x 1.32 (lb/acre-inch)	123	
10. Nutrient balance: net nutrient need (-) or excess (+) after application of manure at calculated rate. Subtract the net nutrient needs of the crop (items 5a, 5b, and 5c) from the nutrient rate applied (items 9a, 9b, and 9c).		
a. N balance: 90 - 90 (lb/acre-inch)	0	
b. P_2O_5 balance: 49 - 16 (lb/acre-inch)	+33	
c. K_2O balance: 123 - 50 (lb/acre-inch)	+73	
Note: Calculation format modified from Pennsylvania Department of Environmental Resources, *Field Application of Manure*, October 1986.		

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www.clemson.edu/.../swine/sch3a-03.pdf

Clemson University

CHAPTER 3

Swine Manure Production and Nutrient Content

John P. Chastain, James J. Camberato, John E. Albrecht, and Jesse Adams, III

INTRODUCTION

Knowledge of the amount of manure and plant nutrients produced on a swine farm is the first step in the proper operation of a swine manure handling, treatment, and utilization system. The nutrient and volatile solids content of swine manure will vary with the digestibility of the ration, animal age, amount of feed wasted, the amount of water wasted, and the amount of water used to remove manure from the building. The data provided in this chapter is to be used for general planning purposes. South Carolina regulations (Standards for the Permitting of Agricultural Animal Facilities: R.61-43) require swine producers to have manure samples analyzed annually to establish land application rates.

MANURE PRODUCTION

The quantity of fresh swine manure (including feces and urine) produced each day is shown in Table 3.1. The quantity of manure, total solids, and volatile solids produced per day are given per animal unit (AU). An animal unit is equal to 1,000 pounds of live animal weight. The quantity of manure produced is given in pounds (lb), cubic feet (ft^3), and gallons (gal).

The total and volatile solids content in swine manure is given in lb/AU/day since these are the units often used to size an anaerobic lagoon or digester (see chapter 4 for more details). The total solids content is the combination of the solids than can be broken down by bacteria and the solids that will never degrade. Volatile solids are the solids that can be decomposed by biological treatment.

Table 3.1. Daily production of fresh manure, total solids, and volatile solids for typical swine farms (adapted from MWPS-18, 1993; ASAE standard D384.1, 1998; and Barker, 1990).

Farm Type	Average Weight lb/PU [2]	Manure Production per AU [1] lb/day	ft^3/day	gal/day	Total Solids lb/AU/day	Volatile Solids lb/AU/day
Farrow-to-Wean	433/sow	60	0.97	7.26	5.9	4.5
Nursery	30/pig	84	1.35	10.1	11.0	8.5
Farrow-to-Feeder	522/sow	64	1.03	7.70	6.7	5.1
Feeder -to- Finish	135/hog	84	1.35	10.1	11.0	8.5
Farrow-to-Finish	1,417/sow	77	1.24	9.28	9.3	7.2

[1] AU = 1,000 lb of live weight.

[2] PU = production unit. The production unit is a sow, pig, or hog as shown.

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CALCULATION OF AVERAGE PRODUCTION LIVE WEIGHT AND NUMBER OF ANIMAL UNITS

The manure and solids production data are given as the pounds or volume per animal unit per day. The average production unit depends on the type of swine that are kept on the farm. For example, the production unit on a farrow-to-wean farm is the sow. The animal weight per sow includes the weight for all pigs produced, gestating and breeding sows, boars, and replacement animals. On a swine farm with only one type of animal, such as a feeder-to-finish farm, the average weight is simply the average weight of the hogs at any time. For example, if the average weight of a feeder pig that is placed in the building is 50 lb and the average weight of a market hog is 220 lb the average weight per hog is (50 + 220)/2 = 135 lb.

Some of the facility and lagoon site selection requirements in the South Carolina regulations depend on the size of the operation. The average production live weight on the farm is used to define farm size. Swine operations with more than 420,000 pounds of average live weight fall under the regulations for large swine facilities. The values in Table 3.1 can be used to calculate the average production live weight using the following equation:

Average Production Live Weight = Number of Production Units x (lb / PU). (3.1)

Example 3.1 Determine the total average production live weight for a 1000 sow, farrow-to-feeder swine farm using equation 3.1. Is this farm subject to the regulations for large swine facilities?

From Table 3.1 the average weight per PU for a farrow-to feeder farm is 522 lb/sow. The average production live weight for a 1,000 sow farm is: 1,000 sows x 522 lb/sow = 522,000 pounds. In the South Carolina regulations a large swine farm is defined as any farm that has a production live weight that is greater than 420,000 pounds. Therefore, a 1,000 sow, farrow-to-feeder farm comes under the regulations for large swine farms.

Example 3.2 What is the largest farrow-to-feeder farm that *does not* come under the regulations for large swine facilities?

Calculate the number of production units that will give an average live weight of 420,000 pounds as follows:

420,000 lb ÷ 522 lb/sow = 804.6 sows.

Therefore, the largest number of sows that can be kept on a farrow-to-feeder farm and still come under the regulations for small swine facilities is 804 sows.

The daily manure production data given in Table 3.1 is given per animal unit (AU). The number of animal units on a farm is calculated as:

Number of Animal Units (No. AU) = Average Production Live Weight ÷ 1000. (3.2)

Example 3.3 Calculate the number of animal units for a 1,000 sow farrow-to-feeder farm. The average production live weight of a 1,000 sow farrow-to-feeder farm was calculated in example 1 and was found to be 522,000 pounds. The number of animal units is: 522,000 ÷ 1,000 = 522.

MANURE VOLUMES FOR DIFFERENT MANURE HANDLING SYSTEMS

The manure production data given in Table 3.1 is for undiluted manure as excreted from the animals. However, the actual volume that must be collected, handled, treated, and stored varies with the methods used to remove manure from the building. In addition, wasted water from waterers and building washdown can increase the manure volume by 10 to 30%.

The volume of manure and wasted water is compared with the amount of liquid manure that flows from pit-recharge and flush buildings in Table 3.2. The manure and wasted water volumes in the table are good estimates of the volume of fresh manure, waterer wastage, and washdown water that is added to a manure handling system each day. This volume is used to calculate the manure storage volume when a lagoon or liquid storage structure is sized.

In South Carolina, most swine facilities use a flush or pit-recharge system with a lagoon or storage pond (chapter 4). The water used to remove manure from a pit-recharge or flush building is typically recycled from the lagoon. Pit-recharge systems are gaining popularity over flush systems because less water volume is required to clean the building.

Table 3.2. Variation of swine manure volume depending on type of manure handling system (to convert to gallons multiply ft^3 by 7.48).

Farm Type	Average Weight lb/PU	Manure and Wasted Water [1] ft^3/AU/day	Pit-Recharge [2] ft^3/AU/day	Flush [3] ft^3/AU/day
Farrow-to-Wean	433 lb	1.16	9.3	9.4
Nursery	30 lb	1.62	9.4	17.6
Farrow-to-Feeder	522 lb	1.24	9.4	10.7
Feeder -to- Finish	135 lb	1.62	6.8	17.6
Farrow-to-Finish	1,417 lb	1.49	7.8	14.9

[1] Dilution water from waterer wastage and washdown was assumed to be 20% of the manure volume. Does not include water for flushing or pit-recharge.
[2] Includes wasted water and water used to remove manure from buildings. Total solids content for pit-recharge systems varies from 1.5% to 2.6%.
[3] Includes wasted water and water used to remove manure from buildings. Total solids for flush systems can vary from 0.5 to 2%. A value of 1% was used to calculate the volumes shown.

The actual amount of manure handled per day on a given farm will vary with farm size and the type of manure handling system used. A flush system will remove manure from a building 4 to

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12 times a day. A pit-recharge system is typically emptied every 5 to 7 days. These daily values can be used to estimate weekly or annual volumes once the manure removal schedule is established.

Example 3.4 A feeder-to-finish swine farm has 6 pit-recharge buildings that are designed to house a maximum of 880 hogs. The manure from one building is emptied every 7 days. What is the volume of manure that must be handled by the waste system? Give the volume in cubic feet and gallons.

Step 1. The average weight per PU for a feeder-to-finish farm is 135 lb/hog (Table 3.2). Calculate the number of animal units in a single building as:
880 x 135 lb/hog ÷ 1,000 lb/AU = 118.8 AU / building.
Step 2. From Table 3.2, the total manure and wasted water produced per AU per day is 6.8 ft^3/AU/day. Calculate the manure volume per day as follows:
118.8 AU/building x 6.8 ft^3 / AU / day x 7 days = 5655 ft^3 of manure/building.
Step 3. The volume in gallons is
5655 ft^3/day x 7.48 gal/ft^3 = 42,299 gal/building.

NUTRIENT CONTENT OF SWINE MANURE

Swine manure contains all 13 of the essential plant nutrients that are used by plants. These include nitrogen (N), phosphorous (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), manganese (Mn), copper (Cu), zinc (Zn), chlorine (Cl), boron (B), iron (Fe), and molybdenum (Mo). Plant nutrients originate from the feed, supplements, medications, and water consumed by the animals. Using swine manure as a fertilizer for crops or trees may provide a portion, or all, of the plant requirements. The amount of nutrients provided depends on the nutrient content of the manure (lb of nutrient / 1,000 gal of manure) and the amount of manure applied (gal of manure / acre). The amount of manure applied per acre (called the ***application rate***) is typically based on the nitrogen needs of the plants. However, phosphorous requirement can also be used to determine the application rate (for more details see Chapter 5, Waste Utilization). South Carolina regulations can also limit the land application rate of swine manure based on the copper or zinc content of the manure.

The nutrient content (lb / 1,000 gal) in swine manure varies depending on the age of the animals, ration, temperature, methods used to collect and store manure, and the moisture content. The amount of water used to remove manure from the building has a large effect on the moisture content. Flush systems generally add more water to the manure than do pit-recharge systems. Dilution water is also added to manure from waterers, and from building washdown.

The variation in the nutrient content of fresh swine manure and manure from several types of storage and treatment alternatives is compared in Table 3.3. These values were developed from a database that combines data taken on South Carolina swine farms with mean values from North Carolina State (Barker, 1990). The values for fresh manure were taken from the ASAE Standard D384.1 (1998).

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The nutrient content in a lagoon or storage will vary by depth. A large fraction of the solids in swine manure will settle to the bottom of a storage structure. As a result, the nutrient composition of the top layer of water in a lagoon or storage will be reduced by the settling process alone. Most of the nitrogen in the top layer of water in a lagoon or storage is in the ammonium form. Ammonium nitrogen (NH_4^+-N) can be readily converted to ammonia gas and be lost from the surface of lagoons and storage ponds by volatilization. Organic nitrogen (organic-N) and phosphorous (P_2O_5) is concentrated in the solids that settle to the bottom of a lagoon.

Anaerobic decomposition will occur in most storages and lagoons. The volatile solids in manure are broken down by anaerobic bacteria. During this process the organic nitrogen is converted to ammonium nitrogen. Over a period of time, the ammonium nitrogen from decomposed volatile solids is converted to ammonia and can be lost to the atmosphere.

Table 3.3. Comparison of the nutrient content of the common forms of swine manure on South Carolina farms (as-sampled or wet basis).

Moisture	90.8%	98.0%	99.63%	90.0%	97.8%	99.5%
Total Solids	9.2%	2%	0.37%	10%	2.2%	0.5%
Manure Type	Fresh [1] Manure	Manure [2] from Building	Lagoon Surface Water	Lagoon Sludge	Agitated Water & Solids [7]	Storage Pond Surface Water
	lb / 1000 gal					
NH_4^+-N	28.6	11.4	3.4	6.1	3.9	4.3
Organic - N	22.7	5.6	1.4	15.5	4.1	2.0
Total - N [3]	51.3	17.0	4.8	21.6	8.0	6.3
ESTIMATES OF AVAILABLE NITROGEN [4]						
Incorporated	36.5	12.5	3.6	14.2	5.6	4.6
Surface	27.9	9.1	---	12.3	4.4	---
Direct Injection	---	14.8	4.2	---	6.4	5.5
P_2O_5 [5]	40.4	13.4	2.8	47.3	11.3	3.6
K_2O [6]	34.5	14.2	6.1	6.3	6.1	7.9
Ca	32.6	3.7	0.86	32.3	6.8	1.1
Mg	6.9	2.4	0.46	11.0	2.5	0.57
Zn	0.49	0.28	0.03	1.8	0.37	0.04
Cu	0.12	0.26	0.02	0.75	0.16	0.03
Mn	0.19	0.12	0.01	0.65	0.13	0.02
S	7.5	1.3	0.31	6.6	1.5	0.39
Na	6.6	2.5	1.8	1.6	1.8	2.2

[1] Nutrient content of manure as excreted (from ASAE Standard D384.1, 1998). All other values based on database compiled by the authors.

[2] The total solids content from flush and pit-recharge buildings will vary from 1.5% to 2.6% depending on building design and animal weight. A mean value of 2% is shown.

[3] Total-N = Organic-N + (NH_4^+- N)

[4] Estimates based on recommendations from the Clemson University Agricultural Services Laboratory.

[5] Total phosphorus expressed as P_2O_5. To get elemental P multiply by 0.44.

[6] Total potassium expressed as K_2O. To get elemental K multiply by 0.83.

[7] Use these values as an estimate of the nutrient content of agitated liquid storage structures and lagoons.

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The nutrient values in Table 3.3 can be used for general planning before a lagoon or manure storage is constructed, or prior to the expansion of an existing farm. In the case of an existing lagoon or storage pond, sample analysis from the structure must be used to perform nutrient balances for land application.

Estimation of Plant Available Nitrogen

Not all of the nitrogen in swine manure is immediately available for plant use. The nitrogen that is available for plant use is called the plant available nitrogen (PAN). Nitrogen (N) can be present in manure as ammonium-N, organic-N, and nitrate-N.

Ammonium Nitrogen and Volatilization Losses

A large portion of the nitrogen in liquid swine manure is in the ammonium (NH_4^+) form. Ammonium (NH_4^+) and ammonia (NH_3) can interchange rapidly depending on the pH. Ammonium will convert to ammonia at a pH that is greater than 6.5. Increasing the pH (more alkaline or less acid) increases the amount of ammonia and decreases the amount of ammonium. Most manure has a pH close to 7.0. Therefore, both ammonium and ammonia are present. The Clemson University Agricultural Services Laboratory reports a single value for the ammonium nitrogen content of manure. This value includes both ammonical forms of nitrogen (NH_4^+ and NH_3). Therefore, whenever the term ammonium nitrogen (also abbreviated NH_4^+-N) is used in this book it should be understood that both ammonia and ammonium are included.

Ammonia (NH_3) is a gas and can be readily lost to the air by ***volatilization***. Volatilization is a process that is similar to evaporation. Volatilization losses can occur from the surface of manure whenever it is exposed to air. Ammonia-N can be lost from manure on concrete lots, from the surface of liquid manure in a pit, from the surface of a lagoon or storage structure, and during land application. The nutrient content of manure is typically measured using a representative sample of the form of manure that is to be land applied. Therefore, volatilization loss resulting from handling and storage of manure has already occurred, and only an estimate of the application loss is used to estimate the amount of ammonium-N that is available.

The amount of ammonium nitrogen that is lost from swine manure depends on the method of land application as shown in Table 3.4. If manure is spread on the ground without being mixed into the soil by a tillage operation (called ***incorporation***) then a large portion of the ammonia nitrogen can be lost to the atmosphere. Ten to fifteen percent of the NH_4^+-N is lost from surface applied manure each day if rain does not fall on the field. In addition, a fraction of the ammonium-N can be lost during the application process. A significant rain (0.25 inches or more) will carry most of the ammonium nitrogen into the soil. All of the NH_4^+ can be converted to ammonia and can be lost if it does not rain for several weeks.

Incorporation of manure on the same day it is applied can reduce the volatilization losses to 30%. Direct injection (using a tank injector or towed-hose direct injector) can reduce volatilization losses to zero. Incorporation of manure conserves valuable nitrogen and increases the precision of using manure as a fertilizer.

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Table 3.4. Estimates of ammonia nitrogen loss based on land application method.

Application Method	Loss of Ammonia Nitrogen Range	Recommended Value
Surface application without incorporation	10 - 100%	50%
Surface application with incorporation the same day or irrigation of liquid manure	5 - 30%	20%
Direct injection below the soil surface	0 - 2%	0%

The ammonium-N availability factor is calculated from the ammonia loss as follows:

$$NH_4^+\text{-N Availability Factor} = (100 - \text{Percent Loss}) \div 100. \quad (3.3)$$

Although NH_4^+-N and NH_3-N both exist in manure and soil they have extremely different properties. Ammonium (NH_4^+) is a charged molecule dissolved in the soil water and can be readily used by plants. Ammonia (NH_3) is a gas and is not significantly taken up by plants. Ammonium does not leach from soil except for extremely coarse sands. However, ammonium typically is converted in the soil to nitrate-N (NO_3^-) which can be easily leached from soil.

Organic Nitrogen and Mineralization

Organic nitrogen (organic-N) is the most abundant form of nitrogen in animal manure with a high solids content (10% total solids or more). Organic-N is not available to plants until it has been decomposed by microbes to ammonium-N. The process of converting organic nitrogen to ammonium-N is called ***mineralization***. Conversion of organic-N to ammonium-N does not occur immediately, and not all of the organic-N is mineralized. Sometimes animal manure with a high solids content is referred to as a slow-release N source because the organic-N is made available over time and not all at once. How fast and how completely this occurs depends on a number of factors including: temperature, soil moisture, soil pH, type of manure, and the extent of incorporation.

The amount of organic-N that is available during the first growing season can range from 30 to 80%. Field measurements taken at the Pee Dee Research Station (Quisenberry, 1998) indicate an average of 60% of the organic-N is mineralized regardless of application method. This is the value used to estimate the plant available nitrogen by the Clemson University Ag. Service Laboratory. However, since many factors effect mineralization the conversion of organic-N to NH_4^+-N may be more or less than 60%.

Organic-N does not leach from soil. Erosion is the only way that organic-N can be lost from the soil.

Nitrate Nitrogen

Most swine manure storage structures store manure in a predominantly anaerobic condition. ***Anaerobic*** means oxygen is excluded. Therefore, very little nitrate nitrogen is present in the manure and is generally not measured. However, interest is increasing in the use of aeration or aerobic treatment systems to control odor. ***Aerobic*** treatment systems maintain elevated levels of oxygen in the manure through natural or mechanical aeration. The process of aeration will result

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in increased nitrate nitrogen in the manure. Therefore, swine manure that is aerated must also be analyzed to determine the nitrate -N content (Section 100.60 (A) 2, e). All of the nitrate-N is available to the crop and is an important component of some commercial fertilizers (ammonium nitrate for example).

Even though nitrate is not typically present in a significant amount in swine manure it is still an important form of nitrogen. Nearly all of the ammonium-N and organic-N will eventually be converted to nitrate in the soil. Although nitrate is readily taken up by crops, it can be easily lost from the soil. Rainfall or irrigation that results in the movement of water through the root zone of the crop will result in the loss of nitrate by leaching. When soil is saturated, and leaching does not occur, nitrate can be converted to nitrogen gas and be lost to the air. Both of these processes can occur rapidly. Therefore, it is best to apply manure or fertilizer nitrogen very close to the time when the crop's requirement for N is the greatest.

Calculation of Plant Available Nitrogen

The plant available nitrogen (PAN) is the sum of the available ammonium nitrogen, the available organic nitrogen, and the nitrate nitrogen. The estimate of PAN is used to calculate the amount of manure that is needed to satisfy the nitrogen needs of a crop. The equation used to estimate the plant available nitrogen is:

$$\begin{aligned} \text{Plant Available Nitrogen (PAN)} &= [NH_4^+\text{-N Availability Factor} \times NH_4^+\text{-N Content}] \\ &+ [0.60 \times \text{Organic-N Content}] \\ &+ [\text{Nitrate-N Content}]. \end{aligned} \qquad (3.4)$$

The use of equation 3.4 is explained in the following example.

Example 3.5 A swine producer had the surface water of his swine manure storage pond tested for plant nutrients by a laboratory. The laboratory results indicated that the water contained 5.4 lb NH_4^+-N /1,000 gal and 1.68 lb organic-N /1,000 gal. The storage pond water will be applied to cropland using a traveling gun irrigation system. Calculate the amount of plant available nitrogen per 1,000 gal. Compare the PAN with the total-N.

Step 1. Determine the NH_4^+-N availability factor from Table 3.4 and equation 3.3.
The recommended ammonia nitrogen loss factor for irrigation is the same as for incorporation and is 20%. The NH_4^+-N availability factor is calculated using equation 3.3 and is 0.80 ((100-20%) ÷ 100).

Step 2. The plant available nitrogen (PAN) is calculated using equation 3.4 as follows:
0.80x 5.4 lb NH_4^+-N/1,000 gal + 0.60 x 1.68 lb organic-N/1,000 gal = 5.33 lb /1,000 gal.
Note that nitrate-N was not considered since the storage is not aerated.

Step 3. The total-N is the sum of the organic and ammonium nitrogen. In this case, total-N = 5.4 + 1.68 = 7.08 lb /1,000 gal. The estimate of PAN is 75% of the total-N for this manure analysis.

Using an Animal Waste Analysis Report

South Carolina regulations require swine producers to have manure samples analyzed at least annually to determine the amount of manure that can be applied to cropland. A sample laboratory report is shown in Table 3.5. This report is for a swine finishing farm that uses a pit-recharge system to collect manure below a slotted floor. The manure is stored in a storage pond (see chapter 4 for description). The surface water of the storage pond is applied using a traveling gun irrigation system. Solids are agitated and removed with the water at least once each year.

Selection of a Sample Number

The first step in the proper use of a laboratory report is the selection of the sample number. The sample number is determined by the person who sends in the sample. The sample number can be any combination of letters or numbers (up to 5 letters or numbers). Select a sample number that helps to identify the type of manure analyzed. In Table 3.5 the sample number is SSW5. This sample number is an abbreviation for Storage Surface Water 5. The number 5 indicates that this is the fifth sample of storage surface water that has been sent to the laboratory for analysis. Therefore, the rolling average for PAN, P_2O_5, K_2O, or other nutrients is the average of 5 values.

LAB NO

The LAB NO (100498 in Table 3.5) is assigned by the Agricultural Service Laboratory. This number is needed if you have a question concerning your waste analysis report. The phone number of the Clemson Agricultural Service Laboratory is 864-656-2068.

Moisture Content

The nutrient content results are given on an as-sampled or wet basis. The moisture content of the manure sample has a large effect on the nutrient content. The moisture content is determined by the laboratory and is given near the bottom of the report. In this case, the manure contains 99.58% water. The solids content of the sample is 0.42% (100-99.58).

Nutrient Content

The contents of all forms of nitrogen, phosphorous, potassium, and the other nutrients are given in two columns. The first column is in either percent (%) or parts per million (ppm). The second column gives the nutrient content in pounds per 1,000 gallons of manure (lbs/1,000 gal). In most cases, nutrient management calculations use the units pounds per 1,000 gallons for liquid manure. If the manure has a high solid content then the results in the second column are given in pounds per ton (lbs/ton).

Estimates of Plant Available Nitrogen

The animal waste report provides up to five different values for manure nitrogen. It is very important for animal waste managers to be able to interpret and use these nitrogen results correctly. The ammonium-N, organic-N, and nitrate-N given on the report are the three basic forms of nitrogen that were discussed previously in the section called Estimation of Plant

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Table 3.5. Sample animal waste analysis report for the surface water of a storage pond for swine manure (finishing buildings with a pit-recharge manure handling system)

ANIMAL WASTE ANALYSIS REPORT

Clemson University
Cooperative Extension Service
Agricultural Service Laboratory
Clemson, S.C. 29634-03921

LAB No. 100498

NAME	Farmer, J.Q.	ACCOUNT	CASH MONEY
ADDRESS	312 Sunny Acres Road	DATE	12-2-1998
CITY	Any Where, SC		
ZIP CODE	29341		

SAMPLE NO. SSW5 MANURE: SWINE STORAGE: STORAGE

RESULTS REPORTED ON AN AS-SAMPLED BASIS

			lbs/1,000gal
Ammonium Nitrogen	0.061	%	5.40
Organic Nitrogen	0.019	%	1.68
Nitrate Nitrogen			
INCORPORATED AVAILABLE NITROGEN ESTIMATE			5.33
SURFACE AVAILABLE NITROGEN ESTIMATE			3.71
Phosphorous as P2O5	0.0286	%	2.53
Potassium as K2O	0.1070	%	9.47
Calcium	0.0055	%	0.49
Magnesium	0.0011	%	0.10
Sulfur	0.0048	%	0.42
Zinc	1.03	ppm	0.01
Copper	0.80	ppm	0.01
Manganese	0.52	ppm	0.00
Sodium	279.13	ppm	2.47
Arsenic			
pH			
Moisture	99.58	%	
Calcium Carbonate Equivalency			

INCORPORATED PLANT AVAILABLE NITROGEN ESTIMATE - 80% of ammonium-N, 60% of organic-N, and 100% of nitrate-N (if determined). Assumes some loss of ammonium-N during application and prior to incorporation.

SURFACE PLANT AVAILABLE NITROGEN ESTIMATE - 50% of ammonium-N, 60% of organic-N, and 100% of nitrate-N (if determined). Assumes the manure will be left on the surface of the soil with no incorporation by plowing or irrigation.

Available nitrogen calculations are estimates and the actual amount received may be more or less than the estimate depending on the composition of the manure, soil type, and environmental conditions.

All of the potash in the animal waste should be plant available in the first year of application. Although not all of the phosphorous is available in the first year, its availability should be comparable to that in commercial fertilizers.

The rate of animal waste to apply for crop production is dependent on the nutrient content of the waste, method of application and incorporation, soil test, crop to be grown, and previous manure applications. In most cases, the plant available nitrogen content of the waste is used to determine the rate of application. Your County Agent can assist you in determining the proper application rate. APPROVED BY _____

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Available Nitrogen. The other two values given are estimates of the plant available nitrogen (PAN) based on the method of application. The incorporated available nitrogen estimate of PAN should be used in the following cases:

- when manure will be mixed with the soil by a tillage operation the same day it is applied (disking, plowing, but not no-till drilling),
- when liquid manure is spread using an irrigation system, or
- during the planning stages when the exact method of application is yet to be decided.

In Table 3.5, the incorporated PAN estimate is 5.33 lbs/1,000 gal. This value was previously calculated using equation 3.3 in example 3.4. Therefore, the incorporated PAN estimate can be obtained from the waste analysis report if the Clemson University Agricultural Service Laboratory is used. If another laboratory is used, use equation 3.3 and Table 3.4 with the results for ammonium-N and organic-N.

The surface available nitrogen estimate should only be used when manure with a high solids content is spread on the surface without being incorporated. Separated solids, slurry manure, and thick lagoon solids are examples of the types of swine manure that could be spread without incorporation. In Table 3.5 the surface applied estimate of PAN is given as 3.71 lb/1,000 gal. However, this value should never be used when the surface water of a lagoon or storage pond is land applied. The high moisture content (99.58%) of this type of manure will cause the ammonium-N to be carried into the soil with the water regardless of application method.

Direct injection of liquid manure is a technology that may become widely used in South Carolina in the future. However, it is not currently a common practice. Direct injection eliminates the ammonia loss associated with irrigation or surface application of liquid or slurry manure. If direct injection is to be used, the PAN estimate is calculated using equation 3.3. For the data shown in Table 3.5, the PAN estimate for direct injection is 6.41 lbs/1,000 gal (5.40 + 0.60 x 1.68) which is 20% higher than the PAN estimate used for irrigation.

Manure Sampling Frequency and Rolling Average

South Carolina regulations require a manure analysis to be obtained for each form of manure that is land applied as indicated below.

> 100.100 (B) 6
> The producer shall be responsible for having representative samples of the swine waste collected and analyzed at least once per year and when the feed composition significantly changes. The amount of swine waste to be land applied so that the permitted application rate (normally the agronomic rate) is met will be determined using a rolling average of the previous analyses. The Department shall establish minimum requirements for the proper method of sampling and analyzing of swine waste.

In most cases, swine manure is applied to crop or pasture land in the following forms: lagoon surface water, storage pond surface water, and agitated water and solids. As shown in Table 3.3, the nutrient content of the swine manure can vary significantly depending on the form that is applied.

The laboratory results from the most recent analysis should be averaged with all previous manure analyses for a particular form of manure. This is what is meant by a ***rolling average***. Each time manure is collected and sent to a laboratory for analysis errors always occur due to: sampling differences in the field, and experimental errors associated with laboratory procedures. Therefore, the best value for the nutrient content of a particular form of swine manure is the average of as many analyses as possible. Separate, representative manure samples must be collected and analyzed for each form of manure applied each year. Most swine producers will need to keep a rolling average for surface water of the lagoon or storage structure, and for agitated manure.

South Carolina regulations require the analysis of a representative sample at least one time per year. However, more frequent sampling is recommend. The need for more frequent sampling can be easily demonstrated using data taken from a swine manure storage pond located in South Carolina.

Sample Data Used to Establish a Rolling Average for Nitrogen and Phosphorous
Surface water samples were collected from a liquid storage pond on a swine finishing farm in July, August, September, October, and November in 1998 (see chapter 7, Manure Sampling Procedures). The samples were analyzed by the Clemson University Agricultural Service Laboratory. The surface water is land applied using a traveling gun irrigation system. Therefore, the incorporated available nitrogen estimate given on the laboratory report (see Table 3.5 for explanation) was used to develop a rolling average for PAN. A rolling average was also maintained for phosphorous (expressed as P_2O_5). The variation in the sample analyses and rolling averages for PAN and P_2O_5 are shown in Figures 3.1 and 3.2. The solid lines in the graphs is the historical rolling averages. Each time a new sample was collected the new value for PAN and P_2O_5 was averaged with all of the previous values. The dashed line is the current average of all 5 samples. It is important to note that the PAN and P_2O_5 measurements came from the same samples.

The phosphorous content, Figure 3.2, did not vary greatly over the sampling period. The rolling average began at a value of 2.2 lb P_2O_5/1,000 gal and decreased to 2.1 lb P_2O_5/1,000 gal. The relatively small amount of variation in the P_2O_5 data suggests that the sampling methods were consistent from month to month. However, the concentration of phosphorous can be effected by rainfall, frequency of pumping, and variations in the amount of manure added.

The plant available nitrogen, PAN, varied from month to month more than the phosphorous content (Figure 3.1). The greater variation in nitrogen content in liquid manure is due to variations in the volatilization losses. Rainfall, pumping frequency, and variations in the amount of manure loaded each day can also effect PAN.

The variation in ammonium-N is the greatest source of fluctuation in PAN. Most of the sources of variation in PAN can not be controlled. Therefore, a rolling average of several samples provides the best value for fertilization calculations.

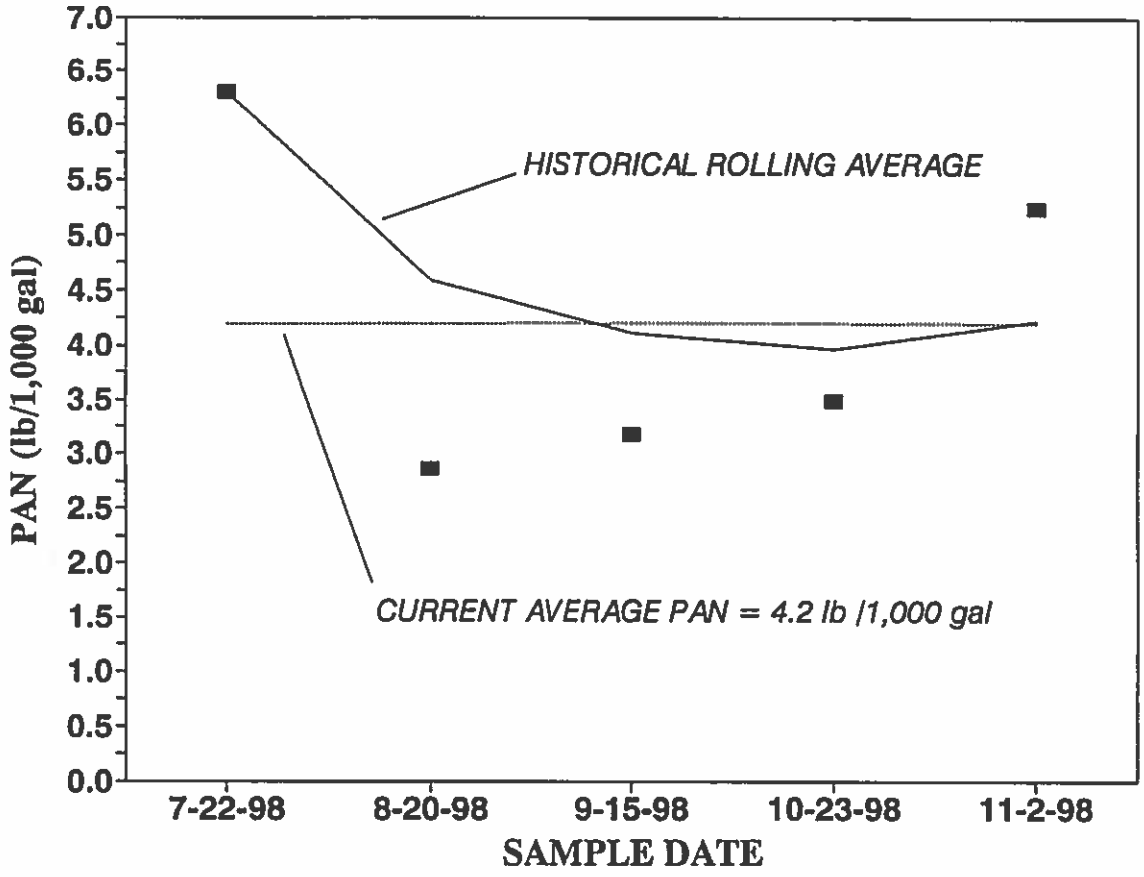

Figure 3.1. Variation in the plant available nitrogen in the top layer (1 ft) of a storage pond used to store liquid swine manure.

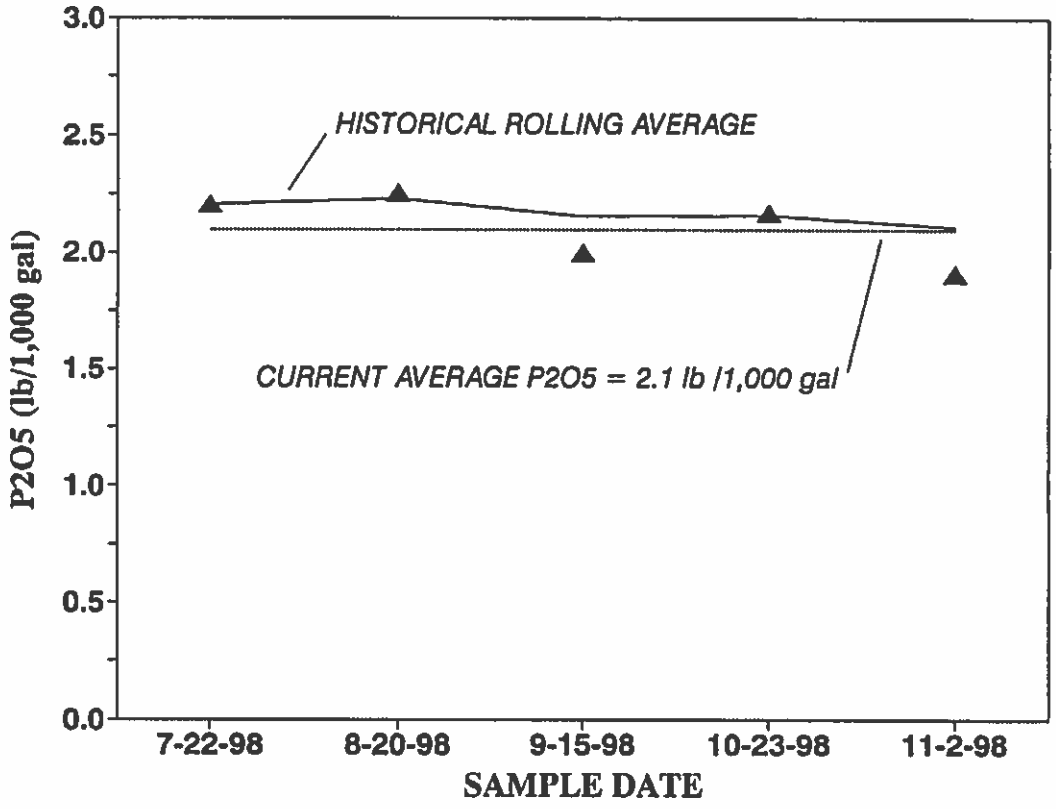

Figure 3.2. Variation in total phosphorous in the top layer of a swine manure storage pond (same samples as Figure 3.1).

Recommended Sampling Frequency

The data shown in Figure 3.1 suggests that a reasonable estimate of the nitrogen content in dilute manure can be obtained with three samples. The variation in the rolling average is relatively small after obtaining five samples. Taking more samples during the first 2 to 3 years of operation will allow a stable rolling average to be established quickly. Specific recommendations on sampling frequency are listed below.

- Lagoon or storage pond surface water is often land applied several times per year. Collect a sample prior to each application during the first two years. Reduce the sampling frequency to 2 to 3 times per year after a stable estimate of the rolling average has been obtained.
- The frequency of solids removal will vary depending on the type of structure used to store manure (see chapter 4). Solids are removed from a storage pond by agitation and pumping 1 to 4 times per year. Sludge removal from a lagoon may take place every 3 to 5 years. Collect a representative sample of agitated solids and liquids whenever possible since it often takes longer to obtain 5 to 10 samples.
- Mechanical or gravity solid-liquid separation yields manure with a relatively high solids content (3 to 30% total solids). Collect three samples from solid-liquid separation processes during the first 2 years of operation. Sampling frequency can be reduced to 1 or 2 times per year after a consistent rolling average is established.

When to Begin a New Rolling Average

A new rolling average is begun only when a major change occurs that would be expected to alter the average plant nutrient content of the manure. Examples of these types of changes are:

- addition of a new manure treatment process (such as liquid solid separation or aeration),
- change in the animal population (such as converting nursery buildings to farrowing buildings, or increasing the total number of swine), or
- making a major change in the ration that will influence nutrient content (such as changing feed sources, reducing nitrogen in the feed by feeding selected amino acids, or feeding phytase to reduce phosphorous).

Copper and Zinc Limits for Land Application of Swine Waste

In most cases, the ***agronomic rate,*** or the amount of nitrogen needed to grow a particular crop (see glossary for complete definition), is used to determine how much swine manure can be applied per acre. However, South Carolina law also requires swine producers to consider the concentrations of copper (Cu) and zinc (Zn) in the manure as part of the land application requirements. The criteria that must be satisfied are as follows.

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100.100 (B) Constituent Limits for Land Application of Swine Waste

1. Swine Waste. The Department may establish constituent limits in permits on a case-by-case basis on swine waste to be land applied. Swine waste containing only the standard constituents at normal concentrations as given by commonly accepted reference sources, such as Clemson University, American Society of Agricultural Engineers, Midwest Planning Service Document, or NRCS, can be land applied at or below agronomic rates without any specific constituent limits in a permit. When the swine waste analysis indicates there are levels of copper, or other constituent of concern, the Department will establish constituent limits in permits for each constituent of concern to ensure the water quality standards of Regulation 61-67 are maintained. For these cases the producer must comply with the following criteria:

a. Constituent Limits. If swine waste subject to a constituent limit is applied to land, either
   i. the cumulative loading rate for each constituent shall not exceed the cumulative constituent loading rate for the constituent in Table 1 of Section 100.100; or
   ii. the concentration of each constituent in the swine waste shall not exceed the concentration for the constituent in Table 2 of Section 100.100.

b. Constituent concentrations and loading rates.
   i. Cumulative constituent loading rates.

TABLE 1 OF SECTION 100.100
CUMULATIVE CONSTITUENT LOADING RATES

Constituent	*Cumulative Constituent Loading Rate*	
	(kilograms per hectare)	*(pounds per acre)*
Copper	1500	1339
Zinc	2800	2499

   ii. Constituent concentrations.

TABLE 2 OF SECTION 100.100
CONSTITUENT CONCENTRATIONS

Constituent	*Monthly Average Concentrations (milligrams per kilogram) Dry weight basis*
Copper	1500
Zinc	2800

   iii. Annual constituent loading rates.

TABLE 3 OF SECTION 100.100
CONSTITUENT CONCENTRATIONS

Constituent	*Annual Constituent Loading Rate*	
	(kilograms per hectare per 365 day period)	*(pounds per acre per 365 day period)*
Copper	75	67
Zinc	140	125

c. Additional constituents may be required, from the application information or subsequent monitoring in a permit thereafter, but such needs will be assessed on an individual project basis.

In most cases the regulatory requirements for the application of zinc and copper can be satisfied by demonstrating that the concentrations of zinc and copper are below the threshold values given in TABLE 2 OF SECTION 100.100 (see box below). The concentration of zinc in swine manure

must be less than 2800 milligrams per kilogram of dry solids (mg/kg) to be excluded from further consideration. The maximum copper concentration is 1500 mg per kg of solids.

The concentrations of zinc and copper provided by the Clemson University Agricultural Service Laboratory (see Table 3.5) are given on an as-sampled basis. Concentrations are given ppm (parts per million) and in pounds per 1,000 gallons (lb/1,000 gal). The moisture content is given in percent. The following equation can be used to convert the as-sampled copper (Cu) and zinc (Zn) contents, in ppm, to the dry basis concentration:

$$\text{mg / kg (dry basis)} = [\text{Cu or Zn Content in ppm}] \div (\text{Solids Fraction}). \quad (3.5)$$

(Note: 1 L of liquid manure has a mass very close to 1 kg.)

The solids fraction needed in equation 3.5 is calculated from the percent moisture as shown below:

$$\text{Solids Fraction} = (100 - \%\ \text{Moisture}) \div 100. \quad (3.6)$$

The nutrient content of manure with a high total solids content is typically given by the Agricultural Services Laboratory in ppm and lb/ton. Equation 3.5 can also be used for dry manure as long as the as-sampled copper and zinc concentrations are given in ppm.

Some laboratories may report the copper and zinc content on a dry weight basis (mg/kg). Therefore, it is very important to read all reports carefully to know how the data is presented.

The use of equations 3.5 and 3.6 is demonstrated in the following example.

Example 3.6 Calculate the Zn and Cu concentrations for swine storage pond water using the manure analysis given in Table 3.5. Are the Zn or Cu concentrations greater than the concern levels as defined by the regulation (TABLE 2 OF SECTION 100.100)?

Step 1: Calculate the solids fraction using equation 3.6.
The average moisture content in Table 3.5 is 99.58% . The solids fraction is $(100 - 99.58) \div 100 = 0.0042$.

Step 2: Calculate the dry matter Zn concentration using equation 3.5.
The Zn content from Table 3.5 is 1.03 ppm wet-basis. The dry matter concentration is calculated using the solids fraction from step 1 as follows.
$1.03 \text{ ppm Zn} \div 0.0042 = 245$ mg Zn / kg (dry basis). Since 245 mg/kg is less than the concern level of 2800 mg/kg we do not need to keep records of the amount of Zn applied to cropland to satisfy regulatory requirements.

Step 3: Calculate the Cu concentration in the same way as for zinc.
$0.80 \text{ ppm} \div 0.0042 = 190$ mg Cu / kg (dry basis).
The dry matter Cu concentration is also below the concern level of 1500 mg Cu/kg. Therefore, Copper will not be a limiting constituent for land application either.

The zinc and copper concentrations for all forms of swine manure that are typically used to fertilize crop or pasture land are shown in Table 3.6. These values were calculated based on the

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data given in Table 3.3. The results indicate that the concentrations of Zn and Cu (dry basis) are below the level of concern in all cases. However, all swine producers will need to test manure from their farm to prove that the Zn and Cu concentrations are below the established limits.

Table 3.6. Concentrations of zinc and copper (dry basis) in swine manure that is land applied.

	Lagoon Surface Water	Lagoon Sludge	Agitated Lagoon Water & Solids	Storage Pond Surface Water
Moisture (%)	99.63%	90.0%	97.8%	99.5%
Zinc, mg/kg	965	2143	2002	952
Copper, mg/kg	644	893	866	714

If manure analysis indicates that zinc or copper dry matter concentrations exceed the regulatory limits then the requirements given in TABLE 1 and TABLE 3 OF SECTION 100.100 must be satisfied. Records must be kept to show that the annual application rate (loading rates in regulation) of copper and zinc do not exceed the limits given in TABLE 3. Also, the cumulative application of copper and zinc must not exceed 1339 pounds of Cu per acre or 2,499 pounds of Zn per acre.

SUMMARY

Knowledge of the nutrient content of swine manure is an essential element in the design and operation of a swine manure management system. Manure volume and nutrient data have been provided that can be used for design and planning purposes. South Carolina regulations require each swine producer to sample each form of swine manure that is land applied at least annually. A rolling average is used for each form of manure applied to cropland to determine application rates. Additional details on nutrient balancing, and lagoon and storage sizing will be presented in other chapters.

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MWPS-18, 1993. Livestock Waste Facilities Handbook. Midwest Plan Service, Iowa State University, Ames, Iowa 50011-3080.

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(CAMM Poultry Chapter 3a, last edit - January, 2003 jpc)

https://www.pca.state.mn.us/sites/default/files/wq-f6-26.pdf

This booklet is prepared by the Minnesota Pollution Control Agency.

The data contained within the booklet is current as of January 1, 2012.

For questions on how to use this booklet, to report errors within the booklet, or to offer suggestions for future printings, please contact your regional Minnesota Pollution Control Agency office.

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wq-f6-26 Updated July 2012

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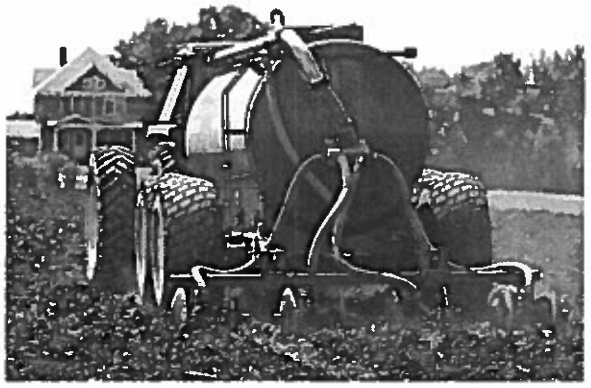
Minnesota Pollution Control Agency

Manure Application Rate Guide



Manage Manure Applications to Protect Water Quality and Save Money

Protect Your Water:

- Protect your well water and nearby surface water by using the correct application rate and observing application setbacks
- Meet state rules and regulations designed to protect water quality

Cut Your Costs:

- Potentially save $10 - $40 per acre in N fertilizer costs by using the correct application rate (based on 20 tons/acre of solid manure)
- You can double N fertilizer savings by immediately incorporating your manure

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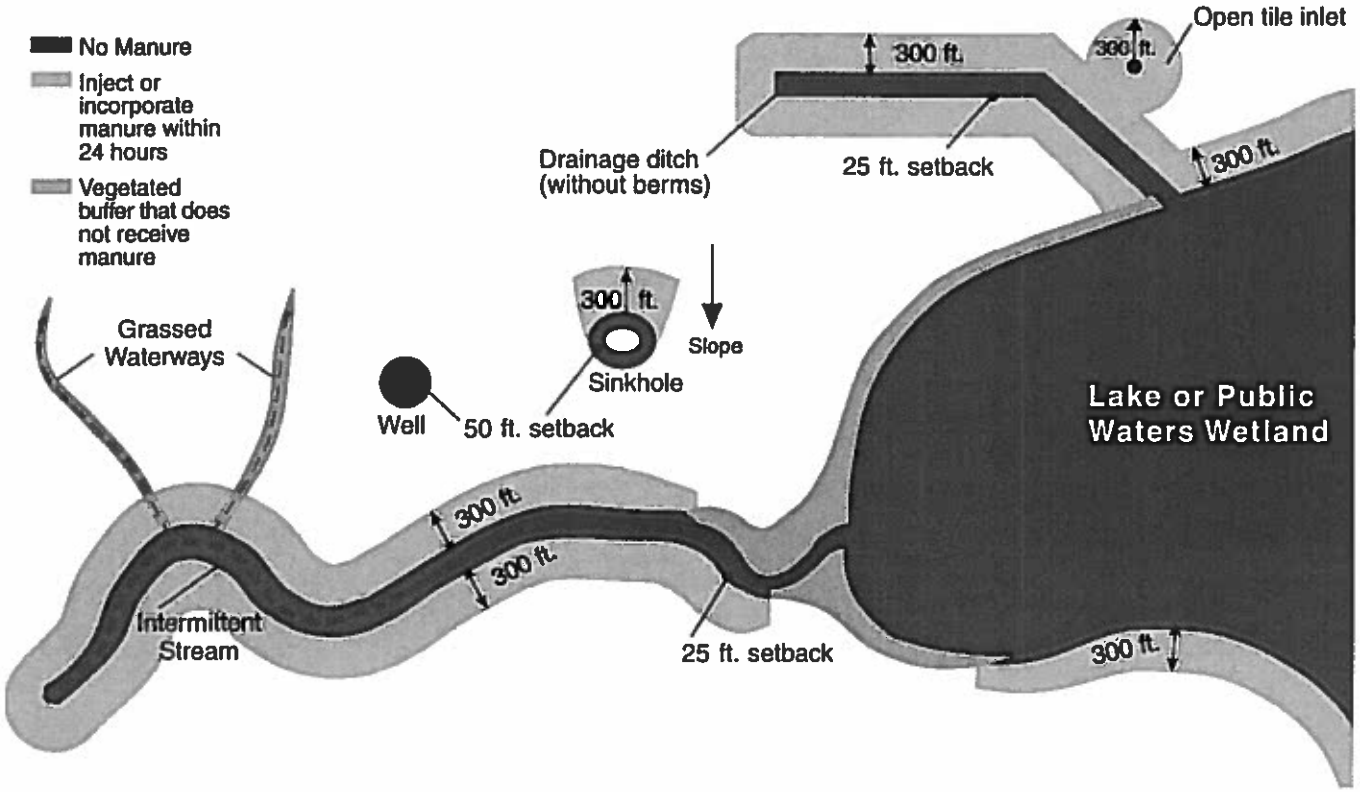
Land Application Setbacks from Waters*

(Further Details on Page 38)



* This graphic summarizes the State setback requirements. County and/or Township requirements may be more restrictive.

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How to Use This Booklet

This booklet is designed to assist anyone applying manure in determining a rate that meets the nitrogen needs of the crop(s) grown.

This booklet should not be used as a substitute for a Manure Management Plan (MMP), but is useful for facilities where a MMP is not required or for those applying manure from facilities where a MMP is not required.

To determine the application rate, first locate the correct chart using the animal and manure type and the method of incorporation at the top of each chart.

Then, identify the manure nitrogen test value in lbs/1000gal or lbs/ton in the far left column.

Next, locate the desired amount of nitrogen you want to be <u>available</u> to the crop(s) grown in the top row of the chart.

Where these two values intersect on the chart is the desired application rate in either 1,000's of gallons per acre or tons per acre.

It is important to note that, due to rounding, applied nitrogen rates may be slightly higher or lower than the values shown in the chart.

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EXAMPLE

Sweep injected liquid swine manure with a nitrogen test value of 52 lbs/1,000 gal.
To obtain 180 lbs of **available** nitrogen the application rate would be 4,500 gal/acre.

Manure Type: Swine Liquids **Incorp:** Sweep Injection **% Avail:** 80%

Manure Application Rate (1,000 gal/acre)											
Manure N Test	**Desired Available N (lbs/acre)**										
	60	80	100	120	130	140	150	160	170	180	200
20	4.0	5.0	6.5	7.5	8.0	9.0	9.5	10.0	10.5	11.5	12.5
24	3.0	4.0	5.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.5
28	2.5	3.5	4.5	5.5	6.0	6.5	6.5	7.0	7.5	8.0	9.0
32	2.5	3.0	4.0	4.5	5.0	5.5	6.0	6.5	6.5	7.0	8.0
36	2.0	3.0	3.5	4.0	4.5	5.0	5.0	5.5	6.0	6.5	7.0
40	2.0	2.5	3.0	4.0	4.0	4.5	4.5	5.0	5.5	5.5	6.5
44	1.5	2.5	3.0	3.5	3.5	4.0	4.5	4.5	5.0	5.0	5.5
48	1.5	2.0	2.5	3.0	3.5	3.5	4.0	4.0	4.5	4.5	5.0
52	1.5	2.0	2.5	3.0	3.0	3.5	3.5	4.0	4.0	4.5	5.0
56	1.5	2.0	2.0	2.5	3.0	3.0	3.5	3.5	4.0	4.0	4.5
60	1.5	1.5	2.0	2.5	2.5	3.0	3.0	3.5	3.5	4.0	4.0
66	1.0	1.5	2.0	2.5	2.5	2.5	3.0	3.0	3.0	3.5	4.0
72	1.0	1.5	1.5	2.0	2.5	2.5	2.5	3.0	3.0	3.0	3.5
78	1.0	1.5	1.5	2.0	2.0	2.0	2.5	2.5	2.5	3.0	3.0

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Estimated Nutrient Content of Liquid and Solid Manure*

Animal Type	Liquid Manure (lbs/1000 gal)			Solid Manure (lbs/ton)		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Beef						
Feeder Cattle/Slaughter Steer	29	18	26	11	7	11
Cow	20	16	24	7	4	7
Calf	27	18	24	9	4	8
Dairy						
Milk Cow	31	15	19	10	3	6
Heifer	32	14	28	10	3	7
Calf	27	14	24	10	3	5
Swine						
Nursery	25	19	22	13	8	4
Finishing	58	44	40	22	22	17
Farrowing	15	12	11	14	6	4
Gestation	25	25	24	9	7	5
Poultry						
Layers	57	52	33	34	51	26
Broilers	63	40	29	46	53	36
Turkey - Tom	53	40	29	40	50	30
Turkey - Hen	60	38	32	40	50	30

* When possible actual manure test results should be used in place of these estimates

Sources – Manure Management in MN (MN Extension Service 2007) & MWPS-18 Sec 1 (2004)

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Nitrogen Availability and Loss, as Affected by Method of Manure Application and Animal Species

Year Available	% of Total Nitrogen Available Per Year				
	Broadcast Incorporation Timing			Injection	
	After 96 hrs.	12 to 96 hrs.	Within 12 hrs.	Sweep	Knife
Beef					
Year 1	25	45	60	60	50
Year 2	25	25	25	25	25
Lost	40	20	5	5	10
Dairy					
Year 1	20	40	55	55	50
Year 2	25	25	25	25	25
Lost	40	20	10	5	10
Swine					
Year 1	35	55	75	80	70
Year 2	15	15	15	15	15
Lost	50	30	10	5	15
Poultry					
Year 1	45	55	70	70	70
Year 2	25	25	25	25	25
Lost	30	20	5	5	5

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Nitrogen Needs and Removal for Various Crops*

Crop	Yield	Crop Last Year	Crop 2 years ago	Max N Needed	Max N Removed
Corn	Any	Corn	No Alfalfa	180	---
Corn	Any	Corn	Alfalfa	130	---
Corn	Any	Soybeans	No Alfalfa	140	---
Corn	Any	Alfalfa	Any	80	---
Corn Silage	Any	Corn	Corn	180	---
Corn Silage	Any	Corn	Alfalfa	130	---
Corn Silage	Any	Alfalfa	Any	80	---
Wheat	60 - 69 bu	Corn	No Alfalfa	110	---
Wheat	60 - 69 bu	Soybeans	No Alfalfa	90	---
Oats	81 - 100 bu	Corn	No Alfalfa	70	---
Oats	81 - 100 bu	Soybeans	No Alfalfa	30	---
Sweet Corn	8 - 9 ton	Corn	Any	120	---
Sweet Corn	8 - 9 ton	Soybeans	Any	90	---
Soybeans	50 bu	Any	Any	---	175
Alfalfa	5 ton	Any	Any	---	252
Grass/Legume	4 ton	Any	Any	---	174

* The nitrogen needs values, in this chart, represent the upper-end of typical crop nitrogen needs and may not be the best nitrogen recommendation for every case. To obtain specific nitrogen recommendations please refer to the applicable University of Minnesota publication(s).

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Manure Type: Swine Liquids **Incorp:** After 4 days **% Avail:** 35%

Manure Application Rate (1,000 gal/acre)											
Manure	**Desired Available N (lbs/acre)**										
N Test	**60**	**80**	**100**	**120**	**130**	**140**	**150**	**160**	**170**	**180**	**200**
8	21.5	28.5	35.5	43.0	46.5	50.0	53.5	57.0	60.5	64.5	71.5
12	14.5	19.0	24.0	28.5	31.0	33.5	35.5	38.0	40.5	43.0	47.5
16	10.5	14.5	18.0	21.5	23.0	25.0	27.0	28.5	30.5	32.0	35.5
20	8.5	11.5	14.5	17.0	18.5	20.0	21.5	23.0	24.5	25.5	28.5
24	7.0	9.5	12.0	14.5	15.5	16.5	18.0	19.0	20.0	21.5	24.0
28	6.0	8.0	10.0	12.0	13.5	14.5	15.5	16.5	17.5	18.5	20.5
32	5.5	7.0	9.0	10.5	11.5	12.5	13.5	14.5	15.0	16.0	18.0
36	5.0	6.5	8.0	9.5	10.5	11.0	12.0	12.5	13.5	14.5	16.0
40	4.5	5.5	7.0	8.5	9.5	10.0	10.5	11.5	12.0	13.0	14.5
44	4.0	5.0	6.5	8.0	8.5	9.0	9.5	10.5	11.0	11.5	13.0
48	3.5	5.0	6.0	7.0	7.5	8.5	9.0	9.5	10.0	10.5	12.0
52	3.5	4.5	5.5	6.5	7.0	7.5	8.0	9.0	9.5	10.0	11.0
56	3.0	4.0	5.0	6.0	6.5	7.0	7.5	8.0	8.5	9.0	10.0
60	3.0	4.0	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.5
66	2.5	3.5	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5
72	2.5	3.0	4.0	5.0	5.0	5.5	6.0	6.5	6.5	7.0	8.0
78	2.0	3.0	3.5	4.5	5.0	5.0	5.5	6.0	6.0	6.5	7.5
84	2.0	2.5	3.5	4.0	4.5	5.0	5.0	5.5	6.0	6.0	7.0

001000

Manure Type: Swine Liquids **Incorp:** (12 – 96 hours) **% Avail:** 55%

Manure Application Rate (1,000 gal/acre)											
Manure N Test	**Desired Available N (lbs/acre)**										
	60	**80**	**100**	**120**	**130**	**140**	**150**	**160**	**170**	**180**	**200**
8	13.5	18.0	22.5	27.5	29.5	32.0	34.0	36.5	38.5	41.0	45.5
12	9.0	12.0	15.0	18.0	19.5	21.0	22.5	24.0	26.0	27.5	30.5
16	7.0	9.0	11.5	13.5	15.0	16.0	17.0	18.0	19.5	20.5	22.5
20	5.5	7.5	9.0	11.0	12.0	12.5	13.5	14.5	15.5	16.5	18.0
24	4.5	6.0	7.5	9.0	10.0	10.5	11.5	12.0	13.0	13.5	15.0
28	4.0	5.0	6.5	8.0	8.5	9.0	9.5	10.5	11.0	11.5	13.0
32	3.5	4.5	5.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	11.5
36	3.0	4.0	5.0	6.0	6.5	7.0	7.5	8.0	8.5	9.0	10.0
40	2.5	3.5	4.5	5.5	6.0	6.5	7.0	7.5	7.5	8.0	9.0
44	2.5	3.5	4.0	5.0	5.5	6.0	6.0	6.5	7.0	7.5	8.5
48	2.5	3.0	4.0	4.5	5.0	5.5	5.5	6.0	6.5	7.0	7.5
52	2.0	3.0	3.5	4.0	4.5	5.0	5.0	5.5	6.0	6.5	7.0
56	2.0	2.5	3.0	4.0	4.0	4.5	5.0	5.0	5.5	6.0	6.5
60	2.0	2.5	3.0	3.5	4.0	4.0	4.5	5.0	5.0	5.5	6.0
66	1.5	2.0	3.0	3.5	3.5	4.0	4.0	4.5	4.5	5.0	5.5
72	1.5	2.0	2.5	3.0	3.5	3.5	4.0	4.0	4.5	4.5	5.0
78	1.5	2.0	2.5	3.0	3.0	3.5	3.5	3.5	4.0	4.0	4.5
84	1.5	1.5	2.0	2.5	3.0	3.0	3.0	3.5	3.5	4.0	4.5

001001

Manure Type: Swine Liquids **Incorp:** (Within 12 hours) **% Avail:** 75%

Manure Application Rate (1,000 gal/acre)											
Manure	**Desired Available N (lbs/acre)**										
N Test	**60**	**80**	**100**	**120**	**130**	**140**	**150**	**160**	**170**	**180**	**200**
8	10.0	13.5	16.5	20.0	21.5	23.5	25.0	26.5	28.5	30.0	33.5
12	6.5	9.0	11.0	13.5	14.5	15.5	16.5	18.0	19.0	20.0	22.0
16	5.0	6.5	8.5	10.0	11.0	11.5	12.5	13.5	14.0	15.0	16.5
20	4.0	5.5	6.5	8.0	8.5	9.5	10.0	10.5	11.5	12.0	13.5
24	3.5	4.5	5.5	6.5	7.0	8.0	8.5	9.0	9.5	10.0	11.0
28	3.0	4.0	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.5
32	2.5	3.5	4.0	5.0	5.5	6.0	6.5	6.5	7.0	7.5	8.5
36	2.0	3.0	3.5	4.5	5.0	5.0	5.5	6.0	6.5	6.5	7.5
40	2.0	2.5	3.5	4.0	4.5	4.5	5.0	5.5	5.5	6.0	6.5
44	2.0	2.5	3.0	3.5	4.0	4.0	4.5	5.0	5.0	5.5	6.0
48	1.5	2.0	3.0	3.5	3.5	4.0	4.0	4.5	4.5	5.0	5.5
52	1.5	2.0	2.5	3.0	3.5	3.5	4.0	4.0	4.5	4.5	5.0
56	1.5	2.0	2.5	3.0	3.0	3.5	3.5	4.0	4.0	4.5	5.0
60	1.5	2.0	2.0	2.5	3.0	3.0	3.5	3.5	4.0	4.0	4.5
66	1.0	1.5	2.0	2.5	2.5	3.0	3.0	3.0	3.5	3.5	4.0
72	1.0	1.5	2.0	2.0	2.5	2.5	3.0	3.0	3.0	3.5	3.5
78	1.0	1.5	1.5	2.0	2.0	2.5	2.5	2.5	3.0	3.0	3.5
84	1.0	1.5	1.5	2.0	2.0	2.0	2.5	2.5	2.5	3.0	3.0

001002

Manure Type: Swine Liquids **Incorp:** (Sweep Injection) **% Avail:** 80%

Manure Application Rate (1,000 gal/acre)											
Manure	**Desired Available N (lbs/acre)**										
N Test	**60**	**80**	**100**	**120**	**130**	**140**	**150**	**160**	**170**	**180**	**200**
8	9.5	12.5	15.5	19.0	20.5	22.0	23.5	25.0	26.5	28.0	31.5
12	6.5	8.5	10.5	12.5	13.5	14.5	15.5	16.5	17.5	18.5	21.0
16	4.5	6.5	8.0	9.5	10.0	11.0	11.5	12.5	13.5	14.0	15.5
20	4.0	5.0	6.5	7.5	8.0	9.0	9.5	10.0	10.5	11.5	12.5
24	3.0	4.0	5.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.5
28	2.5	3.5	4.5	5.5	6.0	6.5	6.5	7.0	7.5	8.0	9.0
32	2.5	3.0	4.0	4.5	5.0	5.5	6.0	6.5	6.5	7.0	8.0
36	2.0	3.0	3.5	4.0	4.5	5.0	5.0	5.5	6.0	6.5	7.0
40	2.0	2.5	3.0	4.0	4.0	4.5	4.5	5.0	5.5	5.5	6.5
44	1.5	2.5	3.0	3.5	3.5	4.0	4.5	4.5	5.0	5.0	5.5
48	1.5	2.0	2.5	3.0	3.5	3.5	4.0	4.0	4.5	4.5	5.0
52	1.5	2.0	2.5	3.0	3.0	3.5	3.5	4.0	4.0	4.5	5.0
56	1.5	2.0	2.0	2.5	3.0	3.0	3.5	3.5	4.0	4.0	4.5
60	1.5	1.5	2.0	2.5	2.5	3.0	3.0	3.5	3.5	4.0	4.0
66	1.0	1.5	2.0	2.5	2.5	2.5	3.0	3.0	3.0	3.5	4.0
72	1.0	1.5	1.5	2.0	2.5	2.5	2.5	3.0	3.0	3.0	3.5
78	1.0	1.5	1.5	2.0	2.0	2.0	2.5	2.5	2.5	3.0	3.0
84	1.0	1.0	1.5	2.0	2.0	2.0	2.0	2.5	2.5	2.5	3.0

001003

Manure Type: Swine Liquids **Incorp:** (Knife Injection) **% Avail:** 70%

Manure Application Rate (1,000 gal/acre)											
Manure	**Desired Available N (lbs/acre)**										
N Test	60	80	100	120	130	140	150	160	170	180	200
8	10.5	14.5	18.0	21.5	23.0	25.0	27.0	28.5	30.5	32.0	35.5
12	7.0	9.5	12.0	14.5	15.5	16.5	18.0	19.0	20.0	21.5	24.0
16	5.5	7.0	9.0	10.5	11.5	12.5	13.5	14.5	15.0	16.0	18.0
20	4.5	5.5	7.0	8.5	9.5	10.0	10.5	11.5	12.0	13.0	14.5
24	3.5	5.0	6.0	7.0	7.5	8.5	9.0	9.5	10.0	10.5	12.0
28	3.0	4.0	5.0	6.0	6.5	7.0	7.5	8.0	8.5	9.0	10.0
32	2.5	3.5	4.5	5.5	6.0	6.5	6.5	7.0	7.5	8.0	9.0
36	2.5	3.0	4.0	5.0	5.0	5.5	6.0	6.5	6.5	7.0	8.0
40	2.0	3.0	3.5	4.5	4.5	5.0	5.5	5.5	6.0	6.5	7.0
44	2.0	2.5	3.0	4.0	4.0	4.5	5.0	5.0	5.5	6.0	6.5
48	2.0	2.5	3.0	3.5	4.0	4.0	4.5	5.0	5.0	5.5	6.0
52	1.5	2.0	2.5	3.5	3.5	4.0	4.0	4.5	4.5	5.0	5.5
56	1.5	2.0	2.5	3.0	3.5	3.5	4.0	4.0	4.5	4.5	5.0
60	1.5	2.0	2.5	3.0	3.0	3.5	3.5	4.0	4.0	4.5	5.0
66	1.5	1.5	2.0	2.5	3.0	3.0	3.0	3.5	3.5	4.0	4.5
72	1.0	1.5	2.0	2.5	2.5	3.0	3.0	3.0	3.5	3.5	4.0
78	1.0	1.5	2.0	2.0	2.5	2.5	2.5	3.0	3.0	3.5	3.5
84	1.0	1.5	1.5	2.0	2.0	2.5	2.5	2.5	3.0	3.0	3.5

001004

Manure Type: Swine Solids **Incorp:** After 4 Days **% Avail:** 35%

Manure Application Rate (ton/acre)											
Manure N Test	**Desired Available N (lbs/acre)**										
	60	80	100	120	130	140	150	160	170	180	200
2	85.5	114.5	143.0	171.5	185.5	200.0	214.5	228.5	243.0	257.0	285.5
4	43.0	57.0	71.5	85.5	93.0	100.0	107.0	114.5	121.5	128.5	143.0
6	28.5	38.0	47.5	57.0	62.0	66.5	71.5	76.0	81.0	85.5	95.0
8	21.5	28.5	35.5	43.0	46.5	50.0	53.5	57.0	60.5	64.5	71.5
10	17.0	23.0	28.5	34.5	37.0	40.0	43.0	45.5	48.5	51.5	57.0
12	14.5	19.0	24.0	28.5	31.0	33.5	35.5	38.0	40.5	43.0	47.5
14	12.0	16.5	20.5	24.5	26.5	28.5	30.5	32.5	34.5	36.5	41.0
16	10.5	14.5	18.0	21.5	23.0	25.0	27.0	28.5	30.5	32.0	35.5
18	9.5	12.5	16.0	19.0	20.5	22.0	24.0	25.5	27.0	28.5	31.5
20	8.5	11.5	14.5	17.0	18.5	20.0	21.5	23.0	24.5	25.5	28.5
22	8.0	10.5	13.0	15.5	17.0	18.0	19.5	21.0	22.0	23.5	26.0
24	7.0	9.5	12.0	14.5	15.5	16.5	18.0	19.0	20.0	21.5	24.0
26	6.5	9.0	11.0	13.0	14.5	15.5	16.5	17.5	18.5	20.0	22.0
28	6.0	8.0	10.0	12.0	13.5	14.5	15.5	16.5	17.5	18.5	20.5
30	5.5	7.5	9.5	11.5	12.5	13.5	14.5	15.0	16.0	17.0	19.0

001005

Manure Type: Swine Solids **Incorp:** 12-96 hours **% Avail:** 55%

Manure Application Rate (ton /acre)											
Manure N Test	**Desired Available N (lbs/acre)**										
	60	80	100	120	130	140	150	160	170	180	200
2	54.5	72.5	91.0	109.0	118.0	127.5	136.5	145.5	154.5	163.5	182.0
4	27.5	36.5	45.5	54.5	59.0	63.5	68.0	72.5	77.5	82.0	91.0
6	18.0	24.0	30.5	36.5	39.5	42.5	45.5	48.5	51.5	54.5	60.5
8	13.5	18.0	22.5	27.5	29.5	32.0	34.0	36.5	38.5	41.0	45.5
10	11.0	14.5	18.0	22.0	23.5	25.5	27.5	29.0	31.0	32.5	36.5
12	9.0	12.0	15.0	18.0	19.5	21.0	22.5	24.0	26.0	27.5	30.5
14	8.0	10.5	13.0	15.5	17.0	18.0	19.5	21.0	22.0	23.5	26.0
16	7.0	9.0	11.5	13.5	15.0	16.0	17.0	18.0	19.5	20.5	22.5
18	6.0	8.0	10.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	20.0
20	5.5	7.5	9.0	11.0	12.0	12.5	13.5	14.5	15.5	16.5	18.0
22	5.0	6.5	8.5	10.0	10.5	11.5	12.5	13.0	14.0	15.0	16.5
24	4.5	6.0	7.5	9.0	10.0	10.5	11.5	12.0	13.0	13.5	15.0
26	4.0	5.5	7.0	8.5	9.0	10.0	10.5	11.0	12.0	12.5	14.0
28	4.0	5.0	6.5	8.0	8.5	9.0	9.5	10.5	11.0	11.5	13.0
30	3.5	5.0	6.0	7.5	8.0	8.5	9.0	9.5	10.5	11.0	12.0

001006

Manure Type: Swine Solids **Incorp:** (Within 12 hours) **% Avail:** 75%

Manure Application Rate (ton/acre)											
Manure N Test	**Desired Available N (lbs/acre)**										
	60	80	100	120	130	140	150	160	170	180	200
2	40.0	53.5	66.5	80.0	86.5	93.5	100.0	106.5	113.5	120.0	133.5
4	20.0	26.5	33.5	40.0	43.5	46.5	50.0	53.5	56.5	60.0	66.5
6	13.5	18.0	22.0	26.5	29.0	31.0	33.5	35.5	38.0	40.0	44.5
8	10.0	13.5	16.5	20.0	21.5	23.5	25.0	26.5	28.5	30.0	33.5
10	8.0	10.5	13.5	16.0	17.5	18.5	20.0	21.5	22.5	24.0	26.5
12	6.5	9.0	11.0	13.5	14.5	15.5	16.5	18.0	19.0	20.0	22.0
14	5.5	7.5	9.5	11.5	12.5	13.5	14.5	15.0	16.0	17.0	19.0
16	5.0	6.5	8.5	10.0	11.0	11.5	12.5	13.5	14.0	15.0	16.5
18	4.5	6.0	7.5	9.0	9.5	10.5	11.0	12.0	12.5	13.5	15.0
20	4.0	5.5	6.5	8.0	8.5	9.5	10.0	10.5	11.5	12.0	13.5
22	3.5	5.0	6.0	7.5	8.0	8.5	9.0	9.5	10.5	11.0	12.0
24	3.5	4.5	5.5	6.5	7.0	8.0	8.5	9.0	9.5	10.0	11.0
26	3.0	4.0	5.0	6.0	6.5	7.0	7.5	8.0	8.5	9.0	10.5
28	3.0	4.0	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.5
30	2.5	3.5	4.5	5.5	6.0	6.0	6.5	7.0	7.5	8.0	9.0

001007

Manure Type: Dairy Liquids **Incorp:** After 4 days **% Avail:** 20%

Manure Application Rate (1,000 gal/acre)											
Manure	**Desired Available N (lbs/acre)**										
N Test	60	80	100	120	130	140	150	160	170	180	200
6	50.0	66.5	83.5	100.0	108.5	116.5	125.0	133.5	141.5	150.0	166.5
8	37.5	50.0	62.5	75.0	81.5	87.5	94.0	100.0	106.5	112.5	125.0
10	30.0	40.0	50.0	60.0	65.0	70.0	75.0	80.0	85.0	90.0	100.0
12	25.0	33.5	41.5	50.0	54.0	58.5	62.5	66.5	71.0	75.0	83.5
14	21.5	28.5	35.5	43.0	46.5	50.0	53.5	57.0	60.5	64.5	71.5
16	19.0	25.0	31.5	37.5	40.5	44.0	47.0	50.0	53.0	56.5	62.5
18	16.5	22.0	28.0	33.5	36.0	39.0	41.5	44.5	47.0	50.0	55.5
20	15.0	20.0	25.0	30.0	32.5	35.0	37.5	40.0	42.5	45.0	50.0
22	13.5	18.0	22.5	27.5	29.5	32.0	34.0	36.5	38.5	41.0	45.5
24	12.5	16.5	21.0	25.0	27.0	29.0	31.0	33.5	35.5	37.5	41.5
26	11.5	15.5	19.0	23.0	25.0	27.0	29.0	31.0	32.5	34.5	38.5
28	10.5	14.5	18.0	21.5	23.0	25.0	27.0	28.5	30.5	32.0	35.5
30	10.0	13.5	16.5	20.0	21.5	23.5	25.0	26.5	28.5	30.0	33.5
32	9.5	12.5	15.5	19.0	20.5	22.0	23.5	25.0	26.5	28.0	31.5
34	9.0	12.0	14.5	17.5	19.0	20.5	22.0	23.5	25.0	26.5	29.5
36	8.5	11.0	14.0	16.5	18.0	19.5	21.0	22.0	23.5	25.0	28.0
38	8.0	10.5	13.0	16.0	17.0	18.5	19.5	21.0	22.5	23.5	26.5
40	7.5	10.0	12.5	15.0	16.5	17.5	19.0	20.0	21.5	22.5	25.0

001008

Manure Type: Dairy Liquids **Incorp:** (12 - 96 hours) **% Avail:** 40%

Manure Application Rate (1,000 gal/acre)											
Manure	**Desired Available N (lbs/acre)**										
N Test	**60**	**80**	**100**	**120**	**130**	**140**	**150**	**160**	**170**	**180**	**200**
6	25.0	33.5	41.5	50.0	54.0	58.5	62.5	66.5	71.0	75.0	83.5
8	19.0	25.0	31.5	37.5	40.5	44.0	47.0	50.0	53.0	56.5	62.5
10	15.0	20.0	25.0	30.0	32.5	35.0	37.5	40.0	42.5	45.0	50.0
12	12.5	16.5	21.0	25.0	27.0	29.0	31.0	33.5	35.5	37.5	41.5
14	10.5	14.5	18.0	21.5	23.0	25.0	27.0	28.5	30.5	32.0	35.5
16	9.5	12.5	15.5	19.0	20.5	22.0	23.5	25.0	26.5	28.0	31.5
18	8.5	11.0	14.0	16.5	18.0	19.5	21.0	22.0	23.5	25.0	28.0
20	7.5	10.0	12.5	15.0	16.5	17.5	19.0	20.0	21.5	22.5	25.0
22	7.0	9.0	11.5	13.5	15.0	16.0	17.0	18.0	19.5	20.5	22.5
24	6.5	8.5	10.5	12.5	13.5	14.5	15.5	16.5	17.5	18.5	21.0
26	6.0	7.5	9.5	11.5	12.5	13.5	14.5	15.5	16.5	17.5	19.0
28	5.5	7.0	9.0	10.5	11.5	12.5	13.5	14.5	15.0	16.0	18.0
30	5.0	6.5	8.5	10.0	11.0	11.5	12.5	13.5	14.0	15.0	16.5
32	4.5	6.5	8.0	9.5	10.0	11.0	11.5	12.5	13.5	14.0	15.5
34	4.5	6.0	7.5	9.0	9.5	10.5	11.0	12.0	12.5	13.0	14.5
36	4.0	5.5	7.0	8.5	9.0	9.5	10.5	11.0	12.0	12.5	14.0
38	4.0	5.5	6.5	8.0	8.5	9.0	10.0	10.5	11.0	12.0	13.0
40	4.0	5.0	6.5	7.5	8.0	9.0	9.5	10.0	10.5	11.5	12.5

001009

Manure Type: Dairy Liquids **Incorp:** (Within 12 hours) **% Avail:** 55%

Manure Application Rate (1,000 gal/acre)											
Manure	**Desired Available N (lbs/acre)**										
N Test	60	80	100	120	130	140	150	160	170	180	200
6	18.0	24.0	30.5	36.5	39.5	42.5	45.5	48.5	51.5	54.5	60.5
8	13.5	18.0	22.5	27.5	29.5	32.0	34.0	36.5	38.5	41.0	45.5
10	11.0	14.5	18.0	22.0	23.5	25.5	27.5	29.0	31.0	32.5	36.5
12	9.0	12.0	15.0	18.0	19.5	21.0	22.5	24.0	26.0	27.5	30.5
14	8.0	10.5	13.0	15.5	17.0	18.0	19.5	21.0	22.0	23.5	26.0
16	7.0	9.0	11.5	13.5	15.0	16.0	17.0	18.0	19.5	20.5	22.5
18	6.0	8.0	10.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	20.0
20	5.5	7.5	9.0	11.0	12.0	12.5	13.5	14.5	15.5	16.5	18.0
22	5.0	6.5	8.5	10.0	10.5	11.5	12.5	13.0	14.0	15.0	16.5
24	4.5	6.0	7.5	9.0	10.0	10.5	11.5	12.0	13.0	13.5	15.0
26	4.0	5.5	7.0	8.5	9.0	10.0	10.5	11.0	12.0	12.5	14.0
28	4.0	5.0	6.5	8.0	8.5	9.0	9.5	10.5	11.0	11.5	13.0
30	3.5	5.0	6.0	7.5	8.0	8.5	9.0	9.5	10.5	11.0	12.0
32	3.5	4.5	5.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	11.5
34	3.0	4.5	5.5	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.5
36	3.0	4.0	5.0	6.0	6.5	7.0	7.5	8.0	8.5	9.0	10.0
38	3.0	4.0	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.5
40	2.5	3.5	4.5	5.5	6.0	6.5	7.0	7.5	7.5	8.0	9.0

001010

Manure Type: Dairy Liquids **Incorp:** (Sweep Injection) **% Avail:** 55%

Manure Application Rate (1,000 gal/acre)											
Manure	**Desired Available N (lbs/acre)**										
N Test	60	80	100	120	130	140	150	160	170	180	200
6	18.0	24.0	30.5	36.5	39.5	42.5	45.5	48.5	51.5	54.5	60.5
8	13.5	18.0	22.5	27.5	29.5	32.0	34.0	36.5	38.5	41.0	45.5
10	11.0	14.5	18.0	22.0	23.5	25.5	27.5	29.0	31.0	32.5	36.5
12	9.0	12.0	15.0	18.0	19.5	21.0	22.5	24.0	26.0	27.5	30.5
14	8.0	10.5	13.0	15.5	17.0	18.0	19.5	21.0	22.0	23.5	26.0
16	7.0	9.0	11.5	13.5	15.0	16.0	17.0	18.0	19.5	20.5	22.5
18	6.0	8.0	10.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	20.0
20	5.5	7.5	9.0	11.0	12.0	12.5	13.5	14.5	15.5	16.5	18.0
22	5.0	6.5	8.5	10.0	10.5	11.5	12.5	13.0	14.0	15.0	16.5
24	4.5	6.0	7.5	9.0	10.0	10.5	11.5	12.0	13.0	13.5	15.0
26	4.0	5.5	7.0	8.5	9.0	10.0	10.5	11.0	12.0	12.5	14.0
28	4.0	5.0	6.5	8.0	8.5	9.0	9.5	10.5	11.0	11.5	13.0
30	3.5	5.0	6.0	7.5	8.0	8.5	9.0	9.5	10.5	11.0	12.0
32	3.5	4.5	5.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	11.5
34	3.0	4.5	5.5	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.5
36	3.0	4.0	5.0	6.0	6.5	7.0	7.5	8.0	8.5	9.0	10.0
38	3.0	4.0	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.5
40	2.5	3.5	4.5	5.5	6.0	6.5	7.0	7.5	7.5	8.0	9.0

001011

Manure Type: Dairy Liquids **Incorp:** (Knife Injection) **% Avail:** 50%

Manure Application Rate (1,000 gal/acre)											
Manure	**Desired Available N (lbs/acre)**										
N Test	60	80	100	120	130	140	150	160	170	180	200
6	20.0	26.5	33.5	40.0	43.5	46.5	50.0	53.5	56.5	60.0	66.5
8	15.0	20.0	25.0	30.0	32.5	35.0	37.5	40.0	42.5	45.0	50.0
10	12.0	16.0	20.0	24.0	26.0	28.0	30.0	32.0	34.0	36.0	40.0
12	10.0	13.5	16.5	20.0	21.5	23.5	25.0	26.5	28.5	30.0	33.5
14	8.5	11.5	14.5	17.0	18.5	20.0	21.5	23.0	24.5	25.5	28.5
16	7.5	10.0	12.5	15.0	16.5	17.5	19.0	20.0	21.5	22.5	25.0
18	6.5	9.0	11.0	13.5	14.5	15.5	16.5	18.0	19.0	20.0	22.0
20	6.0	8.0	10.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	20.0
22	5.5	7.5	9.0	11.0	12.0	12.5	13.5	14.5	15.5	16.5	18.0
24	5.0	6.5	8.5	10.0	11.0	11.5	12.5	13.5	14.0	15.0	16.5
26	4.5	6.0	7.5	9.0	10.0	11.0	11.5	12.5	13.0	14.0	15.5
28	4.5	5.5	7.0	8.5	9.5	10.0	10.5	11.5	12.0	13.0	14.5
30	4.0	5.5	6.5	8.0	8.5	9.5	10.0	10.5	11.5	12.0	13.5
32	4.0	5.0	6.5	7.5	8.0	9.0	9.5	10.0	10.5	11.5	12.5
34	3.5	4.5	6.0	7.0	7.5	8.0	9.0	9.5	10.0	10.5	12.0
36	3.5	4.5	5.5	6.5	7.0	8.0	8.5	9.0	9.5	10.0	11.0
38	3.0	4.0	5.5	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.5
40	3.0	4.0	5.0	6.0	6.5	7.0	7.5	8.0	8.5	9.0	10.0

001012

Manure Type: Dairy Solids **Incorp:** After 4 days **% Avail:** 20%

Manure Application Rate (ton/acre)											
Manure N Test	**Desired Available N (lbs/acre)**										
	60	80	100	120	130	140	150	160	170	180	200
2	150.0	200.0	250.0	300.0	325.0	350.0	375.0	400.0	425.0	450.0	500.0
4	75.0	100.0	125.0	150.0	162.5	175.0	187.5	200.0	212.5	225.0	250.0
6	50.0	66.5	83.5	100.0	108.5	116.5	125.0	133.5	141.5	150.0	166.5
8	37.5	50.0	62.5	75.0	81.5	87.5	94.0	100.0	106.5	112.5	125.0
10	30.0	40.0	50.0	60.0	65.0	70.0	75.0	80.0	85.0	90.0	100.0
12	25.0	33.5	41.5	50.0	54.0	58.5	62.5	66.5	71.0	75.0	83.5
14	21.5	28.5	35.5	43.0	46.5	50.0	53.5	57.0	60.5	64.5	71.5
16	19.0	25.0	31.5	37.5	40.5	44.0	47.0	50.0	53.0	56.5	62.5
18	16.5	22.0	28.0	33.5	36.0	39.0	41.5	44.5	47.0	50.0	55.5
20	15.0	20.0	25.0	30.0	32.5	35.0	37.5	40.0	42.5	45.0	50.0
22	13.5	18.0	22.5	27.5	29.5	32.0	34.0	36.5	38.5	41.0	45.5
24	12.5	16.5	21.0	25.0	27.0	29.0	31.0	33.5	35.5	37.5	41.5
26	11.5	15.5	19.0	23.0	25.0	27.0	29.0	31.0	32.5	34.5	38.5
28	10.5	14.5	18.0	21.5	23.0	25.0	27.0	28.5	30.5	32.0	35.5
30	10.0	13.5	16.5	20.0	21.5	23.5	25.0	26.5	28.5	30.0	33.5

001013

Manure Type: Dairy Solids **Incorp:** 12 - 96 hours **% Avail:** 40%

Manure Application Rate (ton/acre)											
Manure N Test	**Desired Available N (lbs/acre)**										
	60	80	100	120	130	140	150	160	170	180	200
2	75.0	100.0	125.0	150.0	162.5	175.0	187.5	200.0	212.5	225.0	250.0
4	37.5	50.0	62.5	75.0	81.5	87.5	94.0	100.0	106.5	112.5	125.0
6	25.0	33.5	41.5	50.0	54.0	58.5	62.5	66.5	71.0	75.0	83.5
8	19.0	25.0	31.5	37.5	40.5	44.0	47.0	50.0	53.0	56.5	62.5
10	15.0	20.0	25.0	30.0	32.5	35.0	37.5	40.0	42.5	45.0	50.0
12	12.5	16.5	21.0	25.0	27.0	29.0	31.0	33.5	35.5	37.5	41.5
14	10.5	14.5	18.0	21.5	23.0	25.0	27.0	28.5	30.5	32.0	35.5
16	9.5	12.5	15.5	19.0	20.5	22.0	23.5	25.0	26.5	28.0	31.5
18	8.5	11.0	14.0	16.5	18.0	19.5	21.0	22.0	23.5	25.0	28.0
20	7.5	10.0	12.5	15.0	16.5	17.5	19.0	20.0	21.5	22.5	25.0
22	7.0	9.0	11.5	13.5	15.0	16.0	17.0	18.0	19.5	20.5	22.5
24	6.5	8.5	10.5	12.5	13.5	14.5	15.5	16.5	17.5	18.5	21.0
26	6.0	7.5	9.5	11.5	12.5	13.5	14.5	15.5	16.5	17.5	19.0
28	5.5	7.0	9.0	10.5	11.5	12.5	13.5	14.5	15.0	16.0	18.0
30	5.0	6.5	8.5	10.0	11.0	11.5	12.5	13.5	14.0	15.0	16.5

001014

Manure Type: Dairy Solids **Incorp:** (Within 12 hours) **% Avail:** 55%

Manure Application Rate (ton/acre)											
Manure N Test	**Desired Available N (lbs/acre)**										
	60	80	100	120	130	140	150	160	170	180	200
2	54.5	72.5	91.0	109.0	118.0	127.5	136.5	145.5	154.5	163.5	182.0
4	27.5	36.5	45.5	54.5	59.0	63.5	68.0	72.5	77.5	82.0	91.0
6	18.0	24.0	30.5	36.5	39.5	42.5	45.5	48.5	51.5	54.5	60.5
8	13.5	18.0	22.5	27.5	29.5	32.0	34.0	36.5	38.5	41.0	45.5
10	11.0	14.5	18.0	22.0	23.5	25.5	27.5	29.0	31.0	32.5	36.5
12	9.0	12.0	15.0	18.0	19.5	21.0	22.5	24.0	26.0	27.5	30.5
14	8.0	10.5	13.0	15.5	17.0	18.0	19.5	21.0	22.0	23.5	26.0
16	7.0	9.0	11.5	13.5	15.0	16.0	17.0	18.0	19.5	20.5	22.5
18	6.0	8.0	10.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	20.0
20	5.5	7.5	9.0	11.0	12.0	12.5	13.5	14.5	15.5	16.5	18.0
22	5.0	6.5	8.5	10.0	10.5	11.5	12.5	13.0	14.0	15.0	16.5
24	4.5	6.0	7.5	9.0	10.0	10.5	11.5	12.0	13.0	13.5	15.0
26	4.0	5.5	7.0	8.5	9.0	10.0	10.5	11.0	12.0	12.5	14.0
28	4.0	5.0	6.5	8.0	8.5	9.0	9.5	10.5	11.0	11.5	13.0
30	3.5	5.0	6.0	7.5	8.0	8.5	9.0	9.5	10.5	11.0	12.0

001015

Manure Type: Beef Liquids **Incorp:** After 4 days **% Avail:** 25%

Manure Application Rate (1,000 gal/acre)											
Manure	**Desired Available N (lbs/acre)**										
N Test	60	80	100	120	130	140	150	160	170	180	200
6	40.0	53.5	66.5	80.0	86.5	93.5	100.0	106.5	113.5	120.0	133.5
8	30.0	40.0	50.0	60.0	65.0	70.0	75.0	80.0	85.0	90.0	100.0
10	24.0	32.0	40.0	48.0	52.0	56.0	60.0	64.0	68.0	72.0	80.0
12	20.0	26.5	33.5	40.0	43.5	46.5	50.0	53.5	56.5	60.0	66.5
14	17.0	23.0	28.5	34.5	37.0	40.0	43.0	45.5	48.5	51.5	57.0
16	15.0	20.0	25.0	30.0	32.5	35.0	37.5	40.0	42.5	45.0	50.0
18	13.5	18.0	22.0	26.5	29.0	31.0	33.5	35.5	38.0	40.0	44.5
20	12.0	16.0	20.0	24.0	26.0	28.0	30.0	32.0	34.0	36.0	40.0
22	11.0	14.5	18.0	22.0	23.5	25.5	27.5	29.0	31.0	32.5	36.5
24	10.0	13.5	16.5	20.0	21.5	23.5	25.0	26.5	28.5	30.0	33.5
26	9.0	12.5	15.5	18.5	20.0	21.5	23.0	24.5	26.0	27.5	31.0
28	8.5	11.5	14.5	17.0	18.5	20.0	21.5	23.0	24.5	25.5	28.5
30	8.0	10.5	13.5	16.0	17.5	18.5	20.0	21.5	22.5	24.0	26.5
32	7.5	10.0	12.5	15.0	16.5	17.5	19.0	20.0	21.5	22.5	25.0
34	7.0	9.5	12.0	14.0	15.5	16.5	17.5	19.0	20.0	21.0	23.5
36	6.5	9.0	11.0	13.5	14.5	15.5	16.5	18.0	19.0	20.0	22.0
38	6.5	8.5	10.5	12.5	13.5	14.5	16.0	17.0	18.0	19.0	21.0
40	6.0	8.0	10.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	20.0

001016

Manure Type: Beef Liquids **Incorp:** 12 - 96 hours **% Avail:** 45%

Manure Application Rate (1,000 gal/acre)											
Manure	**Desired Available N (lbs/acre)**										
N Test	60	80	100	120	130	140	150	160	170	180	200
6	22.0	29.5	37.0	44.5	48.0	52.0	55.5	59.5	63.0	66.5	74.0
8	16.5	22.0	28.0	33.5	36.0	39.0	41.5	44.5	47.0	50.0	55.5
10	13.5	18.0	22.0	26.5	29.0	31.0	33.5	35.5	38.0	40.0	44.5
12	11.0	15.0	18.5	22.0	24.0	26.0	28.0	29.5	31.5	33.5	37.0
14	9.5	12.5	16.0	19.0	20.5	22.0	24.0	25.5	27.0	28.5	31.5
16	8.5	11.0	14.0	16.5	18.0	19.5	21.0	22.0	23.5	25.0	28.0
18	7.5	10.0	12.5	15.0	16.0	17.5	18.5	20.0	21.0	22.0	24.5
20	6.5	9.0	11.0	13.5	14.5	15.5	16.5	18.0	19.0	20.0	22.0
22	6.0	8.0	10.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	20.0
24	5.5	7.5	9.5	11.0	12.0	13.0	14.0	15.0	15.5	16.5	18.5
26	5.0	7.0	8.5	10.5	11.0	12.0	13.0	13.5	14.5	15.5	17.0
28	5.0	6.5	8.0	9.5	10.5	11.0	12.0	12.5	13.5	14.5	16.0
30	4.5	6.0	7.5	9.0	9.5	10.5	11.0	12.0	12.5	13.5	15.0
32	4.0	5.5	7.0	8.5	9.0	9.5	10.5	11.0	12.0	12.5	14.0
34	4.0	5.0	6.5	8.0	8.5	9.0	10.0	10.5	11.0	12.0	13.0
36	3.5	5.0	6.0	7.5	8.0	8.5	9.5	10.0	10.5	11.0	12.5
38	3.5	4.5	6.0	7.0	7.5	8.0	9.0	9.5	10.0	10.5	11.5
40	3.5	4.5	5.5	6.5	7.0	8.0	8.5	9.0	9.5	10.0	11.0

001017

Manure Type: Beef Liquids **Incorp:** (Within 12 hours) **% Avail:** 60%

Manure Application Rate (1,000 gal/acre)											
Manure	**Desired Available N (lbs/acre)**										
N Test	**60**	**80**	**100**	**120**	**130**	**140**	**150**	**160**	**170**	**180**	**200**
6	16.5	22.0	28.0	33.5	36.0	39.0	41.5	44.5	47.0	50.0	55.5
8	12.5	16.5	21.0	25.0	27.0	29.0	31.5	33.5	35.5	37.5	41.5
10	10.0	13.5	16.5	20.0	21.5	23.5	25.0	26.5	28.5	30.0	33.5
12	8.5	11.0	14.0	16.5	18.0	19.5	21.0	22.0	23.5	25.0	28.0
14	7.0	9.5	12.0	14.5	15.5	16.5	18.0	19.0	20.0	21.5	24.0
16	6.5	8.5	10.5	12.5	13.5	14.5	15.5	16.5	17.5	19.0	21.0
18	5.5	7.5	9.5	11.0	12.0	13.0	14.0	15.0	15.5	16.5	18.5
20	5.0	6.5	8.5	10.0	11.0	11.5	12.5	13.5	14.0	15.0	16.5
22	4.5	6.0	7.5	9.0	10.0	10.5	11.5	12.0	13.0	13.5	15.0
24	4.0	5.5	7.0	8.5	9.0	9.5	10.5	11.0	12.0	12.5	14.0
26	4.0	5.0	6.5	7.5	8.5	9.0	9.5	10.5	11.0	11.5	13.0
28	3.5	5.0	6.0	7.0	7.5	8.5	9.0	9.5	10.0	10.5	12.0
30	3.5	4.5	5.5	6.5	7.0	8.0	8.5	9.0	9.5	10.0	11.0
32	3.0	4.0	5.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.5
34	3.0	4.0	5.0	6.0	6.5	7.0	7.5	8.0	8.5	9.0	10.0
36	3.0	3.5	4.5	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.5
38	2.5	3.5	4.5	5.5	5.5	6.0	6.5	7.0	7.5	8.0	9.0
40	2.5	3.5	4.0	5.0	5.5	6.0	6.5	6.5	7.0	7.5	8.5

001018

Manure Type: Beef Liquids **Incorp:** (Sweep Injection) **% Avail:** 60%

Manure Application Rate (1,000 gal/acre)											
Manure	**Desired Available N (lbs/acre)**										
N Test	60	80	100	120	130	140	150	160	170	180	200
6	16.5	22.0	28.0	33.5	36.0	39.0	41.5	44.5	47.0	50.0	55.5
8	12.5	16.5	21.0	25.0	27.0	29.0	31.5	33.5	35.5	37.5	41.5
10	10.0	13.5	16.5	20.0	21.5	23.5	25.0	26.5	28.5	30.0	33.5
12	8.5	11.0	14.0	16.5	18.0	19.5	21.0	22.0	23.5	25.0	28.0
14	7.0	9.5	12.0	14.5	15.5	16.5	18.0	19.0	20.0	21.5	24.0
16	6.5	8.5	10.5	12.5	13.5	14.5	15.5	16.5	17.5	19.0	21.0
18	5.5	7.5	9.5	11.0	12.0	13.0	14.0	15.0	15.5	16.5	18.5
20	5.0	6.5	8.5	10.0	11.0	11.5	12.5	13.5	14.0	15.0	16.5
22	4.5	6.0	7.5	9.0	10.0	10.5	11.5	12.0	13.0	13.5	15.0
24	4.0	5.5	7.0	8.5	9.0	9.5	10.5	11.0	12.0	12.5	14.0
26	4.0	5.0	6.5	7.5	8.5	9.0	9.5	10.5	11.0	11.5	13.0
28	3.5	5.0	6.0	7.0	7.5	8.5	9.0	9.5	10.0	10.5	12.0
30	3.5	4.5	5.5	6.5	7.0	8.0	8.5	9.0	9.5	10.0	11.0
32	3.0	4.0	5.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.5
34	3.0	4.0	5.0	6.0	6.5	7.0	7.5	8.0	8.5	9.0	10.0
36	3.0	3.5	4.5	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.5
38	2.5	3.5	4.5	5.5	5.5	6.0	6.5	7.0	7.5	8.0	9.0
40	2.5	3.5	4.0	5.0	5.5	6.0	6.5	6.5	7.0	7.5	8.5

001019

Manure Type: Beef Liquids **Incorp:** (Knife Injection) **% Avail:** 50%

Manure Application Rate (1,000 gal/acre)											
Manure	**Desired Available N (lbs/acre)**										
N Test	60	80	100	120	130	140	150	160	170	180	200
6	20.0	26.5	33.5	40.0	43.5	46.5	50.0	53.5	56.5	60.0	66.5
8	15.0	20.0	25.0	30.0	32.5	35.0	37.5	40.0	42.5	45.0	50.0
10	12.0	16.0	20.0	24.0	26.0	28.0	30.0	32.0	34.0	36.0	40.0
12	10.0	13.5	16.5	20.0	21.5	23.5	25.0	26.5	28.5	30.0	33.5
14	8.5	11.5	14.5	17.0	18.5	20.0	21.5	23.0	24.5	25.5	28.5
16	7.5	10.0	12.5	15.0	16.5	17.5	19.0	20.0	21.5	22.5	25.0
18	6.5	9.0	11.0	13.5	14.5	15.5	16.5	18.0	19.0	20.0	22.0
20	6.0	8.0	10.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	20.0
22	5.5	7.5	9.0	11.0	12.0	12.5	13.5	14.5	15.5	16.5	18.0
24	5.0	6.5	8.5	10.0	11.0	11.5	12.5	13.5	14.0	15.0	16.5
26	4.5	6.0	7.5	9.0	10.0	11.0	11.5	12.5	13.0	14.0	15.5
28	4.5	5.5	7.0	8.5	9.5	10.0	10.5	11.5	12.0	13.0	14.5
30	4.0	5.5	6.5	8.0	8.5	9.5	10.0	10.5	11.5	12.0	13.5
32	4.0	5.0	6.5	7.5	8.0	9.0	9.5	10.0	10.5	11.5	12.5
34	3.5	4.5	6.0	7.0	7.5	8.0	9.0	9.5	10.0	10.5	12.0
36	3.5	4.5	5.5	6.5	7.0	8.0	8.5	9.0	9.5	10.0	11.0
38	3.0	4.0	5.5	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.5
40	3.0	4.0	5.0	6.0	6.5	7.0	7.5	8.0	8.5	9.0	10.0

001020

Manure Type: Beef Solids **Incorp:** After 4 days **% Avail:** 25%

Manure Application Rate (ton/acre)											
Manure N Test	**Desired Available N (lbs/acre)**										
	60	80	100	120	130	140	150	160	170	180	200
2	120.0	160.0	200.0	240.0	260.0	280.0	300.0	320.0	340.0	360.0	400.0
4	60.0	80.0	100.0	120.0	130.0	140.0	150.0	160.0	170.0	180.0	200.0
6	40.0	53.5	66.5	80.0	86.5	93.5	100.0	106.5	113.5	120.0	133.5
8	30.0	40.0	50.0	60.0	65.0	70.0	75.0	80.0	85.0	90.0	100.0
10	24.0	32.0	40.0	48.0	52.0	56.0	60.0	64.0	68.0	72.0	80.0
12	20.0	26.5	33.5	40.0	43.5	46.5	50.0	53.5	56.5	60.0	66.5
14	17.0	23.0	28.5	34.5	37.0	40.0	43.0	45.5	48.5	51.5	57.0
16	15.0	20.0	25.0	30.0	32.5	35.0	37.5	40.0	42.5	45.0	50.0
18	13.5	18.0	22.0	26.5	29.0	31.0	33.5	35.5	38.0	40.0	44.5
20	12.0	16.0	20.0	24.0	26.0	28.0	30.0	32.0	34.0	36.0	40.0
22	11.0	14.5	18.0	22.0	23.5	25.5	27.5	29.0	31.0	32.5	36.5
24	10.0	13.5	16.5	20.0	21.5	23.5	25.0	26.5	28.5	30.0	33.5
26	9.0	12.5	15.5	18.5	20.0	21.5	23.0	24.5	26.0	27.5	31.0
28	8.5	11.5	14.5	17.0	18.5	20.0	21.5	23.0	24.5	25.5	28.5
30	8.0	10.5	13.5	16.0	17.5	18.5	20.0	21.5	22.5	24.0	26.5

001021

Manure Type: Beef Solids **Incorp:** 12 - 96 hours **% Avail:** 45%

Manure Application Rate (ton/acre)											
Manure N Test	**Desired Available N (lbs/acre)**										
	60	80	100	120	130	140	150	160	170	180	200
2	66.5	89.0	111.0	133.5	144.5	155.5	166.5	178.0	189.0	200.0	222.0
4	33.5	44.5	55.5	66.5	72.0	78.0	83.5	89.0	94.5	100.0	111.0
6	22.0	29.5	37.0	44.5	48.0	52.0	55.5	59.5	63.0	66.5	74.0
8	16.5	22.0	28.0	33.5	36.0	39.0	41.5	44.5	47.0	50.0	55.5
10	13.5	18.0	22.0	26.5	29.0	31.0	33.5	35.5	38.0	40.0	44.5
12	11.0	15.0	18.5	22.0	24.0	26.0	28.0	29.5	31.5	33.5	37.0
14	9.5	12.5	16.0	19.0	20.5	22.0	24.0	25.5	27.0	28.5	31.5
16	8.5	11.0	14.0	16.5	18.0	19.5	21.0	22.0	23.5	25.0	28.0
18	7.5	10.0	12.5	15.0	16.0	17.5	18.5	20.0	21.0	22.0	24.5
20	6.5	9.0	11.0	13.5	14.5	15.5	16.5	18.0	19.0	20.0	22.0
22	6.0	8.0	10.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	20.0
24	5.5	7.5	9.5	11.0	12.0	13.0	14.0	15.0	15.5	16.5	18.5
26	5.0	7.0	8.5	10.5	11.0	12.0	13.0	13.5	14.5	15.5	17.0
28	5.0	6.5	8.0	9.5	10.5	11.0	12.0	12.5	13.5	14.5	16.0
30	4.5	6.0	7.5	9.0	9.5	10.5	11.0	12.0	12.5	13.5	15.0

001022

Manure Type: Beef Solids **Incorp:** (Within 12 hours) **% Avail:** 60%

Manure Application Rate (ton/acre)											
Manure N Test	**Desired Available N (lbs/acre)**										
	60	80	100	120	130	140	150	160	170	180	200
2	50.0	66.5	83.5	100.0	108.5	116.5	125.0	133.5	141.5	150.0	166.5
4	25.0	33.5	41.5	50.0	54.0	58.5	62.5	66.5	71.0	75.0	83.5
6	16.5	22.0	28.0	33.5	36.0	39.0	41.5	44.5	47.0	50.0	55.5
8	12.5	16.5	21.0	25.0	27.0	29.0	31.5	33.5	35.5	37.5	41.5
10	10.0	13.5	16.5	20.0	21.5	23.5	25.0	26.5	28.5	30.0	33.5
12	8.5	11.0	14.0	16.5	18.0	19.5	21.0	22.0	23.5	25.0	28.0
14	7.0	9.5	12.0	14.5	15.5	16.5	18.0	19.0	20.0	21.5	24.0
16	6.5	8.5	10.5	12.5	13.5	14.5	15.5	16.5	17.5	19.0	21.0
18	5.5	7.5	9.5	11.0	12.0	13.0	14.0	15.0	15.5	16.5	18.5
20	5.0	6.5	8.5	10.0	11.0	11.5	12.5	13.5	14.0	15.0	16.5
22	4.5	6.0	7.5	9.0	10.0	10.5	11.5	12.0	13.0	13.5	15.0
24	4.0	5.5	7.0	8.5	9.0	9.5	10.5	11.0	12.0	12.5	14.0
26	4.0	5.0	6.5	7.5	8.5	9.0	9.5	10.5	11.0	11.5	13.0
28	3.5	5.0	6.0	7.0	7.5	8.5	9.0	9.5	10.0	10.5	12.0
30	3.5	4.5	5.5	6.5	7.0	8.0	8.5	9.0	9.5	10.0	11.0

001023

Manure Type: Poultry Liquids **Incorp:** After 4 days **% Avail:** 45%

Manure Application Rate (1,000 gal/acre)											
Manure	**Desired Available N (lbs/acre)**										
N Test	60	80	100	120	130	140	150	160	170	180	200
40	3.5	4.5	5.5	6.5	7.0	8.0	8.5	9.0	9.5	10.0	11.0
42	3.0	4.0	5.5	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.5
44	3.0	4.0	5.0	6.0	6.5	7.0	7.5	8.0	8.5	9.0	10.0
46	3.0	4.0	5.0	6.0	6.5	7.0	7.0	7.5	8.0	8.5	9.5
48	3.0	3.5	4.5	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.5
50	2.5	3.5	4.5	5.5	6.0	6.0	6.5	7.0	7.5	8.0	9.0
52	2.5	3.5	4.5	5.0	5.5	6.0	6.5	7.0	7.5	7.5	8.5
54	2.5	3.5	4.0	5.0	5.5	6.0	6.0	6.5	7.0	7.5	8.0
56	2.5	3.0	4.0	5.0	5.0	5.5	6.0	6.5	6.5	7.0	8.0
58	2.5	3.0	4.0	4.5	5.0	5.5	5.5	6.0	6.5	7.0	7.5
60	2.0	3.0	3.5	4.5	5.0	5.0	5.5	6.0	6.5	6.5	7.5
62	2.0	3.0	3.5	4.5	4.5	5.0	5.5	5.5	6.0	6.5	7.0
64	2.0	3.0	3.5	4.0	4.5	5.0	5.0	5.5	6.0	6.5	7.0
66	2.0	2.5	3.5	4.0	4.5	4.5	5.0	5.5	5.5	6.0	6.5
68	2.0	2.5	3.5	4.0	4.0	4.5	5.0	5.0	5.5	6.0	6.5
70	2.0	2.5	3.0	4.0	4.0	4.5	5.0	5.0	5.5	5.5	6.5
72	2.0	2.5	3.0	3.5	4.0	4.5	4.5	5.0	5.0	5.5	6.0
74	2.0	2.5	3.0	3.5	4.0	4.0	4.5	5.0	5.0	5.5	6.0

001024

Manure Type: Poultry Liquids **Incorp:** 12 - 96 hours **% Avail:** 55%

Manure Application Rate (1,000 gal/acre)											
Manure	**Desired Available N (lbs/acre)**										
N Test	60	80	100	120	130	140	150	160	170	180	200
40	2.5	3.5	4.5	5.5	6.0	6.5	7.0	7.5	7.5	8.0	9.0
42	2.5	3.5	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5
44	2.5	3.5	4.0	5.0	5.5	6.0	6.0	6.5	7.0	7.5	8.5
46	2.5	3.0	4.0	4.5	5.0	5.5	6.0	6.5	6.5	7.0	8.0
48	2.5	3.0	4.0	4.5	5.0	5.5	5.5	6.0	6.5	7.0	7.5
50	2.0	3.0	3.5	4.5	4.5	5.0	5.5	6.0	6.0	6.5	7.5
52	2.0	3.0	3.5	4.0	4.5	5.0	5.0	5.5	6.0	6.5	7.0
54	2.0	2.5	3.5	4.0	4.5	4.5	5.0	5.5	5.5	6.0	6.5
56	2.0	2.5	3.0	4.0	4.0	4.5	5.0	5.0	5.5	6.0	6.5
58	2.0	2.5	3.0	4.0	4.0	4.5	4.5	5.0	5.5	5.5	6.5
60	2.0	2.5	3.0	3.5	4.0	4.0	4.5	5.0	5.0	5.5	6.0
62	2.0	2.5	3.0	3.5	4.0	4.0	4.5	4.5	5.0	5.5	6.0
64	1.5	2.5	3.0	3.5	3.5	4.0	4.5	4.5	5.0	5.0	5.5
66	1.5	2.0	3.0	3.5	3.5	4.0	4.0	4.5	4.5	5.0	5.5
68	1.5	2.0	2.5	3.0	3.5	3.5	4.0	4.5	4.5	5.0	5.5
70	1.5	2.0	2.5	3.0	3.5	3.5	4.0	4.0	4.5	4.5	5.0
72	1.5	2.0	2.5	3.0	3.5	3.5	4.0	4.0	4.5	4.5	5.0
74	1.5	2.0	2.5	3.0	3.0	3.5	3.5	4.0	4.0	4.5	5.0

001025

Manure Type: Poultry Liquids **Incorp:** (Within 12 hours) **% Avail:** 70%

Manure Application Rate (1,000 gal/acre)											
Manure	**Desired Available N (lbs/acre)**										
N Test	60	80	100	120	130	140	150	160	170	180	200
40	2.0	3.0	3.5	4.5	4.5	5.0	5.5	5.5	6.0	6.5	7.0
42	2.0	2.5	3.5	4.0	4.5	5.0	5.0	5.5	6.0	6.0	7.0
44	2.0	2.5	3.0	4.0	4.0	4.5	5.0	5.0	5.5	6.0	6.5
46	2.0	2.5	3.0	3.5	4.0	4.5	4.5	5.0	5.5	5.5	6.0
48	2.0	2.5	3.0	3.5	4.0	4.0	4.5	5.0	5.0	5.5	6.0
50	1.5	2.5	3.0	3.5	3.5	4.0	4.5	4.5	5.0	5.0	5.5
52	1.5	2.0	2.5	3.5	3.5	4.0	4.0	4.5	4.5	5.0	5.5
54	1.5	2.0	2.5	3.0	3.5	3.5	4.0	4.0	4.5	5.0	5.5
56	1.5	2.0	2.5	3.0	3.5	3.5	4.0	4.0	4.5	4.5	5.0
58	1.5	2.0	2.5	3.0	3.0	3.5	3.5	4.0	4.0	4.5	5.0
60	1.5	2.0	2.5	3.0	3.0	3.5	3.5	4.0	4.0	4.5	5.0
62	1.5	2.0	2.5	3.0	3.0	3.0	3.5	3.5	4.0	4.0	4.5
64	1.5	2.0	2.0	2.5	3.0	3.0	3.5	3.5	4.0	4.0	4.5
66	1.5	1.5	2.0	2.5	3.0	3.0	3.0	3.5	3.5	4.0	4.5
68	1.5	1.5	2.0	2.5	2.5	3.0	3.0	3.5	3.5	4.0	4.0
70	1.0	1.5	2.0	2.5	2.5	3.0	3.0	3.5	3.5	3.5	4.0
72	1.0	1.5	2.0	2.5	2.5	3.0	3.0	3.0	3.5	3.5	4.0
74	1.0	1.5	2.0	2.5	2.5	2.5	3.0	3.0	3.5	3.5	4.0

001026

Manure Type: Poultry Liquids **Incorp:** (Sweep Injection) **% Avail:** 70%

Manure Application Rate (1,000 gal/acre)											
Manure	**Desired Available N (lbs/acre)**										
N Test	60	80	100	120	130	140	150	160	170	180	200
40	2.0	3.0	3.5	4.5	4.5	5.0	5.5	5.5	6.0	6.5	7.0
42	2.0	2.5	3.5	4.0	4.5	5.0	5.0	5.5	6.0	6.0	7.0
44	2.0	2.5	3.0	4.0	4.0	4.5	5.0	5.0	5.5	6.0	6.5
46	2.0	2.5	3.0	3.5	4.0	4.5	4.5	5.0	5.5	5.5	6.0
48	2.0	2.5	3.0	3.5	4.0	4.0	4.5	5.0	5.0	5.5	6.0
50	1.5	2.5	3.0	3.5	3.5	4.0	4.5	4.5	5.0	5.0	5.5
52	1.5	2.0	2.5	3.5	3.5	4.0	4.0	4.5	4.5	5.0	5.5
54	1.5	2.0	2.5	3.0	3.5	3.5	4.0	4.0	4.5	5.0	5.5
56	1.5	2.0	2.5	3.0	3.5	3.5	4.0	4.0	4.5	4.5	5.0
58	1.5	2.0	2.5	3.0	3.0	3.5	3.5	4.0	4.0	4.5	5.0
60	1.5	2.0	2.5	3.0	3.0	3.5	3.5	4.0	4.0	4.5	5.0
62	1.5	2.0	2.5	3.0	3.0	3.0	3.5	3.5	4.0	4.0	4.5
64	1.5	2.0	2.0	2.5	3.0	3.0	3.5	3.5	4.0	4.0	4.5
66	1.5	1.5	2.0	2.5	3.0	3.0	3.0	3.5	3.5	4.0	4.5
68	1.5	1.5	2.0	2.5	2.5	3.0	3.0	3.5	3.5	4.0	4.0
70	1.0	1.5	2.0	2.5	2.5	3.0	3.0	3.5	3.5	3.5	4.0
72	1.0	1.5	2.0	2.5	2.5	3.0	3.0	3.0	3.5	3.5	4.0
74	1.0	1.5	2.0	2.5	2.5	2.5	3.0	3.0	3.5	3.5	4.0

001027

Manure Type: Poultry Liquids **Incorp:** (Knife Injection) **% Avail:** 70%

Manure Application Rate (1,000 gal/acre)											
Manure	**Desired Available N (lbs/acre)**										
N Test	60	80	100	120	130	140	150	160	170	180	200
40	2.0	3.0	3.5	4.5	4.5	5.0	5.5	5.5	6.0	6.5	7.0
42	2.0	2.5	3.5	4.0	4.5	5.0	5.0	5.5	6.0	6.0	7.0
44	2.0	2.5	3.0	4.0	4.0	4.5	5.0	5.0	5.5	6.0	6.5
46	2.0	2.5	3.0	3.5	4.0	4.5	4.5	5.0	5.5	5.5	6.0
48	2.0	2.5	3.0	3.5	4.0	4.0	4.5	5.0	5.0	5.5	6.0
50	1.5	2.5	3.0	3.5	3.5	4.0	4.5	4.5	5.0	5.0	5.5
52	1.5	2.0	2.5	3.5	3.5	4.0	4.0	4.5	4.5	5.0	5.5
54	1.5	2.0	2.5	3.0	3.5	3.5	4.0	4.0	4.5	5.0	5.5
56	1.5	2.0	2.5	3.0	3.5	3.5	4.0	4.0	4.5	4.5	5.0
58	1.5	2.0	2.5	3.0	3.0	3.5	3.5	4.0	4.0	4.5	5.0
60	1.5	2.0	2.5	3.0	3.0	3.5	3.5	4.0	4.0	4.5	5.0
62	1.5	2.0	2.5	3.0	3.0	3.0	3.5	3.5	4.0	4.0	4.5
64	1.5	2.0	2.0	2.5	3.0	3.0	3.5	3.5	4.0	4.0	4.5
66	1.5	1.5	2.0	2.5	3.0	3.0	3.0	3.5	3.5	4.0	4.5
68	1.5	1.5	2.0	2.5	2.5	3.0	3.0	3.5	3.5	4.0	4.0
70	1.0	1.5	2.0	2.5	2.5	3.0	3.0	3.5	3.5	3.5	4.0
72	1.0	1.5	2.0	2.5	2.5	3.0	3.0	3.0	3.5	3.5	4.0
74	1.0	1.5	2.0	2.5	2.5	2.5	3.0	3.0	3.5	3.5	4.0

001028

Manure Type: Poultry Solids **Incorp:** After 4 days **% Avail:** 45%

Manure Application Rate (ton/acre)											
Manure N Test	**Desired Available N (lbs/acre)**										
	60	80	100	120	130	140	150	160	170	180	200
30	4.5	6.0	7.5	9.0	9.5	10.5	11.0	12.0	12.5	13.5	15.0
32	4.0	5.5	7.0	8.5	9.0	9.5	10.5	11.0	12.0	12.5	14.0
34	4.0	5.0	6.5	8.0	8.5	9.0	10.0	10.5	11.0	12.0	13.0
36	3.5	5.0	6.0	7.5	8.0	8.5	9.5	10.0	10.5	11.0	12.5
38	3.5	4.5	6.0	7.0	7.5	8.0	9.0	9.5	10.0	10.5	11.5
40	3.5	4.5	5.5	6.5	7.0	8.0	8.5	9.0	9.5	10.0	11.0
42	3.0	4.0	5.5	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.5
44	3.0	4.0	5.0	6.0	6.5	7.0	7.5	8.0	8.5	9.0	10.0
46	3.0	4.0	5.0	6.0	6.5	7.0	7.0	7.5	8.0	8.5	9.5
48	3.0	3.5	4.5	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.5
50	2.5	3.5	4.5	5.5	6.0	6.0	6.5	7.0	7.5	8.0	9.0
52	2.5	3.5	4.5	5.0	5.5	6.0	6.5	7.0	7.5	7.5	8.5
54	2.5	3.5	4.0	5.0	5.5	6.0	6.0	6.5	7.0	7.5	8.0
56	2.5	3.0	4.0	5.0	5.0	5.5	6.0	6.5	6.5	7.0	8.0
58	2.5	3.0	4.0	4.5	5.0	5.5	5.5	6.0	6.5	7.0	7.5
60	2.0	3.0	3.5	4.5	5.0	5.0	5.5	6.0	6.5	6.5	7.5
62	2.0	3.0	3.5	4.5	4.5	5.0	5.5	5.5	6.0	6.5	7.0
64	2.0	3.0	3.5	4.0	4.5	5.0	5.0	5.5	6.0	6.5	7.0

001029

Manure Type: Poultry Solids **Incorp:** 12 - 96 hours **% Avail:** 55%

Manure Application Rate (ton/acre)											
Manure N Test	Desired Available N (lbs/acre)										
	60	80	100	120	130	140	150	160	170	180	200
30	3.5	5.0	6.0	7.5	8.0	8.5	9.0	9.5	10.5	11.0	12.0
32	3.5	4.5	5.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	11.5
34	3.0	4.5	5.5	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.5
36	3.0	4.0	5.0	6.0	6.5	7.0	7.5	8.0	8.5	9.0	10.0
38	3.0	4.0	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.5
40	2.5	3.5	4.5	5.5	6.0	6.5	7.0	7.5	7.5	8.0	9.0
42	2.5	3.5	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5
44	2.5	3.5	4.0	5.0	5.5	6.0	6.0	6.5	7.0	7.5	8.5
46	2.5	3.0	4.0	4.5	5.0	5.5	6.0	6.5	6.5	7.0	8.0
48	2.5	3.0	4.0	4.5	5.0	5.5	5.5	6.0	6.5	7.0	7.5
50	2.0	3.0	3.5	4.5	4.5	5.0	5.5	6.0	6.0	6.5	7.5
52	2.0	3.0	3.5	4.0	4.5	5.0	5.0	5.5	6.0	6.5	7.0
54	2.0	2.5	3.5	4.0	4.5	4.5	5.0	5.5	5.5	6.0	6.5
56	2.0	2.5	3.0	4.0	4.0	4.5	5.0	5.0	5.5	6.0	6.5
58	2.0	2.5	3.0	4.0	4.0	4.5	4.5	5.0	5.5	5.5	6.5
60	2.0	2.5	3.0	3.5	4.0	4.0	4.5	5.0	5.0	5.5	6.0
62	2.0	2.5	3.0	3.5	4.0	4.0	4.5	4.5	5.0	5.5	6.0
64	1.5	2.5	3.0	3.5	3.5	4.0	4.5	4.5	5.0	5.0	5.5

001030

Manure Type: Poultry Solids **Incorp:** Within 12 hours **% Avail:** 70%

Manure Application Rate (ton/acre)											
Manure N Test	Desired Available N (lbs/acre)										
	60	80	100	120	130	140	150	160	170	180	200
30	3.0	4.0	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.5
32	2.5	3.5	4.5	5.5	6.0	6.5	6.5	7.0	7.5	8.0	9.0
34	2.5	3.5	4.0	5.0	5.5	6.0	6.5	6.5	7.0	7.5	8.5
36	2.5	3.0	4.0	5.0	5.0	5.5	6.0	6.5	6.5	7.0	8.0
38	2.5	3.0	4.0	4.5	5.0	5.5	5.5	6.0	6.5	7.0	7.5
40	2.0	3.0	3.5	4.5	4.5	5.0	5.5	5.5	6.0	6.5	7.0
42	2.0	2.5	3.5	4.0	4.5	5.0	5.0	5.5	6.0	6.0	7.0
44	2.0	2.5	3.0	4.0	4.0	4.5	5.0	5.0	5.5	6.0	6.5
46	2.0	2.5	3.0	3.5	4.0	4.5	4.5	5.0	5.5	5.5	6.0
48	2.0	2.5	3.0	3.5	4.0	4.0	4.5	5.0	5.0	5.5	6.0
50	1.5	2.5	3.0	3.5	3.5	4.0	4.5	4.5	5.0	5.0	5.5
52	1.5	2.0	2.5	3.5	3.5	4.0	4.0	4.5	4.5	5.0	5.5
54	1.5	2.0	2.5	3.0	3.5	3.5	4.0	4.0	4.5	5.0	5.5
56	1.5	2.0	2.5	3.0	3.5	3.5	4.0	4.0	4.5	4.5	5.0
58	1.5	2.0	2.5	3.0	3.0	3.5	3.5	4.0	4.0	4.5	5.0
60	1.5	2.0	2.5	3.0	3.0	3.5	3.5	4.0	4.0	4.5	5.0
62	1.5	2.0	2.5	3.0	3.0	3.0	3.5	3.5	4.0	4.0	4.5
64	1.5	2.0	2.0	2.5	3.0	3.0	3.5	3.5	4.0	4.0	4.5

001031

Minimum State Setback Requirements for Sensitive Areas [a]

Sensitive Area	No Incorporation or Incorporation after 24 hrs	Injection or Incorporation within 24 hrs
Lake	300 ft [b]	25 ft [d]
Perennial Stream	300 ft [b]	25 ft [d]
Intermittent Stream	300 ft [c]	25 ft [d]
Protected Wetlands (10+ acres)	300 ft [c]	25 ft [d]
Drainage Ditches (no berms)	300 ft [c]	25 ft [d]
Sinkhole (no berms/diversions)	300 ft up / 50 ft down	50 ft
Mine, Quarry, or Gravel Pit	50 ft	50 ft
Open Tile Intakes (including rock/blind inlets)	300 ft	0 ft
Road Ditches	No application directly into the road ditch	
High Phosphorus Soils	Permit may be needed – No soil-P buildup at some sites	
DWSMA/Wellhead Protection	Permit may be needed	
Steeply Sloping Land	Permit may be needed	
Non-Protected Wetlands	Consider developing a management strategy	
Frequently Flooded Soils	Consider developing a management strategy	
High Water Table Soils	Consider developing a management strategy	
Coarse-Textured Soils	Consider developing a management strategy	
Shallow Soils Over Bedrock	Consider developing a management strategy	

[a] County and/or NPDES permit requirements may be more restrictive

[b] 100 ft non-manured vegetated buffer can be used instead of the 300 ft setback (non-winter)

[c] 50 ft non-manured vegetated buffer can be used instead of the 300 ft setback (non-winter)

[d] Where soil phosphorus exceeds 21 ppm Bray or 16 ppm Olsen, phosphorus must be managed to prevent buildup over a 6 year period.

001032

Short-Term Manure Stockpile Requirements

Location Restrictions

Feature	Requirement
Waters of the State, Tile Intakes, Road Ditches, Sinkholes, Non-Farmed Wetlands, and Rock Outcroppings	Setback of 300 ft of flow distance and at least 50 ft horizontal distance
Private well	Setback of 100 ft*
Public Water Supply Well	Setback of 1,000 ft
Shoreland or Floodplain	Stockpiling is prohibited
Land with greater than a 6% slope	Stockpiling is prohibited
Land with greater than 2 % slope and no clean water diversions and erosion control measures	Stockpiling is prohibited
Land where soil texture to a depth of five feet, except the plow layer, is entirely coarser than a sandy-loam	Stockpiling is prohibited
Sand/Gravel Pits, Quarries, On Bedrock	Stockpiling is prohibited
Drain Tile with less than 3 ft of soil cover	Setback of 100 ft

* Setback increases to 200 ft if the well has less than 50 ft of watertight casing and is not cased through a confining layer at least 10 ft thick

Other Restrictions

- Each stockpile must not exceed agronomic needs of the crops on 320 acres
- Maintain 2 ft separation from the base of the stockpile to the seasonal high water table
- Stockpile must be removed within one year (otherwise considered a permanent stockpile)
- Must have vegetated cover or cropping history for at least one full growing season prior to re-use of the stockpiling site
    - Exemption: If stockpiled for less than 10 consecutive days and no more than 6 times per year, or within open lots with less than 100 animal units.

001033

Minimum State Soil Phosphorus Requirements [e]

Bray P1 (ppm) [d]	**< 22**	**22-75**	**76-150**	**> 150**
Olsen (ppm) [d]	**< 17**	**17-60**	**61-120**	**> 120**
More than 300 ft from waters [a]	No Phosphorus management requirements	No Phosphorus management requirements	No Phosphorus management requirements	Permit required if over 300 AU [c]
Less than 300 ft from waters [a]	No Phosphorus management requirements	Prevent long-term build-up of Soil P [b]	Prevent long-term build-up of Soil P [b] Permit required if over 300 AU [c]	Prevent long-term build-up of Soil P [b] Permit required if over 300 AU [c]

[a] Lakes, rivers, streams, intermittent streams, protected wetlands, or unbermed drainage ditches. Also includes tile intakes when soil P levels are above 75 Bray (60 Olsen) or at a CAFO or NPDES permitted site above 21 Bray (16 Olsen)

[b] The rate and frequency of manure applications must not allow soil phosphorus build-up over a six year period. Single year applications can be based on crop nitrogen needs if remaining phosphorus is removed by subsequent crops. This typically results in manure applications only 1 - 3 times in a six year period (see next page for more information).

[c] Only if over 300 AU. MMP must describe how phosphorus will be managed to prevent phosphorus transport (diet manipulation, soil conservation, fewer applications, etc.).

[d] If soil test are in lbs/acre divide by 2 for approximate levels in ppm. If the Mehlich III test is used, the values in the table columns are approximately <30, 31-90, 91-180, >180.

[e] Restrictions do not apply if a 100 ft non-manured vegetative buffer along lakes and streams, or a 50 ft non-manured vegetative buffer along intermittent streams, protected wetlands, and unbermed drainage ditches is maintained.

001034

Phosphorus Removal by Various Crops

Crop	P_2O_5 Removal	
Alfalfa	10.8	lbs/ton
Barley (grain)	0.41	lbs/bu
Barley (grain & straw)	0.55	lbs/bu
Clover	10.7	lbs/ton
Corn (grain)	0.34	lbs/bu
Corn silage	3.8	lbs/ton
Edible beans	0.01	lbs/lb
Grass hay or pasture	8.9	lbs/ton
Grass/legume	11.2	lbs/ton
Oats (grain)	0.25	lbs/bu

Crop	P_2O_5 Removal	
Oats (grain & straw)	0.32	lbs/bu
Peas	0.01	lbs/lb
Potatoes	0.14	lbs/cwt
Rye (grain)	0.44	lbs/bu
Rye (grain & straw)	0.59	lbs/bu
Soybeans	0.82	lbs/bu
Sugar beets	0.961	lbs/ton
Sweet corn	11	lbs/ton
Wheat (grain)	0.53	lbs/bu
Wheat (grain & straw)	0.64	lbs/bu

How to Calculate Crop P_2O_5 Removal Over a Six Year Period

Step 1

Determine average P uptake during the crop rotation (multiply expected yields by values above).

Ex: 170 bu Corn - [170 * 0.34] = 58 lbs P_2O_5 removed per year

45 bu Soybeans - [45 * 0.82] = 37 lbs P_2O_5 removed per year

Average = 48 lbs P_2O_5 removed per year

Step 2

Determine the amount of P_2O_5 that is typically applied in manure applications.

Ex: 4000 gals/ac * 35 lbs P_2O_5 /1000 gals * 0.8 = 112 lbs P_2O_5 applied

Step 3

Divide step 2 by the average in step 1; Ex: 112/48 = 2.3

Then take 6 years divided by this result and round down to the nearest whole number.

Ex: 6 years/2.3 = 2.6 (manure can be applied 2 out of 6 years without expecting soil P build-up).

001035

Manure Spreader Calibration

Solid Manure

Step 1

Weigh the spreader both empty and full.

Subtract the empty weight from the full weight to determine the tons of manure per load.

Step 2

Calculate how many acres are covered by one load - multiply the distance traveled by the width of the spread.

Example: 800 ft traveled x 20 ft spread = 16,000 sq ft = 0.37 acres per load

6 tons per load / 0.37 acres covered per load = 16 tons/acre

Alternative to Step 2

Calculate how many loads it takes to cover a field when going at a known tractor speed.

Example: 30 loads x 6 tons per load = 180 tons applied

180 tons applied / 11 acres covered = 16 tons/acre

Liquid Manure

Step 1

Determine 1000's of gallons per load by multiplying tank volume by 90%.

Step 2

Determine acres covered per load using the same procedure as in Step 2 for solid manure.

001036

How to Take a Manure Sample

Liquid samples can be taken by dipping a plastic cup or small can attached to a pole, and solid samples can be taken with a pitchfork, shovel, or plastic glove. You will need a clean 5 gallon bucket for mixing sub-samples, as well as a sample bottle/container from the lab. After mixing many sub-samples in the bucket, transfer a smaller sample to the lab bottle/container.

Sample Source	Method
Loaded Liquid Tanker or Solids Spreader	Take sub-samples from many loads and mix in bucket to get a representative sample. Avoid large chunks of manure.
Liquid Manure Storage Structures	Take sub-samples from many depths and locations and mix in bucket to get a representative sample. Avoid sampling the bottom foot, edges, scum, and debris.
Stockpile or Manure Pack	Take many sub-samples from different depths and locations and mix together in bucket to get a representative sample. Avoid sampling the outer 1 ½ feet.
Scrape and Haul	Scrape the floor or lot at many locations and mix together in bucket to get a representative sample. Avoid areas very close to waterers, drains, or feedbunks.
Litter	Take many sub-samples to the depth of the floor throughout the house and mix together in bucket to get a representative sample. Avoid areas very close to feeders or waterers.
Overhead Irrigation, Traveling Gun, or Towed Hose.	Prior to application place many catch pans or buckets in the field, or take many sub-samples at the pump, and mix in one bucket to get a representative sample.

For more information, refer to U of MN publication "Livestock Manure Sampling".

001037

Land Application of Manure Record Keeping Requirements*

100 – 299 AU [a]	300 or More AU	
Manure test results	Manure test results	Manure P_2O_5 available
Field ID & acreage	Field ID & acreage	Fertilizer P_2O_5 applied
Date, method, incorp. timing, and rate of manure application	Crop grown, previous crop, yield goal, N needs of the crop	Total lbs N available/acre to crops (manure + fertilizer)
Carry-over N from previous manure applications	Date, method, incorp. timing, and rate of manure application	Total lbs P_2O_5 available/acre to crops (manure + fertilizer)
Manure N available to crops	Carry-over N from previous manure applications	Soil P test dates and results
Fertilizer N applied	Manure N available to crops	Commercial applicator name
Total lbs N available/acre to crops (manure + fertilizer)	Fertilizer N applied	Soil nitrate testing results (if recommended by U of M)

[a] No records are required if less than 100 AU

Transferred-Ownership of Manure	
Feedlot Owner Requirements	**Cropland Manager Requirements**
Manure transfer date and amounts	Manure test results (from feedlot)
Manure test results (provide to recipient)	Stockpiling practices and locations (stockpile owner)
Who manure was transferred to	Field locations & acreage
Stockpiling practices (from recipient)	Date, method, incorporation timing, and rate of manure application
Field locations (from applicator)	N & P_2O_5 applied (account for all sources)
Application rates/acre (from applicator)	Soil P test dates and results

* Records of manure application must be kept for a minimum of 3 years. However, if manure is applied in sensitive areas or if the manure is generated at a CAFO or NPDES permitted facility, the records must be kept for a minimum of 6 years.

001038

Spill Response

What To Do If You Have a Spill

- Tend to all injuries first and foremost!!!
- Plug culverts and tile inlets that manure could enter
- Contain the spill by creating berms to stop the manure flow
- Contact the Minnesota Duty Officer (**1-800-422-0798**) with:
  - the location, date, and time of spill,
  - what was spilled and the approximate amount spilled,
  - which local officials have been notified (sheriff, fire dept., etc.),
  - the responsible party,
  - any surface water(s) impacted,
  - what has happened or is happening now, and;
  - a call back number.
- Contact the County Feedlot Officer or MPCA
- Recover pooled manure and solids; get a pump truck if necessary
- Scrape large accumulations; leave vegetation if possible
- If spilled on the road, recover what is possible and scrape/sweep the remainder off of the road
- Work areas of bare soils and re-seed

Manure Management Plan

A Step-by-Step Guide for Minnesota Feedlot Operators

Revised February 2010

_____ _____

Name of farming operation **MPCA registration number**

Minnesota Pollution Control Agency

University of Minnesota Extension Service

wq-f8-09

001040

Comments Welcome, More Information Available

Written by Jim Courneya, Minnesota Pollution Control Agency, with special thanks to the University of Minnesota Extension Service and Kevin Blanchet who developed many of the forms used in developing this Manure Management Plan.

The MPCA welcomes your comments or suggestions for improving future editions of this handbook. Please send them to feedlot staff at your regional office.

Brainerd (218) 828-2492
Detroit Lakes (218) 847-1519
Mankato (507) 389-5977
Marshall (507) 537-7146
Rochester (507) 285-7343
St. Paul (651) 296-6300
Willmar (320) 214-3786

More information about MPCA feedlot programs and regulations, as well as an electronic version of this handbook and forms which can be printed out on a home computer, are available on the Web:

- http://www.pca.state.mn.us/hot/feedlot-management.html

- http://www.pca.state.mn.us/hot/feedlot-publications.html

Introduction to Developing a Manure Management Plan

Manure should not be considered a waste product requiring disposal. Rather, it should be stored, handled and applied with the same care given to expensive commercial fertilizers. Applied properly, manure can yield considerable savings in fertilizer costs. If over-applied, nutrients will be wasted and water resources can be negatively impacted.

Minnesota Pollution Control Agency (MPCA) feedlot regulations require many farms to develop and follow a **manure management plan** (sometimes called a **nutrient management plan**). A manure management plan can help all feedlots comply with application requirements near waters, and is required when applying for a permit for construction or expansion. Most feedlots with 300 animal units or more are required to have a completed manure management plan by Jan. 1, 2006.

Can't get to a workshop? This guide provides "home schooling"

There are numerous consultants available to write manure management plans for producers and computer programs are available from the University of Minnesota and MPCA. In addition, the University offers workshops designed to allow producers to write at least a portion of a manure management plan in a classroom setting.

This guide was developed using the forms and procedures taught in University of Minnesota workshops and is designed to allow those unable to attend a workshop to develop and follow a Manure Management Plan at home by answering these four main questions:

Step 1. How much manure is produced on the farm?
Step 2. How many nutrients are contained in the manure?
Step 3. How many nutrients are needed for a growing crop and how much should be applied?
Step 4. How should manure be managed in sensitive areas and high phosphorous soils?

Some sections need to be updated annually, such as the ***Field Nutrient Management Plan***. For more information on manure management plan components, a checklist is available at: http://www.pca.state.mn.us/hot/feedlot-management.html

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Step 1. How much manure is produced on the farm? (Completing the *Master Worksheet - Manure Storage, Handling and Testing*)

Begin by filling out the ***Master Worksheet - Manure Storage, Handling and Testing*** worksheet. This will become the main worksheet for the plan.

Notice that the vertical columns on this worksheet are labeled "Manure Source #1" and "Manure Source #2." When calculating manure and nutrient production on the farm, each barn or open lot should be treated as a separate manure source, unless feeding and management for each lot is essentially the same. If more than two barns or lots are in use, an additional copy of this worksheet is included at the end of the booklet. This may also be photocopied along with any of the other forms or tables in this booklet.

Master Worksheet – Manure Storage, Handling and Testing

Producer name/operator _____ Date _____

	Manure Source #1	Manure Source #2	*Example Dairy Barn*
I. Livestock Information			
Animal (#1) type			*Dairy cows*
Animal (#1) number, size			*50 @ 1400 lbs.*
Animal (#2) type			*Dairy heifers*
Animal (#2) number, size			*7 @ 800 lbs.*
II. Manure Storage			
Storage type			*Above ground tank*
Storage capacity (tons, gals.)			*5000,000 gallons*
Storage (days, months)			*7 months*
III. Application Methods			
Commercial hauler			*No*
Spreader type[1]			*Slurry tanker*

I. Livestock Information

Indicate the animal type, number and size. Size is defined as the average weight of the animal during the time it is in the building. For example, the size of a hog that increases from 40 pounds to 300 pounds while in the building would be the initial weight plus the final weight divided by two (300+40 = 340/2) or **170 pounds**. The far right column shows examples of how to enter the information.

II. Manure Storage

a. **Storage type** - Indicate the type of storage for each building or lot. Some common examples include: above ground tank, under-floor pit, earthen basin, poured concrete pit, manure pack or stockpile.

b. **Storage capacity** - Indicate the storage capacity in tons (for dry manure) or gallons (for liquid).

1. Capacity in gallons for rectangular liquid basins can be determined by multiplying **Length** (in feet) x **Width** (in feet) x **Depth** (in feet) x **7.48 gal/ft^3** (gallons per cubic foot).

2. Capacity in gallons for round or cylinder shaped tanks or basins can be determined by multiplying the **Diameter** (in feet) x **Diameter** (in feet) x **Height** or **Depth** (in feet) x **0.785** x **7.48 gal/ft^3**.

c. **Storage time** - Indicate the average length of time manure is stored in each location prior to field application.

Completing the **"Master Worksheet – Manure Storage, Handling and Testing"** *form continued on page 6*

Master Worksheet – Manure Storage, Handling and Testing

Producer name/operator _____ **Date** _____

	Manure Source #1	Manure Source #2	*Example Dairy Barn*
I. Livestock Information			
Animal (#1) type			*Dairy cows*
Animal (#1) number, size			*50 @ 1400 lbs.*
Animal (#2) type			*Dairy heifers*
Animal (#2) number, size			*7 @ 800 lbs.*
II. Manure Storage			
Storage type			*Above ground tank*
Storage capacity (tons, gal)			*5000,000 gallons*
Storage (days, months)			*7 months*
III. Application Methods			
Commercial hauler			*No*
Spreader type[1]			*Slurry tanker*
Spreader calibrated (date)			*Yes, 11/03/2001*
When applied[2]			*Fall and spring*
Application method[3]			*Knife inject*
Incorporation timing[4]			*Immediate*
IV. Manure Analysis			
Sampling frequency			*Annually*
Sampling methods			*Spreader during filling*
Date analyzed			*11/03/2001*
N (lbs./ton or 1000 gal)			*24 lbs./1000 gal*
P_2O_5 (lbs. per ton, 1000 gal)			*18 lbs./1000 gal*
K_2O (lbs./ton or 1000 gal)			*29 lbs./1000 gal*
V. Annual Manure/Nutrients Generated			
Manure volume or tons per year			*450,000 gallons*
Manure volume/tons based on records			*Yes*
Annual amount N (lbs.)[5]			*24 x 450=10,800 lbs.*
Annual amount P_2O_5 (lbs.)[5]			*18 x 450 = 8,100 lbs.*
Annual amount K_2O (lbs.)[5]			*29 x 450 = 13,050 lbs.*

1. "Spreader types" are: Slurry tanker, Solids spreader, Towed hose, Center pivot, Other sprinkler
2. "When applied" choices: Daily, Every other day, Weekly, Every 2 weeks, Monthly, Fall, Winter, Spring, Summer
3. "Application method" choices: Surface broadcast, Sweep inject, Knife inject
4. "Incorporation time" choices: Immediate, less than 12 hours, 12-96 hours, greater than 96 hours
5. Annual nitrogen from manure (in lbs) to be land applied after accounting for storage losses.

An additional copy of this worksheet is located on page 28.

III. Application Method

a. **Commercial Hauler** - Indicate whether or not you hire a commercial hauler or applicator.

b. **Spreader Type** - Refer to footnote #1 at the bottom of the worksheet to indicate the type of spreader used.

c. **Spreader Calibrated** - Enter the date the spreader was last calibrated. Spreaders should be calibrated to accurately determine the application rate. Refer to the Minnesota Extension bulletin **"Calibrating Manure Spreaders"** found at http://www.manure.umn.edu/applied/calibration_of_manure_spreaders/index.html or contact your NRCS office for assistance in calibrating your spreader.

d. **When Applied** – Refer to footnote #2 at the bottom of the worksheet and indicate the time period or interval that best describes your practices.

e. **Application Method** – Refer to footnote #3 at the bottom of the worksheet and enter your application method.

f. **Incorporation Timing** – Refer to footnote #4 at the bottom of the worksheet. For any type of injection, enter "immediate" on this line.

Step 2.
How many nutrients are contained in the manure?

The second step in creating a good manure management plan is determining the nutrient content of each source of manure, as well as the total amount of nutrients produced on the farm. Continue with the ***Master Worksheet – Manure Storage, Handling and Testing.***

IV. Manure Analysis

- **a. Sampling frequency**
- **b. Sampling methods**
- **c. Date Analyzed**

Ideally, manure from each source should be sampled and analyzed each year for three consecutive years to develop an average nutrient analysis for each source. After the initial three years of sampling, each source should be sampled at least once every four years or whenever feeding or management changes significantly. This allows you to maintain a "rolling" average analysis and helps to fine tune manure nutrient application. If you have manure nutrient sample results, they should be entered here. Sampling **must** be done for manure sources from 100 animal units or more.

If you do not have manure sample results, refer to **Table A3** ***Estimated nutrient content of liquid and solid manure*** on page 26 until an actual manure test result is available. Find the **animal type** for each manure source on your farm and fill in the N, P_2O_5 and K_2O on the worksheet. Be sure to use the numbers under the appropriate heading "Liquid" or "Solid."

V. Animal Manure/Nutrients Generated

Determine the annual amount of manure produced and the annual amount of nutrients produced from each manure source. There are two methods of finding the amount of manure produced on the farm:

1. Past farm records of the annual amount of manure that was hauled from each manure source. **Or,**
2. Animal manure excretion estimates using the *Manure and Nutrient Generation Worksheet* on page 9.

If you have records for the amount of manure in thousand gallon units or tons, multiply this number by the manure analysis in pounds of nutrient per 1000 gallons or tons from Section IV. See example.

Example – In the far right column of the worksheet on Page 5, 450,000 gallons are produced annually and the analysis for nitrogen was 24 lbs. per thousand gallons (from Section IV) so:
450 (thousand gallons) x 24 (pounds N per 1000 gal.)=10,800 lbs. of N produced annually
Repeat this procedure for P_2O_5 (phosphate) and K_2O (potash)

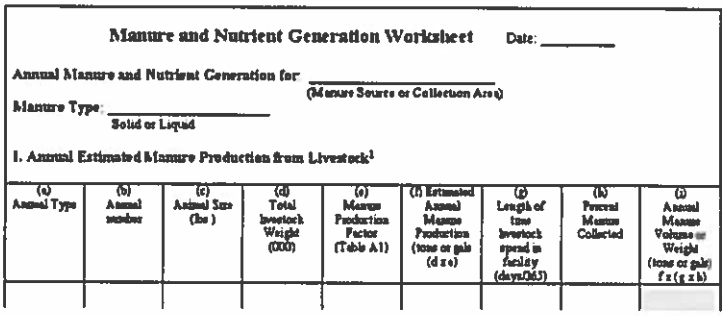
NOTE: If you do not have records or do not know the amount of manure produced on the farm, you must fill out the *Manure and Nutrient Generation Worksheet* that follows before you can complete Section V.

Instructions for completing the *Manure and Nutrient Generation Worksheet*

(Complete if you do not have records or know the amount of manure produced on the farm. Enter results in Section V of Master Worksheet.)

Instructions for Top Half

The top half of this worksheet is devoted to determining the amount of manure produced annually. **Use a new worksheet for each manure source.** The bottom half of this worksheet will determine the quantity of nutrient produced annually after storage losses.



Manure and Nutrient Generation Worksheet Date: _____

Annual Manure and Nutrient Generation for _____ (Manure Source or Collection Area)

Manure Type: _____ Solid or Liquid

I. Annual Estimated Manure Production from Livestock[1]

(a) Animal Type	(b) Animal number	(c) Animal Size (lbs)	(d) Total livestock Weight (000)	(e) Manure Production Factor (Table A1)	(f) Estimated Annual Manure Production (tons or gals (d x e)	(g) Length of time livestock spend in facility (days/365)	(h) Percent Manure Collected	(i) Annual Manure Volume or Weight (tons or gals) f x (g x h)

At the top of the page, indicate the source or collection area such as "barn pit # 1", "earthen basin", or "north lot" etc. Indicate whether manure is liquid or solid. Then proceed to the top of table titled: **"I. Annual Estimated Manure Production from Livestock."**

(a) Enter the animal type. This should be the same as the animal type you entered
   a. in Section I of the Master Worksheet.

(b) Enter the number of animals. Again, this should be the same number entered on the master worksheet.

(c) Enter the average weight of the animals over the entire time they are housed in this barn or lot. For example: The average weight of "growing and finishing" swine during the entire time they are on the farm might be 165 lbs. This number should be the same as the number entered in Section I of the Master worksheet.

(d) Multiply (b) x (c) or (animal number x animal size) then divide the result by 1,000. Enter this final result in column (d).

(e) Find **Table A1** on page 26 of this booklet. Find the "Animal Type" and look under the first two columns "Manure Production" to find the correct "Manure Production Factor". For example: Grow-Finish swine with liquid manure shows a Manure Production Factor of 2166. Find the correct factor for your animal type and manure type and enter it in column (e) of the worksheet.

(f) Multiply (d) x (e) or (Total livestock weight x Manure Production Factor) and enter the result in column (f).

(g) Determine the number of days the animals are in the lot or barn and divide that number by 365. For example: if the animals are in the facility for 180 days, then 180 / 365 = 0.493. Enter your result in column (g).

(h) Enter the percent of manure (expressed as a decimal) produced by these animals that is collected. In total confinement housing, this number will generally be 1.0. For example, 75% would be expressed as 0.75.

(i) Multiply (g) x (h) and then multiply the result x (f). Enter the result in column (i).

Manure and Nutrient Generation Worksheet

Date: _____

Annual Manure and Nutrient Generation for: _____
Manure Source or Collection Area

Manure Type: _____
Solid or Liquid

I. Annual Estimated Manure Production from Livestock[1]

(a) Animal Type	(b) Animal Number	(c) Animal Size (lbs.)	(d) Total livestock Weight (000) (b x c)/1,000	(e) Manure Production Factor (Table A1)	(f) Estimated Annual Manure Production (tons or gals) (d x e)	(g) Length of time livestock spend in facility (days/365)	(h) Percent Manure Collected (%)	(i) Annual Manure Volume or Weight (tons or gals) f x g x h

Total Estimated Manure Volume or Weight Produced Per Year

1. Annual estimated manure production does not include dilution from bedding or water

II. Annual Estimated Nutrients Excreted by Livestock

(a) Animal Type	(b) Total livestock Weight (000)	Nutrient Production Factors (Table A1)			(f) Nitrogen Availability After Storage (1 - % N loss) (Table A2)	(g) Length of time livestock spend in facility (days/365)	Annual Excreted Nutrients After Storage Losses		
		(c) N	(d) P_2O_5	(e) K_2O			(h) N (lbs) b x c x f x g	(i) P_2O_5 (lbs) b x d x g	(j) K_2O (lbs) b x e x g

	N (lbs)	P_2O_5 (lbs)	K_2O (lbs)
Total Estimated Nutrients Excreted Per Year after Storage Losses			

Manure and Nutrient Generation Worksheet

Date: _____

Annual Manure and Nutrient Generation for: _____
Manure Source or Collection Area

Manure Type: _____
Solid or Liquid

I. Annual Estimated Manure Production from Livestock[1]

(a) Animal Type	(b) Animal Number	(c) Animal Size (lbs.)	(d) Total livestock Weight (000) (b x c)/1,000	(e) Manure Production Factor (Table A1)	(f) Estimated Annual Manure Production (tons or gals) (d x e)	(g) Length of time livestock spend in facility (days/365)	(h) Percent Manure Collected (%)	(i) Annual Manure Volume or Weight (tons or gals) f x g x h

Total Estimated Manure Volume or Weight Produced Per Year

1. Annual estimated manure production does not include dilution from bedding or water

II. Annual Estimated Nutrients Excreted by Livestock

(a) Animal Type	(b) Total livestock Weight (000)	Nutrient Production Factors (Table A1)			(f) Nitrogen Availability From Storage (1 - % N loss) (Table A2)	(g) Length of time livestock spend in facility (days/365)	Annual Excreted Nutrients After Storage Losses		
		(c) N	(d) P_2O_5	(e) K_2O			(h) N (lbs) b x c x f x g	(i) P_2O_5 (lbs) b x d x g	(j) K_2O (lbs) b x e x g

	N (lbs)	P_2O_5 (lbs)	K_2O (lbs)
Total Estimated Nutrients Excreted Per Year after Storage Losses			

Completing the *Manure and Nutrient Generation Worksheet* (Bottom Half)

The bottom half of this form is used to determine the **estimated quantity of nutrients** produced. You cannot simply multiply the estimated amount of manure produced by the analysis of N, P and K because there will be storage losses for N. Storage losses are already accounted for when you sample and test manure before application. If samples have not been tested, you must do the calculations on this page before entering the final numbers on the Master Worksheet. Refer to the bottom half of the worksheet titled ***"II. Annual Estimated Nutrients Excreted by Livestock"***

(a) Enter the animal type exactly as you did in the top half of this worksheet.

(b) Enter the total livestock weight in thousands of pounds. For example, if the total weight is 70,000 pounds, enter "70." The total livestock weight is found by multiplying the "animal number" (b) by "animal size" (c) from the top half of this worksheet.

(c) , (d) and **(e).** Turn to **Table A1** (page 26) and look at the last three columns under the heading "Excreted Nutrients in Manure per 1,000 lbs. of Animal Weight." Find the Nutrient Production Factor for each nutrient (N, P_2O_5 and K_2O) that corresponds to the correct animal type. For example: the factors for a dairy milk cow would be 263, 135 and 146 for N, P_2O_5 and K_2O, respectively. Enter the correct numbers for each animal type on the worksheet.

(f) Return to the tables on page 26 and find **Table A2,** "Nitrogen losses from animal manure as affected by method of storage." Find the manure storage and handling method employed on your farm for each manure source. Be sure to distinguish between "liquid" and "solid." The number on the far right of this table represents the percentage of Nitrogen that is lost during storage. For example, in a "**Daily scrape and Haul**" management system, 25 percent of the nitrogen will be lost before it is applied. If you subtract 25 percent from 1, the remainder will be 0.75. Subtract the storage loss of your storage and handling method from "1" and enter it in column (f) of the worksheet.

(g) If animals are kept in a barn, lot or facility for less than a full year, divide the number of days they are in the facility by 365 and enter this factor in column (g). If animals are in the facility the entire year, enter a "1" in column (g).

(h) Multiply (b) x (c) x (f) (g)= lbs. N.
In our example we had 70 (thousand pounds) x 263 (N production factor for dairy cows) x 0.75 (remaining N in storage system after storage loss) x (g) [time in facility factor] = 13,807 lbs. of N produced by our dairy cows. Do the calculations using your numbers.

(i) And **(j)** For P_2O_5 and K_2O, multiply (b) x (d) x (g) = lbs. of P_2O_5. or (b) x (e) (g) for K_2O **Do Not multiply by the storage loss %.** Storage loss is only used when calculating Nitrogen.

Once you have calculated the "Annual Excreted Nutrients" for each type of animal, add up the numbers and fill them in at the bottom of the worksheet. Now return to the ***Master Worksheet – Manure Storage, Handling and Testing*** and also enter these numbers in the final spaces in Section V, "Annual amounts of N, P_2O_5 and K_2O."

Step 3.
How many nutrients are needed for a growing crop?
(Completing the *Field Nutrient Management Plan*)

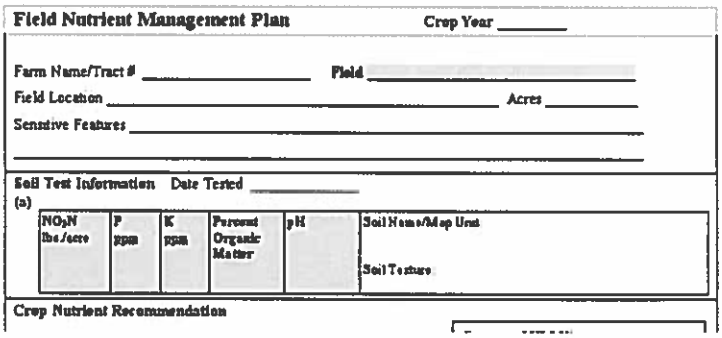
The next step is to start planning manure applications to specific field and crop situations. Before you start the planning process, you will need to gather basic field information such as field size and location, sensitive features, past soil testing, and crop information.

You will need to gather aerial photos and/or field maps for all fields that could receive manure from your livestock operation. On these maps or photos, each field should be identified and outlined. Show any sensitive features (ditches, tiles, lakes, streams, wetlands etc.), for each field and the planned setbacks from those features. Refer to the MPCA publication "Applying Manure in Sensitive Areas" for complete information on how to identify sensitive areas. This publication is available on the Web at: http://www.pca.state.mn.us/publications/feedlots-manureapplication.pdf

The next step is completing a ***Field Nutrient Management Plan*** for **each** field that may receive manure. Two copies of this form are provided on the following pages. Before filling out the form(s), make numerous copies so you will have one for **each** field as well as extras for yearly plan updates.

At the top of the form, fill in the individual field information. Be sure to include any sensitive features.

(a) Fill in the most recent soil test information for this specific field. In order to get the most benefit from manure nutrients, it is vital to perform regular soil testing. If you do not know the Soil Name/Map Unit, you can obtain this from your local SWCD.


Field Nutrient Management Plan Crop Year _____

Farm Name/Tract # _____ Field _____

Field Location _____ Acres _____

Sensitive Features _____

Soil Test Information Date Tested _____

(a)

NO_3N lbs./acre	P ppm	K ppm	Percent Organic Matter	pH	Soil Name/Map Unit Soil Texture

Crop Nutrient Recommendation

(b) Determine **Crop Nutrient Recommendation** for each field by using the soil test and crop information that was previously gathered. For most crops besides corn, refer to the University of Minnesota publication "Fertilizer Recommendations for Agronomic Crops in Minnesota" which you may have received with this manure management planning booklet. It can also be found, along with corn recommendation publications, at: http://www.extension.umn.edu/Corn/genfertility.html. Fruit and vegetable publication can be found at http://www.extension.umn.edu/Vege&Fruit/. Information is also available at http://www.extension.umn.edu/distribution/cropsystems/DC3553.html.

Completing the **"Field Nutrient Management Plan"** ***continued on page 15***

Field Nutrient Management Plan

Crop Year _____

Farm Name/Tract # _____ **Field** _____

Field Location _____ Acres _____

Sensitive Features _____

_____

Soil Test Information Date Tested _____

(a)

NO_3N lbs/acre	P ppm	K ppm	Percent Organic Matter	pH	Soil Name/Map Unit: Soil Texture:

Crop Nutrient Recommendation

Planned Crop _____ Yield Goal _____

Previous Crop _____ Quality/Yield _____

Source of UMN Nitrogen Recommendation
- O UMN Nitrogen Tables
- O Western MN Soil Nitrate Test

	Pounds Per Acre N	P_2O_5	K_2O	
(b)	--------	---------	--------	**UM Broadcast Nutrient Recommendation** First-year legume nitrogen credits are already accounted for on line (b)

Other Nitrogen Credits

(c) _____ Second-Year Legume Nitrogen Credit **Crop/Quality** _____

(d) _____ Second-Year Manure Nitrogen Credit

(e) _____ Nitrogen Credit Based on Early-Spring Soil Nitrate Test

(f) _____ _____ _____ **Net Nutrients Needed**

(g) _____ _____ _____

Planned Manure Applications

Manure Source	Timing	Method	Rate/acre	N	P_2O_5	K_2O

(h) _____ _____ _____ **Supplemental Nutrient Needs**

(i) _____ _____ _____

Planned Fertilizer Application

Fertilizer form	Timing	Method	Rate/acre	N	P_2O_5	K_2O

(j) _____ _____ _____ **Total Nutrients to be Applied in Planning Year**

Sensitive Area Management (See page 19)

Field Nutrient Management Plan

Crop Year _____

Farm Name/Tract # _____ **Field** _____

Field Location _____ Acres _____

Sensitive Features _____

_____

Soil Test Information Date Tested _____

(a)

NO_3N lbs/acre	P ppm	K ppm	Percent Organic Matter	pH	Soil Name/Map Unit: Soil Texture:

Crop Nutrient Recommendation

Planned Crop _____ Yield Goal _____

Previous Crop _____ Quantity/Yield _____

Source of UMN Nitrogen Recommendation
- O UMN Nitrogen Tables
- O Western MN Soil Nitrate Test

Pounds Per Acre			
	N	P_2O_5	K_2O
(b)	--------	---------	--------

UM Broadcast Nutrient Recommendation
First-year legume nitrogen credits are already accounted for on line (b)

Other Nitrogen Credits

(c) _____ Second-Year Legume Nitrogen Credit **Crop/Quality** _____

(d) _____ Second-Year Manure Nitrogen Credit

(e) _____ Nitrogen Credit Based on Early-Spring Soil Nitrate Test

(f) _____ _____ _____ **Net Nutrients Needed**

(g) _____ _____ _____

Planned Manure Applications

Manure Source	Timing	Method	Rate/acre	N	P_2O_5	K_2O

(h) _____ _____ _____ **Supplemental Nutrient Needs**

(i) _____ _____ _____

Planned Fertilizer Application

Fertilizer form	Timing	Method	Rate/acre	N	P_2O_5	K_2O

(j) _____ _____ _____ **Total Nutrients to be Applied in Planning Year**

Sensitive Area Management (see page 19)

(c) If forage legumes were in the rotation of this field in the last 2 years, refer to Table 19 and the discussion on the top of page 12 of the University of Minnesota fertilizer recommendations booklet for second year legume nitrogen credits when growing corn. For other crops to be grown this year, refer to the text in the discussion sections of the publication.

(d) If manure was applied last year on this field, enter the second-year available nutrients as determined on the Manure Nutrient Credit Worksheet.

(e) If you performed an early spring soil nitrate test, enter the result here. If you enter a result here, do not enter a second year legume credit (c) or a second year manure credit (d) since this test will be measuring these nitrogen sources.

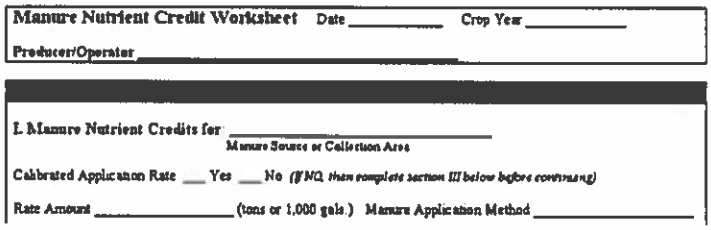
(f) Subtract the nitrogen credits identified in (c), (d) and (e) from the U of Minnesota recommendations listed in (b) and record the **Net Nutrient Needs** for this field.

(g) In order to determine the amount of nutrients that will be available from your planned manure application, you will now take a break from this form and fill out the **Manure Nutrient Credit Worksheet.** Once completed, the results from the worksheet (d-1, d-2, and d-3) will be entered here and you will resume filling out the Field Management Plan on page 18.

Completing the *Manure Nutrient Credit Worksheet* *(see p. 17)*

I. Manure Nutrient Credit

If your manure applicator is calibrated to apply a specific amount in tons or thousand gallons, enter the rate here. For instance, if your applicator applies 3,500 gallons per acre, enter "3.5," and then move on to Section III.



Manure Nutrient Credit Worksheet Date _____ Crop Year _____

Producer/Operator _____

I. Manure Nutrient Credits for _____
Manure Source or Collection Area

Calibrated Application Rate ___ Yes ___ No *(If NO, then complete section III below before continuing)*

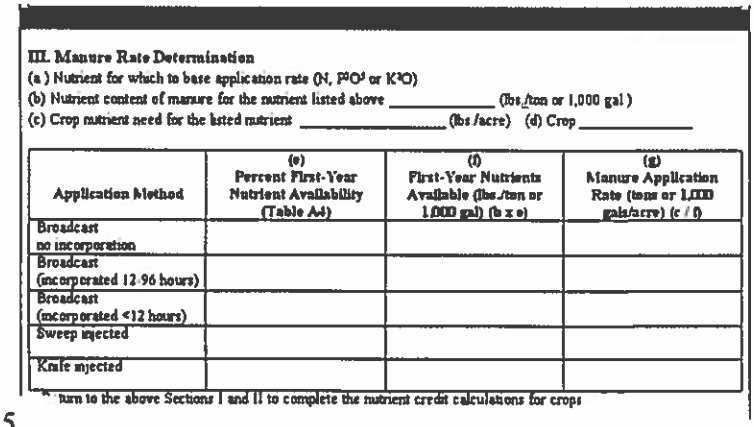
Rate Amount _____ (tons or 1,000 gals.) Manure Application Method _____

If you do not have a set calibrated application rate, complete Section II next.

II. Manure Rate Determination

(a) Choose the Nutrient for which your application rates will be determined. In most cases, you will determine your rate of application based on the nitrogen content of the manure and the nitrogen needs of the crop to be planted. In the case of high or very high phosphorus soil tests, refer to the *High Phosphorus Soils* worksheet on page 23 of this booklet.

(b) Fill in the nutrient content for the nutrient you chose to base your application rates on. This number can be found in section IV of the **Master Worksheet.**



III. Manure Rate Determination

(a) Nutrient for which to base application rate (N, P_2O_5 or K_2O)

(b) Nutrient content of manure for the nutrient listed above _____ (lbs./ton or 1,000 gal)

(c) Crop nutrient need for the listed nutrient _____ (lbs./acre) (d) Crop _____

Application Method	(e) Percent First-Year Nutrient Availability (Table A4)	(f) First-Year Nutrients Available (lbs./ton or 1,000 gal) (b x e)	(g) Manure Application Rate (tons or 1,000 gals/acre) (c / f)
Broadcast no incorporation			
Broadcast (incorporated 12-96 hours)			
Broadcast (incorporated <12 hours)			
Sweep injected			
Knife injected			

* Turn to the above Sections I and II to complete the nutrient credit calculations for crops

(c) Fill in the crop nutrient need for the listed nutrient. This can be found in your partially completed Field Nutrient Management Plan.

(d) Fill in the crop.

(e) Turn to **Table A4** (page 27) which begins with the words "Nitrogen availability and loss....." Find the type of animal you raise and follow the **Year 1** line across the table. These numbers are the percentage of nitrogen available for crop use based on different manure application methods. Copy these numbers for your animal type into column (e) of this form. Remember that the numbers in the table are expressed as a percentage so you need to put a decimal point in front of them when copying into column (e). For example if the number in Table A4 is 25, write it in column (e) as 0.25. *Note: The percentages listed in Table A4 are used for **nitrogen only**. If you base your manure application rate on Phosphorus, always use 0.80 as the first year available percentage and would therefore enter 0.80 behind all application methods in column (e).*

(f) Multiply the nitrogen content in your manure (b) by each of the decimal percentages in column (e) and enter them in column (f).

(g) Divide the crop nutrient needs (c) by the results recorded in column (f) and record the results in column (g). Column (g) represents the amount of manure in "tons" or "1000 gallons" you would need to apply to fully meet the crop nutrient needs in the first year.

III. First- and Second-Year Nutrient Availability to Crops

(a) Fill in the nutrient analysis of your manure from section IV of the *Master Worksheet.*
(b) Enter the manure application rate in tons or thousand gallons. This can be an application rate chosen after completing section II of this worksheet or a calibrated rate at which you normally apply manure.
(c) Multiply (a) x (b) under each of the nutrients. This is the total pounds of each nutrient you will apply before calculating first year availability.

First and Second Year Availability – Multiply the first-year availability percentage (expressed as a decimal) x the Total Nutrients Applied (c). Notice that the percentage availability for P_2O_5 and K_2O are set at 0.80 and 0.90 respectively, regardless of application method or animal type. For nitrogen, refer to **Table A4** (page 27) to find the appropriate first and second year availability percentage for your application method. The calculated pounds per acre first-year and second-year available nutrients are used when planning manure applications to individual field and crop situations. Complete this worksheet and transfer the results (d-1, d-2, and d-3) to line (g) of the Field Nutrient Management Plan.

Manure Nutrient Credit Worksheet

Date _____ Crop Year _____

Producer/Operator _____

I. Manure Nutrient Credits for: _____

Manure Source or Collection Area

Calibrated Application Rate ___ Yes ___ No *(If NO, then complete section III below before continuing)*

Rate Amount _____ (tons or 1,000 gal) Manure Application Method _____

II. Manure Rate Determination

(a) Nutrient for which to base application rate (N, P_2O_5 or K_2O)

(b) Nutrient content of manure for the nutrient listed above _____ (lbs./ton or 1,000 gal)

(c) Crop nutrient need for the listed nutrient _____ (lb/acre) (d) Crop _____

Application Method	(e) Percent First-Year Nutrient Availability (Table A4)	(f) First-Year Nutrients Available (lb/ton or 1,000 gal) (b x e)	(g) Manure Application Rate (tons or 1,000 gal/acre) (c / f)
Broadcast no incorporation			
Broadcast (incorporated 12-96 hours)			
Broadcast (incorporated <12 hours)			
Sweep injected			
Knife injected			

III. First- and Second-Year Manure Nutrient Availability to Crops

	N	P_2O_5	K_2O
Manure Analysis (lbs./ton or 1,000 gals.)	(a)	(a)	(a)
Application Rate (tons or 1,000 gal/acre)	(b)	(b)	(b)
Total Nutrients Applied (lbs./acre)	(a x b) = (c)	(a x b) = (c)	(a x b) = (c)

Nutrient Availability to Crops	N (lbs./acre)	P_2O_5 (lbs./acre)	K_2O (lbs./acre)
First-Year Availability	(% N available from Table A4) x (c) = (d-1)	(0.80) x (c)= (d-2)	(0.90) x (c)= (d-3)
Second-Year Availability	(% N available from Table A4) x (c) =		

Field Nutrient Management Plan (continued from page 15)

Returning to Step 3, Completing the Field Nutrient Management Plan (pages 13, 14)

(h) (*Supplementary nutrient needs*) Subtract the nutrients from Planned Manure Applications (g) from the Net Nutrients Needed (f) and fill in the result here. If the nutrients from manure are higher than the Net Nutrients Needed, then you may be over applying at your planned application rate and you may need to reduce the manure application rate. If this field has a high phosphorus soil test, you should plan a long-term strategy of how often manure can be applied so that soil test levels do not continue to increase. Refer to Part 14 on page 23.

(i) Record any planned fertilizer applications such as starter fertilizers or supplemental broadcast fertilizer needed to complete the crop needs. Enter the fertilizer type under "fertilizer form" and fill in the timing, method, rate/acre and actual pounds of each nutrient.

(j) Add the Nutrients from Planned Manure Applications (g) and Planned Fertilizer Applications (i) and enter the result here. These are the total nutrients to be applied to this field in the planning year.

At the bottom of the page, record any sensitive area management and complete the form on p. 24.

Remember, you must fill out one of these ***Field Nutrient Management Plan*** forms for **each** field on the farm. This form is a vital part of your overall Manure Management Plan that should be updated each year to help you manage manure nutrient application on your farm.

An additional copy of the Field Nutrient Management Plan form is provided on page 29. Use this copy to make photocopies.

Step 4.
How Will I Manage Manure in Sensitive Areas and High Phosphorus Soils?

If you apply manure in sensitive areas, you are required to include sensitive area management in your overall manure management plan before it will be considered complete.

Instructions:
Step 1. **Fields** – In the middle of the top row of Sensitive Area Management Table on page 20, list the field name or identification number (for all fields to receive manure). If more than nine fields are used, photocopy this form and complete for remaining fields. Make sure that the field acreage and location information for these same field names is listed in the manure management plan.

Step 2. **Sensitive Areas** – For each field listed on Sensitive Area Management Table, check all of the sensitive features that are in the field or adjacent to the field. For surface waters, check the box if the water type is within 300 feet of areas receiving manure. For floodplains, only check if manure is to be applied within a floodplain that is more than 300 feet from the water. A "public well management area" can be identified by asking city water managers (check if the fields are within about a mile of a community water supply well).

Whenever one or more fields has a sensitive feature, look at the right hand column to find out which part of the following pages (***"Sensitive Areas parts 1-14"***) needs to be completed. For example if a field has an open tile intake, then complete part 4 in sensitive areas (identify the setback option to be used for each field with an open tile intake). If no tile intakes are found in any field, then part 4 of Sensitive Areas does not need to be completed.

Step 3. **Soil Test Phosphorus** – For each field listed on Sensitive Area Management Table, check either a, b, c, or d, based on the field average soil phosphorus test levels.
Only one of the four boxes should be checked. If b, c, or d are checked for any of the fields, then follow the instructions in the right hand column (e.g. complete the corresponding Parts 13 and/or 14).

Step 4. **Timing of application** – For each field in Sensitive Area Management Table, check one of the five seasons that corresponds to the time manure will be applied onto that field. Follow the instructions in the right hand column of the Table. For example, if manure is to be applied to frozen or snow-covered soils, then complete Sensitive Areas Parts 11 and 12.

Step 5. **Soil Conservation** – All CAFOs and NPDES permitted feedlots must include a description of soil conservation practices. For all fields receiving manure from your CAFO facility, complete part 12 of Sensitive Areas. Part 12 is also required when manure will likely be applied onto frozen or snow-covered soils.

Sensitive Area Management Table

Field name/tract # Show same field name/tract # on maps or aerial photos of fields	Example field A	1	2	3	4	5	6	7	8	9	10	**What is needed to complete the manure management plan when one or more fields are checked in the row?**
Sensitive areas (check each feature that is within 300 ft of field)												Sensitive areas parts 1-14 are found on the following pages.
a. Lake or Stream												Complete Sensitive Areas part 1
b. Intermittent stream												Complete Sensitive Areas part 2
c. Drainage ditch without protective berms	X											Complete Sensitive Areas part 2
d. Wetlands over 10 acre (public waters wetland)												Complete Sensitive Areas part 3
e. Open tile intakes	X											Complete Sensitive Areas part 4
f. Wetlands under 10 acres												Complete Sensitive Areas part 5
g. Sinkhole, well, mine or quarry												Complete Sensitive Areas parts 6 and 7
h. Floodplain												Complete Sensitive Areas part 8
i. Public well mgmt. area												Complete Sensitive Areas part 9
k. Shallow soil over fractured rock												Complete Sensitive Areas part 10
l. Other conduits to water												Complete Sensitive Areas part 2, if CAFO
Soil test Phos. (ppm) check one (a-d)												Note: Use field average P
a. Under 22 ppm Bray P1 or 17 Olsen												No state restrictions on P applications
b. 22-75 Bray P1 or 17-60 Olsen	X											If field is within 300 ft of sensitive areas a,b,c,or d, above, then complete Sensitive Areas part 13
c. 76-150 Bray P1 or 61-120 Olsen												If field is within 300 ft of the sensitive areas a, b, c, d **or** e above, then complete Sensitive Areas part 14
d. Over 150 Bray P1 or 120 Olsen												Complete Sensitive Areas part 14
Timing of application (check one)												
June, July or August												Describe cover crop:
September to mid/late-October												If CAFO, no application to coarse-textured soils until soil temps drop below 50° F
Late Oct. to soil freeze	X											No added requirements
Frozen or snow-covered soils												Complete Sensitive Areas parts 11 and 12
Spring application to unfrozen soils												No added requirements
Soil Conservation												
Is feedlot a CAFO or NPDES permitted site?	N											Complete Sensitive Areas part 12 if the feedlot is a CAFO

Sensitive Areas Parts 1-14

Part 1. Lake or perennial stream

Option A

- inject or incorporate within 24 hours and prior to rainfall (within 300 feet), and
- 25 foot setback with no manure applied
- avoid long term soil P build-up

Option B – 100 ft wide non-manured grassed buffer
Option C – 100 ft non-manured setback with at least one rod (16.5') as grassed buffer
Option D – other (describe)

_____

Field _____ Option ___
Field _____ Option ___
Field _____ Option ___
Field _____ Option ___
Field _____ Option ___

Part 2. Intermittent stream or drainage ditch without protective berm

Option A

- inject or incorporate within 24 hours and prior to rainfall (within 300 feet), and
- 25 foot setback with no manure applied
- Avoid long term soil P build-up

Option B – 50 ft wide non-manured grassed buffer
Option C – 100 ft non-manured setback with at least one rod (16.5') as grassed buffer
Option D – other (describe) _____

_____

All fields..... Option ___
Field _____ Option ___
Field _____ Option ___
Field _____ Option ___
Field _____ Option ___
Field _____ Option ___

Part 3. Public waters wetland (i.e. >10 acres)

Option A

- inject or incorporate within 24 hours and prior to rainfall (within 300 feet), and
- 25 ft setback with no manure applied
- avoid long term soil P build up

Option B – 50 ft wide non-manured grassed buffer
Option C – 100 ft non-manured setback with at least one rod (16.5') as grassed buffer
Option D – other (describe) _____

_____

All Fields..... Option ___
Field _____ Option ___
Field _____ Option ___
Field _____ Option ___

Part 4. Tile intakes

Option A

- inject or incorporate within 24 hours and prior to rainfall (within 300 ft of intake)
- 25 foot setback with no manure applied
- avoid long term soil P build-up

Option B

- inject or incorporate within 24 hours and prior to rainfall (within 300 ft of intake), and
- Use a riser pipe that allows at least 75% solids settling in ponded area surrounding the intake*

Option C – 35 foot non-manured grassed buffer
Option D – 100 foot non-manured setback with at least one rod (16.5') as grassed buffer
Option E – other (describe) _____

_____

* Note: needed if NPDES permitted facility

All fields..... Option ___
Field _____ Option ___
Field _____ Option ___
Field _____ Option ___
Field _____ Option ___

Part 5. Wetlands under 10 acres

No specific state-wide requirements. Check which practices will be followed to meet any permit conditions and/or to voluntarily protect water quality:

- ☐ Setback of _____ ft
- ☐ Grassed buffer _____ ft wide
- ☐ No long term soil P build-up
- ☐ Incorporate manure within _____ ft
- ☐ Soil conservation practices
- ☐ Other _____
- ☐ Other _____

Part 6. Sinkhole

Option A

- inject or incorporate within 24 hours and prior to rainfall (upslope and within 300 ft), and
- 50 ft setback with no manure applied (100 ft setback for CAFOs)

Option B – Diversion berm to prevent runoff into the sinkhole

Field _____ Option ___
Field _____ Option ___
Field _____ Option ___
Field _____ Option ___
Field _____ Option ___
Field _____ Option ___
Field _____ Option ___

Part 7. Wells, Mines, Quarries

50 ft setback – minimum required
(100 ft if CAFO applying near agricultural wellhead)

Field _____ setback _____
Field _____ setback _____
Field _____ setback _____
Field _____ setback _____
Field _____ setback _____
Field _____ setback _____

Part 8. Floodplains extending beyond 300 feet of waters

No minimum state-wide requirements.
Check which practices will be followed:

□ Avoid manure application during peak flooding periods
□ Incorporate or inject manure when there is a risk of flooding
□ Avoid winter-time manure applications
□ Other _____

Part 9. Public Well Management Areas

i.e. Those vulnerable to contamination

No state requirements specifically for these areas.
Check which practices will be followed:

□ Follow practices recommended in city wellhead protection plans
□ Maintain a setback of _____ ft
□ Soil nitrate test will be used to refine nitrogen rate management decisions
□ Apply no earlier than late October, or when soil temperatures are less than 50°F
□ Use crops that mine nitrogen out of the soil (e.g. alfalfa, legume grasses, etc.)
□ Other _____

Part 10. Shallow soil over fractured bedrock

(i.e. < 3 feet above limestone)

No specific state requirements
Check which practices will be followed:

□ Use composted manure or other processes which kill bacteria
□ Till manure into soil
□ Maximize separation between fractured bedrock and manure
□ Other _____

Part 11. Winter Application Sites

Fields used for winter application

Field	Slope	Distance to nearest water

Check which practices will be followed for **winter application fields.**

Required for all sites:

□ I will not apply manure to frozen or snow-covered soils within 300 feet of lakes, streams, intermittent streams, public waters wetlands, drainage ditches without berms, and open tile intakes.

Management Options Check which will be followed (all are Required for CAFOs)

□ Avoid spreading during snowmelt that creates runoff or when rainfall over ¼ inch is expected within 24 hrs
□ Spread liquid Manure to slopes less than 2 percent and solid Manure to slopes less than 6 percent.
□ Spread manure where tillage is on the contour (if slopes >2%)
□ Apply liquids at rates that prevent runoff during the application process
□ Find alternative fields or management where MPCA determines that water will be polluted

Part 12. Conservation Practices

Check which conservation practices will be used:

□ grassed waterways
fields: _____
□ field edge buffers
fields: _____
□ contour stripcropping
fields: _____
□ chisel or disk tillage w/residue
fields: _____
□ contour buffer strip
fields: _____
□ no-till
fields: _____
□ sediment control basin
fields: _____
□ terrace
fields: _____
□ cover crop
fields: _____
□ rotations that include crops other than row crops
fields: _____
□ meets tolerable soil erosion losses "T" defined by NRCS
□ Other _____

Part 13. High phosphorus soils

Over 21 ppm Bray P1 (weak Bray);
Over 16 ppm Olsen; or
Over 30 ppm Mehlich III

If applying manure to high phosphorus soils that are within 300 feet of lakes, streams, intermittent streams, public waters wetlands (i.e. over 10 acres), and drainage ditches without protective berms, check the box and insert the planned frequency of application.

☐ I will maintain or reduce my soil P levels when applying manure within 300 feet of waters by applying manure no more than _____ times during a six-year period. Additionally, I will test my soils and further reduce manure rates and/or frequency of application if soil test levels are found to continue to increase.

To determine the number of times that manure should be applied during a six year period to prevent long-term soil P build-up follow the three steps below.

Step 1. Determine average P removal during the crop rotation (multiply expected yields by the crops' P_2O_5 removal rates as listed in Table A5 on page 27).
Example: Corn/soybean rotation with 160 bushel corn and 45 bushel beans -
Corn – [160 * 0.34] = 54 lbs P_2O_5 removed per year
Soybeans [45 * 0.82] = 37 lbs P_2O_5 removed per year
Average – 45 lbs P_2O_5 removed per year

Step 2. Determine the amount of P_2O_5 that is typically applied in manure applications (multiply rate of application times manure P_2O_5 content times 0.80).
Example: 4000 gals/ac * 28 lbs P2O5 /1000 gals * 0.8 = 90 lbs P_2O_5 applied

Step 3. Divide result of step 2 by result of step 1.
Example: 90/45 = 2 (i.e. manure can be applied on average once every 2 years or three times in a 6-year rotation without expecting soil P build-up).

Part 14. Extremely high phosphorus soils

Proximity to waters*	Bray P1 (ppm)	Olsen (ppm)	Mehlich III (ppm)
Within 300 ft of waters or open tile intakes	>75	>60	>90
All other land away from waters and intakes	>150	>120	>180

Below, circle the option(s) that will be used for soils exceeding the thresholds in the above table for extremely high P soils. Check appropriate boxes and fill in other needed information.

Option A. Discontinue manure applications to the following fields.
Field _____
Field _____
Field _____
Field _____

Option B. I will follow all NRCS 590 standards for extremely high P soils as stated in the three conditions below:

☐ I will Maintain or reduce soil P levels by applying manure no more than _____ times during a six-year period to all manured fields with extremely high P (use same procedure as described for high P soils near waters).

☐ I will not apply manure to fields with sheet and rill erosion exceeding 4 tons/acre, unless a 100 foot grassed buffer is along all receiving waters and erosion is less than 6 tons/acre (list fields that will not receive manure due to these conditions):
Field _____
Field _____
Field _____
Field _____

☐ I will not apply manure within 300 feet of waters if soil P exceeds 150 ppm Bray P1 (or 120 Olsen), except if a 100 foot grass buffer exists along the water and erosion is less than 2 tons/acre (list fields that will not receive manure due to these conditions):
Field _____
Field _____
Field _____

Option C

☐ I have used the University of Minnesota soil phosphorus index and will only apply manure to those fields which show a low or very low rating. The phosphorus index can be found at the following web site: www.mnpi.umn.edu. Attach P index results for fields where manure applications are planned.

☐ Additionally, I will maintain or reduce my soil P levels by only re-applying manure after the manure P is removed by crops planted after the manure application (see attached table of crop P removal).

Definitions of Sensitive Features

Tile intakes – a direct conduit (e.g. piping) from the ground surface to waters of the state and any other mechanism used to drain surface runoff ponding from fields that does not result in effective treatment or removal of pollutants (i.e. including blind inlets or rock inlets). This also includes side inlets through berms along drainage ditches.

Drainage ditch – edge of field drainage ditches (typically shown on U.S. Geological Survey quadrangle maps), excluding ditches that have berms sufficiently high to prevent runoff into the ditch.

Lakes, River or Stream – Lakes can be generally considered as bodies of waters over 25 acres. Rivers or streams flow continuously.

Intermittent streams – Streams which do not flow all year. They can flow continuously for long or short periods of time, and when a storm or major snowmelt occurs. They are denoted by dashed lines on U.S. Geological Survey Topographic maps.

Wetlands over 10 acres (public waters wetlands) – DNR protected wetlands, which are typically over 10 acres in rural areas.

Wetlands under 10 acres (non-farmed wetlands) – Wetlands under 10 acres, excluding wetlands that are used for agricultural purposes.

Floodplains – Land that regularly floods during the spring or during large storms.

Public well management area – Drinking water supply management areas delineated in accordance with Minnesota Health Department rules, where the aquifer/well is considered vulnerable. The well owner/manager should know whether the land is in such an area.

Shallow bedrock – Areas with bedrock less than 36 inches below the soil surface as identified in the soil survey, field checks, or NRCS evaluations.

Sinkhole – A surface depression caused by a collapse of soil or overlying formation above a fractured or cavernous bedrock.

Well, Mine or Quarry – Active wells, inactive unsealed wells, or any human excavations to remove stone, gravel, sand, iron, or other minerals.

Other conduits to waters – This category can include road ditches, especially those which are mapped as intermittent streams, or other pipes or channels that lead directly to waters of the state.

Final Steps, Additional Forms

Aerial Photographs

As discussed on page 12, your Manure Management Plan is not complete until you secure aerial photos of each field you will have access to for manure spreading. On the photos, outline each field and also outline any sensitive areas or areas of special concern where you might need to use special management practices such as setbacks or immediate incorporation.

It is suggested that you staple these photos to the back page of this booklet.

Soil and Manure Test Results

It is also a good idea to gather copies of all soil test results and manure nutrient analysis results and keep them with this booklet for quick reference.

A Living Document

Remember that this Manure Management Plan is a living and working document. That is, once completed, it needs to be updated each year with new cropping information or any changes in management or test results. If it is not followed, you will not benefit from the maximum value of the manure nutrients produced on your farm.

Extra Forms

Additional copies of the Master Worksheet and Field Nutrient Management Plan are located on the following pages. Use these copies to make any additional photocopies you may need to develop or update your plan.

Additional information on sensitive area management, including additional forms, is available on the MPA Web site:

http://www.pca.state.mn.us/hot/feedlots.html#forms
http://www.pca.state.mn.us/publications/feedlots-manureapplication.pdf

Check the Checklist

Remember to download and use the Manure Management Plan Requirements and Checklist available on the MPCA Web site to make sure you have completed all the necessary components of the plan.
http://www.pca.state.mn.us/hot/feedlot-management.html

Nutrient/Manure Management Information Tables

Table A1. Annual manure production and nutrient excretion from livestock.

Animal Type	Manure production per 1,000 lbs. Animal Weight		Excreted Nutrient in Manure per 1,000 lbs. of Animal Weight		
	Solid (tons/year)	Liquid (gals/year)	N	P_2O_5	K_2O
BEEF					
calf	19.5	4591	162	73	130
finishing	9.0	2141	131	39	83
cow	16.8	3982	128	66	106
DAIRY					
calf	14.6	3358	146	24	122
heifer	11.0	2536	112	39	112
lactating	20.3	4876	263	135	146
dry	9.3	2241	110	40	88
veal	4.8	1153	44	29	73
SWINE					
nursery	13.9	3358	292	146	146
finishing	9.0	2166	219	73	97
gestating	4.1	998	61	37	49
lactating	8.5	2025	165	107	127
boar	3.8	900	49	37	37
POULTRY					
broiler	17.3	4198	383	256	183
layer	9.1	2068	316	97	146
turkey (female)	8.6	2044	285	186	124
turkey (male)	6.8	1606	203	135	88
duck	20.1	4836	392	310	237
HORSE					
pleasure	9.9	2394	66	22	22
SHEEP					
feeder	7.5	1825	146	73	146

Adapted from *Manure Characteristics*, MWPS-18 Section 1, MidWest Plan Service, 2004

Calibrating Your Manure Spreader

1. Determine manure weight (solid manure) or manure volume (liquid manure) per spreader load.

(Use measured manure weight or 90% of the manufacturer's listed volume for liquid.)

2. Calculate rate based on loads applied per field

OR

Calculate rate based on acres covered per load.

Table A2. Nitrogen losses by storage/handling method

Storage, handling method	Manure type	% N loss
Daily scrape, haul	Solid (tons)	25
Manure pack	Solid (tons)	30
Open lot	Solid (tons)	50
Litter	Solid (tons)	35
Above ground tank	Liquid (gals)	20
Below ground covered pit	Liquid (gals)	20
Below ground open pit	Liquid (gals)	25
Under-floor dry	Solid (tons)	25
Under-floor liquid	Liquid (gals)	20
Earthen storage	Liquid (gals)	30
Lagoon	Liquid (gals)	75

Table A3. Estimated nutrient content of liquid and solid manure.

Animal type	Liquid Manure lbs./1,000 gals			Solid Manure lbs./ton		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Beef - Feeder cattle	29	18	26	14	9	14
Cow	20	16	24	11	7	9
Dairy - Heifer	32	14	28	13	12	19
Cow	25	15	27	11	7	9
Swine – Sow, litter	15	12	11	14	6	4
Nursery	25	19	22	13	8	4
Grow, finish	53	39	29	16	9	5
Gestation	25	25	24	9	7	5
Poultry - Layers	57	52	33	34	51	26
Broilers	63	40	29	46	53	36
Turkey	53	40	29	44	63	34
Horse				14	4	14
Sheep				18	11	26

Sources: Manure Management in Minnesota, WW-03553 (2007), University of Minnesota Extension Service; Manure Characteristics, MWPS-18 Sec. 1, MidWest Plan Service, 2004; Livestock Waste Facilities Handbook, MWPS-18, MidWest Plan Service, 1985

Table A4. Nitrogen availability and loss as affected by method of manure application and animal type

Year Available	Broadcast Incorporation Timing[2]			Injection	
	> 96 hrs	12 - 96 hrs	< 12 hrs	Sweep	Knife
Beef	Percent of Total Nitrogen Available Per Year				
Year 1	25	45	60	60	50
Year 2	25	25	25	25	25
Lost	*40*	*20*	*5*	*5*	*10*
Dairy					
Year 1	20	40	55	55	50
Year 2	25	25	25	25	25
Lost	*40*	*20*	*10*	*5*	*10*
Swine					
Year 1	35	55	75	80	70
Year 2	15	15	15	15	15
Lost	*50*	*30*	*10*	*5*	*15*
Poultry					
Year 1	45	55	70	NA	NA
Year 2	25	25	25	NA	NA
Lost	*30*	*20*	*5*		

Adapted from: Manure Planning Record Keeping Guide, BU-6957, University of Minnesota Extension Service, 2001

1. Third year available N is not listed but can be computed by adding years 1 and 2 and lost percentages and subtracting this sum from 100.
2. Timing categories: length of time between application and incorporation.

Conversion Factors

1 acre = 43,560 ft^2
1 cubic ft = 7.48 gallons
1 gal of water = 8.33 lbs

Soil Testing Conversions

Plow layer (6-7 in.) = ppm x 2 = lb/acre
Top 12 in. = ppm x 4 = lbs./acre
Top 24 in. = ppm x 8 = lbs./acre
P_2O_5 x 0.44 = P
P x 2.29 = P_2O_5
K_2O x 0.83 = K
K x 1.20 = K_2O

Fertilizer Conversions

1 gal of UAN (28%) = 10.66 lbs
1 gal (10-34-0) = 11.65 lbs
1 gal (7-21-7) = 11.0 lbs
1 gal (9-18-9) = 11.11 lbs

Table A5. Nutrient removal in harvested portion of the crop – Source (http://plants.usda.gov/plants/index.html)

Crop	Yield Units	Crop Nutrient Removal (lbs. per unit)		
		N	P_2O_5	K_2O
Alfalfa	Tons (air dry)	50.4	10.8	46.2
Alsike clover	Tons (air dry)	40.8	10.5	54.0
Barley (grain)	Bushels		0.41	0.28
Barley (grain and straw)	Bushels		0.55	1.67
Birdsfoot trefoil	Tons (air dry)	45.3	9.3	41.1
Canola	Cwt.		1.3	1.1
Corn (grain)	Bushels		0.34	0.19
Corn silage	Tons (as fed)		3.8	7.4
Edible beans	Pounds		0.01	0.03
Grass hay or pasture	Tons (air dry)	27.1	8.9	31.3
Grass/legume	Tons (air dry)	43.5	11.2	41.3
Oats (grain)	Bushels		0.25	0.16
Oats (grain and straw)	Bushels		0.32	1.31
Peas	Pounds		0.01	0.01
Potatoes	Cwt.		0.14	0.56
Red Clover	Tons (air dry)	45.1	10.8	41.1
Rye (grain)	Bushels		0.44	0.31
Rye grain, straw	Bushels		0.59	1.25
Soybeans	Bushels	3.5	0.82	1.0
Sugar beets	Tons		2.2	7.3
Sunflowers	Pounds		0.01	0.01
Sweet corn	Tons		11.0	13.9
Wheat (grain)	Bushels		0.53	0.3
Wheat (grain and straw)	Bushels		0.64	1.5

Common Fertilizer Analysis

Fertilizer	Analysis
Nitrogen (N)	
Anhydrous ammonia	82-0-0
Ammonium nitrate	34-0-0
Urea	46-0-0
UAN solution (Urea Ammonium Nitrate)	28 to 32-0-0
Aqua ammonia	20-0-0
Ammonium sulfate	21-0-0-24(S)
Phosphorous (P)	
Triple superphosphate	0-44 to 46-0
Diammonium phosphate	18-46-0
Monoammonium phosphate (MAP)	11-48-0
Ammonium polyphosphate liquid	10-34-0
Ammonium polyphosphate Dry	15-62-0
Potassium (K)	
Potassium chloride (Muriate of potash)	0-0-60
Potassium sulfate	0-0-50-18(S)
Potassium-magnesium sulfate (Sulf-fo-mag)	0-022-22S-11(Mg)
Potassium nitrate	13-0-44

More information from the Extension Service is available online:
http://www.manure.umn.edu/applied/application.html

Master Worksheet – Manure Storage, Handling and Testing

Producer name/operator _____ **Date** _____

	Manure Source #1	Manure Source #2	*Example Dairy Barn*
I. Livestock Information			
Animal (#1) type			*Dairy cows*
Animal (#1) number, size			*50 @ 1400 lbs.*
Animal (#2) type			*Dairy heifers*
Animal (#2) number, size			*7 @ 800 lbs.*
II. Manure Storage			
Storage type			*Above ground tank*
Storage capacity (tons, gal)			*5000,000 gallons*
Storage (days, months)			*7 months*
III. Application Methods			
Commercial hauler			*No*
Spreader type[1]			*Slurry tanker*
Spreader calibrated (date)			*Yes, 11/03/2001*
When applied[2]			*Fall and spring*
Application method[3]			*Knife inject*
Incorporation timing[4]			*Immediate*
IV. Manure Analysis			
Sampling frequency			*Annually*
Sampling methods			*Spreader during filling*
Date analyzed			*11/03/2001*
N (lbs per ton or 1000 gal)			*24 lbs./1000 gal*
P_2O_5 (lbs per ton, 1000 gal)			*18 lbs./1000 gal*
K_2O (lbs per ton or 1000 gal)			*29 lbs./1000 gal*
V. Annual Manure/Nutrients Generated			
Manure volume or tons per year			*450,000 gallons*
Manure volume/tons based on records			*Yes*
Annual amount N (lbs)[5]			*24 x 450 = 10,800 lbs*
Annual amount P_2O_5 (lbs)[5]			*18 x 450 = 8,100 lbs*
Annual amount K_2O (lbs)[5]			*29 x 450 = 13,050 lbs*

1. "Spreader types" are: Slurry tanker, Solids spreader, Towed hose, Center pivot, Other sprinkler
2. "When applied" choices: Daily, Every other day, Weekly, Every 2 weeks, Monthly, Fall, Winter, Spring, Summer
3. "Application method" choices: Surface broadcast, Sweep inject, Knife inject
4. "Incorporation time" choices: Immediate, less than 12 hours, 12-96 hours, greater than 96 hours
5. Annual nitrogen of manure in lbs to be land applied after accounting for storage losses.

Field Nutrient Management Plan

Crop Year _____

Farm Name/Tract # _____ **Field** _____

Field Location _____ Acres _____

Sensitive Features _____

_____

Soil Test Information Date Tested _____

(a)

NO_3N lbs/acre	P ppm	K ppm	Percent Organic Matter	pH	Soil Name/Map Unit: Soil Texture:

Crop Nutrient Recommendation

Planned Crop _____ Yield Goal _____

Previous Crop _____ Quality/Yield _____

Source of UMN Nitrogen Recommendation
- O UMN Nitrogen Tables
- O Western MN Soil Nitrate Test

	Pounds Per Acre N	P_2O_5	K_2O
(b)	--------	---------	--------

UM Broadcast Nutrient Recommendation
First-year legume nitrogen credits are already accounted for on line (b)

Other Nitrogen Credits

(c) _____ Second-Year Legume Nitrogen Credit **Crop/Quality** _____

(d) _____ Second-Year Manure Nitrogen Credit

(e) _____ Nitrogen Credit Based on Earl-Spring Soil Nitrate Test

(f) _____ _____ _____ **Net Nutrients Needed**

(g) _____ _____ _____

Planned Manure Applications

Manure Source	Timing	Method	Rate/acre	N	P_2O_5	K_2O

(h) _____ _____ _____ **Supplemental Nutrient Needs**

(i) _____ _____ _____

Planned Fertilizer Application

Fertilizer form	Timing	Method	Rate/acre	N	P_2O_5	K_2O

(j) _____ _____ _____ **Total Nutrients to be Applied in Planning Year**

Sensitive Area Management (see page 19)

Aerial Photos

Attach aerial photos here

APPENDIX D

Nutrient Management Plan

DEHAAN, GRABS & ASSOCIATES, LLC
Consulting Engineers

Nutrient Management Plan For

ROLLING GREEN FAMILY FARMS RE, LLP

Cass County, ND

Prepared by DeHaan, Grabs & Associates, LLC,
Mandan, ND

December 2015

DeHaan, Grabs & Associates, LLC
PO Box 522 | Mandan, ND | 58554
www.dgaengineering.com

1. Introduction

This Nutrient Management Plan was developed for Rolling Green Family Farms RE, LLP. This facility is by Buffalo, ND (2 miles south on ND-38 from Buffalo, ND and 2 ½ miles east on 36th street). The site will located on the south side of 36th Street. The facility is a confinement barn where they plan to have 800 nursery pigs, 1600 finish pigs, 5312 gestating sows, and 1344 sows and litters. Animals are confined the whole year. This Nutrient Management Plan was developed as a joint effort between Pipestone Vet and DeHaan, Grabs & Associates, LLC.

The total nutrients available for crop application of N (153,761lbs), available P_2O_5 (141,346), and total K_2O (172,661) produced annually by the livestock was determined by DeHaan, Grabs & Associates, LLC using AWMFH from Tables 4.5 to 4.9 and ASAE D384.2 Table 19. The manure will be collected through slotted floors in the confinement barn which will be applied to the fields via knife or sweep injection. The CNMP includes 3,280.4 acres of agricultural land which is available for manure application. Rolling Green Family Farms RE, LLP plans to rotate between corn and beans with conventional tillage. All of the manure application sites are dryland. Plant uptake from the fields in an average corn/bean rotation is calculated at 449,300 lbs of N and 128,526 P_2O_5 respectively. Commercial fertilizer will need to be applied to meet the N requirements of the crops. It is important to remember that the rotation will be adjusted based off of market forces, weather, feed requirements, economic influences, etc. When calculating projected land base requirements and RUSLE 2 calculations, Cass County average yields x 110% was used unless the approved yield for the field was higher. When calculating annual nutrient application needs, actual yields on a per field basis will be used.

2. Record Keeping.

It is recommended that records be maintained for at least 5 years to document plan implementation and maintenance. As applicable, records include:

1) Soil, plant tissue, water, manure, and organic by-products analyses resulting in recommendations for nutrient application.
2) Quantities analyses and sources of nutrients applied on the forms in Section 10.F.
3) Dates, methods of nutrient applications, source of nutrients, and rates of application.
4) Weather conditions and soil moisture at the time of application; lapsed time to manure incorporation; rainfall or irrigation event,
5) Crops planted, planting and harvest dates, yields, nutrient analyses of harvested biomass and crop residues removed.
6) All enhanced efficiency fertilizer products used.
7) Maps identifying the variable rate application source, timing, amount, and placement of all plant nutrients applied and

8) GPS-based yield maps for crops where yields can be digitally collected.
9) Prepare an annual Nutrient Management Plan based on current data.

3. **Soil Sampling.**
Nutrient planning recommendations should be based on current soil, manure, and tissue test results developed in accordance with NDSU recommendations. Current soil tests are those that are no older than 3 years. The soil and tissue tests must include analyses of pertinent to monitoring or amending the annual nutrient budget, e.g., pH, electrical conductivity (EC) and sodicity where salts are a concern, soil organic matter, phosphorus, potassium, or other nutrients and test for nitrogen where applicable. The sampling procedure shall be followed as shown in Section K.

4. **Manure Sampling.**
a. Manure samples in conjunction with soil samples, will be taken prior to land application to determine land application rate.

b. Liquid and solid manure samples will be analyzed by a certified laboratory for, potassium, total nitrogen, ammonium-nitrogen and phosphorus and total solids.

5. **Nutrient Budget for Land Application.**
a. Nutrient loss due to volitization, evaporation, and crop uptake will be accounted for each time liquid manure is applied to the land application area.
b. Planned nutrient application rates for nitrogen, phosphorus and potassium must not exceed the land-grant university guidelines or industry practice.

6. **Timing, Rate, and Frequency of Liquid and Solid Manure Applications.**
a. Timing and placement of all nutrients must correspond as closely as practical with plant nutrient uptake (utilization by crops), and consider nutrient source, cropping system limitations, soil properties, weather conditions, drainage system, soil biology, and nutrient risk assessment results.
b. Nutrients shall not be applied to frozen, snow-covered or saturated soil, or when the top 2 inches of soil are saturated from rainfall or snow melt.

Land applications will be conducted in the spring, summer and fall.

d. Land application will be conducted in a manner which will prevent a discharge or drainage of manure to ground or surface waters of the State.

e. Land application practices are managed so as to reduce or minimize

ponding or puddling of liquid manure on the site, contamination of ground or surface waters, and occurrence of nuisance conditions such as odors, flies, and rodents.

f. Land application practices will minimize the possibility of contamination of surface and groundwaters of the State.

7. **Land Application of Liquid Manure**

a. The land application of the manure plans to be either knifed or sweeped directly into the ground.

8. **Amounts of Nitrogen Applied.**

a. Liquid and solid manure will typically be applied at agronomic rates for nitrogen, however, the phosphorus application will follow the North Dakota state phosphorous index risk assessment to ensure that the phosphorus levels are not becoming a risk to surface water pollution.

Section 10.B. lists the crop requirements for nitrogen as defined by a Licensed Professional Engineer.

b. Calculations for quantity of liquid manure that can be applied to agronomic rates to crop production land are performed by the staff soil scientist or contract professional. The maximum manure application rates can be seen in Section 10.B. The following land application formulas can be used for determining application rates or ones prepared by North Dakota State University Extension.

1) Nitrogen Need (lb/ac) = 35 + (1.2 x EY) - (8 x NO_3 - N ppm) - (0.14 x EY x OM) - other N credits
where, EY = Expected yield (bu/acre).
NO_3 - N ppm = average nitrate - nitrate concentration in the root zone.
OM = percent organic matter.
other N credits = nitrogen from legumes, manure and other organic waste products and irrigation water.

2) Manure N content (lbs/ac-in) = ((Total N ppm) x 0.2267)) x 0.4
where, 0.4 = nitrogen loss coefficient.
(The nitrogen loss coefficient may change with further improved research investigation.)

c. Max. application (lbs/ac)/Manure N Content (lbs/ac-in) = Max. manure application (ac-in).

d. Acres for application x Max. manure application (ac-in) x 27154 = Max. pumping volume (gallons).

e. The spreadsheet log for land application can be utilized for land application calculations.

9. Management Considerations for Nitrogen

Groundwater Concerns

The groundwater concern comes primary from nitrogen. If not captured by plant roots it can move down below the root zone and may enter the groundwater. The speed at which nitrate moves depends on the amount of precipitation received, soil texture and the amount of organic matter in the soil. Water moves through sandy soil much more rapidly than a clay soil.

Because nitrate moves through the soil with water, it is extremely important that the rate applied, either as manure or fertilizer, does not exceed that which can be used by the crops. Any nitrate remaining in the soil profile at the end of the season is subject to leaching.

Nitrogen Best Management Practices to Conserve N

- Match Manure Nutrient applications to crop needs.
- Apply manure as close to the time of crop utilization as possible. Apply commercial fertilizer nitrogen in a side-dress or split application when fields are located over shallow aquifers or on soils that have a high leaching potential.
- Delay fall manure applications until soil temperatures drop below 50 degrees F to minimize nitrate leaching and ammonia volatilization.
- Avoid applying manure on wet soils to minimize soil compaction, runoff, nitrate leaching, and denitrification.
- Inject or incorporate the manure into the soil preferably within 24 hours for maximum nutrient-use efficiency and to reduce odor and runoff chances. Significant volatilization losses will occur when manure is left on the surface for several days.

Water Quality Risk Assessment Maps will be labeled with the symbol "L" on fields that are vulnerable to N Leaching. These practices are not required only encouraged, specifically on fields that have high leaching capacity.

10. Phosphorus Risk Assessment

a. The phosphorus risk assessment was done for every field as can be seen in Section 10.B.2. The Best Managements Practices are shown in Section I.1 for site specific ratings. Subsequent assessments will be conducted if risk factors change or 5 years has passed since the previous assessment.

i. Low or Medium Risk

For a field or field segment with a low or medium risk of phosphorus movement from the field, a single year's application of manure may be based on the expected annual nitrogen requirement for the planned crop.

ii. High Risk

For a field or field segment where there is a high risk of phosphorus movement from the field, the manure will be applied at a rate equal to or less than the expected phosphorus removal in harvested plant biomass for a planned crop sequence of five years or less. The total nutrient application will not exceed the expected annual nutrient requirement for the planned crop.

iii. Very High Risk

For a field or field segment with a very high risk of phosphorus movement from the field, manure will not be applied.

11. Management Considerations for Phosphorus

Surface Water Concerns

Surface water concerns focus primarily on phosphorus. Phosphorus acts very differently in soils than nitrogen. It attaches tightly to soils and does not generally move down through the soil profile. This lack of movement through soils results in accumulations of phosphorus in soil if phosphorus rates, either from manure or fertilizer, are greater than crop removal. Increases in phosphorus concentrations in soil can result in more phosphorus moving off the field either attached to soil particles lost by erosion or dissolved in the runoff water. In some situations phosphorus could move into surface waters with manure itself if the manure is applied in such a manner that it moves directly into waterways.

Water Quality Risk Assessment Maps: will be labeled with the symbol "R" on fields that have limitations to Phosphorus applications.

1) In no case shall manure or organic by product applications (broadcast or incorporated/injected) be made within 100 feet of a surface water or conveyance.

Phosphorus Base Manure Application

If the manure application is required to be based on phosphorus crop removal, the application rate shall be based on phosphorus removed in the harvested portion of the crop.

Phosphorus Best Management Practices

1) Establish and maintain grass filter strips at the point where water leaves the field to trap sediment and nutrients

2) Control sheet and rill erosion by installing conservation practices including conservation tillage, contour farming, strip cropping, terraces and cover crops.

3) Control ephemeral erosion by installing grassed waterways, diversions and sediment retention structures.

4) Incorporate or inject manure and commercial fertilizer where possible while maintaining sufficient crop residue levels for erosion control.

5) Grow high yielding, high phosphorus removing crops on fields with already high soil test phosphorus to reduce test levels.

12. Solid Accumulation in the deep pits.

a. Solids will be agitated and land applied with the general liquid fertilizer utilizing available technology at the time of application.

13. Setback Requirements.

a. Manure shall not be applied any closer than a 100 feet to any down-gradient surface waters, open tile line intake structures, sinkholes, agricultural well heads or other conduits to surface waters.

b. Manure shall be injected or incorporated within eight hours if applied within ½ mile of an occupied residence (other than the owner's residence) building or public area where people may be present. The operator shall be required to inject or incorporate the manure into the soil if manure is applied in a manner such that is causes an odor reading, for two or more days within a 10-day period, (as measured with a scentometer) of 7 or greater within 100 feet of an occupied residence, building or public area. A plan to minimize excess odors will be required before future application of manure in this area.

14. Typical Crops Grown and Crop Yields for the Land Application Areas:

a. Soybeans – 37 bushels/acre
b. Corn Grain – 141 bushels/acre
c. Edible Beans – 1476 pounds/acre

15. Nutrient Utilization Plan Amendments.

a. This plan may be amended when it fails to provide for protection of environmental resources or as appropriate.

b. This plan will also need to be amended with Department of Health and Environment approval when one of the following conditions exist:

1) Additional land to which waste will be applies is not described in the approved plans.

2) A procedure will be used that is not described in an approved plan.

3) Land described in an approved plan is no longer available for nutrient application.

A test result exceed the phosphorous-holding capacity of the soil as determined by the North Dakota state phosphorus index risk assessment.

2. Nutrient Management Planner for ND Livestock Feeding Operations and Planned Manure

The Nutrient Management Planner for ND Livestock Feeding Operations determines the recommended required nutrients along with the maximum amount of manure that can be applied based off the crop need, available manure nutrients and type of application method.

Planning the amount of manure to be land applied shall be up to the owner of the Diamond J Angus Ranch. For the crop year 2015 the following Planner on the next page makes recommendations for tons/acre per field along with supplemental commercial fertilizer. Things to consider when determining on how much to apply should be:

- Does the manure address the crop nutrient needs for N, P_2O_5 and K_2O. If the manure is applied on an N basis, this most likely means that P_2O_5 and K_2O are over applied, is this most economic solution? Or is it better to land apply on P_2O_5 basis and add commercial N?

Planning Manure Application

Using the crop recommendations from NDSU, SF 882 and the manure analysis from the ASAE, 2005, D384.2, the following nutrient% should be used to calculate the plant available nutrients.

Table 1. For **Inorganic N** (Ammonia N), MF-2562 Estimating Manure Nutrient Availability, Use:

1. Sweep Injected: 100% of Ammonia N
2. Knife injected or Immediate incorporated: 90% of Ammonia N
3. Incorporated after 1 day: 65% of Ammonia N
4. Sprinkler Irrigation or Incorporated at 2 days: 50% of Ammonia N
5. Incorporated at 3 days: 40%
6. Incorporated at 4 days: 30%
7. Incorporated at 5 days: 20%
8. Incorporated at 6 days: 10%
9. Incorporated at 7 days: 5%

Table 2. For **Organic N** %mineralization available for crop, NM-1629, North Dakota Manure Fertilizer Use Recommendations and MF-2562 Estimating Manure Nutrient Availability use:

1. Liquid Manure: Year 1= 30%, Year 2 = 12%, Year 3 = 6%
2. Solid Manure: Year 1= 45%, Year 2 = 12%, Year 3 = 6%
3. Compost Manure: Year 1= 20%, Year 2 = 6%, Year 3 = 3%

Table 3. For **P_2O_5** % nutrient available for crop use:

1. If Soil test for Olsen is lower than 32 ppm: Use 50% of Manure analysis
2. If Soil test for Olsen is greater than 32 ppm: Use 100% of Manure analysis

For **K_2O** use 85% of manure analysis for nutrient available for crop use

Table 4. Example of manure calculation

Assumptions:

- Wheat was planted previous year.
- 10-tons/acre of manure were applied previous year assuming the same as the ASAE, 2005, D 384.2 standard.

- Corn to be planted this year with SF-882 recommendations of 86, 24, 0
- The manure is to be broadcasted and not incorporated.
- Manure analysis results: lbs/ton, Total N =13.0, Total P_2O_5 = 13.0, Total K_2O = 6.6, Ammonia N = 3.0.

How many tons/acre to meet N requirements: Note 86.0 lbs recommended

Since the manure is to be broadcast all Ammonia N is lost, and referring to Table 2. 45% of Organic N is available for Year 1 = (13.0-3.0) * 0.45 = 4.5 lb/tons/acre

Year 2 credit manure credit = (13.0 lbs-3.0 lbs) * 0.12 *10 -tons/acre = 12.0 lbs.

Total tons/acre to meet Crop N needs = (86 lbs – 12.0 lbs)/4.5 = **16.4**-tons/acre.

How many tons/acre to meet P2O5 requirements: Note 24 lbs recommended

The soil test for P is 11 ppm so 100% of P_2O_5 is crop available.

Crop need is = 24 lbs /13 lbs-ton/acre = **1.8**-tons/acre

Summary

Crop needs, manure analysis, commercial fertilizer costs, transport costs all need to play a part in determining the amount of manure to land apply.

1. FARM NUTRIENT OUTPUT

Using the proposed animal numbers and ASAE D 384.2 Standard for Manure, the annual output was calculated. This along with existing Manure tests the total amount of nutrients available for land application was determined. Then by using NM-1629, North Dakota Manure Fertilizer Use Recommendations and MF-2562 Estimating Manure Nutrient Availability the amount available for the crop was determined. It is to be noted that the mineralization of organic N recommendations for the liquid manure is as follows:

1. Manure Application Year 1 = 30%
2. Manure Application Year 2 = 12%
3. Manure Application Year 3 = 6%

It is to be noted that the mineralization of organic N recommendations for the solid manure is as follows:

1. Manure Application Year 1 = 45%
2. Manure Application Year 2 = 12%
3. Manure Application Year 3 = 6%

RCIS
Representing RURAL COMMUNITY INSURANCE COMPANY

Production and Yield Worksheet/Report

1. Insured Information	2. Agent / Agency Information	3. Crop Year	4. Policy Number
TIM BERNTSON 3311 142ND AVE SE BUFFALO, ND 58011-9767 Person Type MARRIED Phone (701) 633-5602 SSN XXX-XX-8319	AGCOUNTRY FCS FARGO MN BRADLEY D SCHWAB 1900 44TH ST S PO BOX 6020 FARGO, ND 58108 Phone (701) 235-9858 Agency Code 22-3188 11	2015	ND-951-971957
		5. State Code / Name	
		ND	NORTH DAKOTA
		6. County Code / Name	
		017	CASS

7. Crop BEANS **8. Farm Name**
9. Plan YP **10. Map Area** 002 **11. T-Yield** 1,523.0
12. Unit 0001-0000-000 **13. Area Class**
14. Type PINTO **15. Record Type****
16. Practice IBRNI **17. Insurability** I **18.** ☒ New Prod*
19. Multi Crop Year Reporting Reason *** **20.** ☐ CRP/USDA ☐ NB ☐ NS
21. Estimated Share
22. Shareholder[LLT]
23. Remarks
****NEW PRODUCER

24. Year	25. Production	26. Acres	27. Yield	28. Desc.
2005	0.0	0.0	0	Z
2006	0.0	0.0	0	Z
2007	0.0	0.0	0	Z
2008	0.0	0.0	0	Z
2009	0.0	0.0	0	Z
2010	0.0	0.0	0	Z
2011	0.0	0.0	1,523	I
2012	0.0	0.0	1,523	I
2013	0.0	0.0	1,523	I
2014	0.0	0.0	1,523	I

29. Sect Twp Rng or Other	FSA Farm/ Tract/Field #
29 140N054W	9838

30. Date Signed 11/12/2014

31. Prior Yield	32. Approved Yield	33. Adj Yld	34. SA Yld
1,523	1,523.0	0.0	

7. Crop CORN **8. Farm Name**
9. Plan RP **10. Map Area** **11. T-Yield** 129.0
12. Unit 0001-0002-000 **13. Area Class**
14. Type GRAIN **15. Record Type****
16. Practice NIRR **17. Insurability** I **18.** ☐ New Prod*
19. Multi Crop Year Reporting Reason *** **20.** ☐ CRP/USDA ☐ NB ☐ NS
21. Estimated Share 1.000
22. Shareholder[LLT]
23. Remarks

24. Year	25. Production	26. Acres	27. Yield	28. Desc.
2005	16,939.1	86.0	197	A
2006	0.0	0.0	0	Z
2007	10,784.7	153.1	70	A
2008	0.0	0.0	0	Z
2009	10,400.0	72.0	144	A
2010	14,898.0	78.0	191	A
2011	10,988.4	75.1	146	A
2012	13,968.0	112.2	124	A
2013	8,830.6	76.1	116	A
2014	26,459.0	153.1	173	A

29. Sect Twp Rng or Other	FSA Farm/ Tract/Field #
32 140N054W	9838

30. Date Signed 11/12/2014

31. Prior Yield	32. Approved Yield	33. Adj Yld	34. SA Yld
151	156.0 TA	145.0	

Trend Adjusted Yield (TA)

7. Crop CORN **8. Farm Name**
9. Plan RP **10. Map Area** **11. T-Yield** 129.0
12. Unit 0001-0001-000 **13. Area Class**
14. Type GRAIN **15. Record Type****
16. Practice NIRR **17. Insurability** I **18.** ☐ New Prod*
19. Multi Crop Year Reporting Reason *** **20.** ☐ CRP/USDA ☐ NB ☐ NS
21. Estimated Share 1.000
22. Shareholder[LLT]
23. Remarks

24. Year	25. Production	26. Acres	27. Yield	28. Desc.
2005	0.0	0.0	0	Z
2006	31,816.3	266.0	119	A
2007	0.0	0.0	0	Z
2008	39,718.8	259.6	153	A
2009	34,600.0	228.0	152	A
2010	52,300.0	288.3	181	A
2011	39,210.8	275.8	142	A
2012	43,225.0	288.4	150	A
2013	36,861.9	276.6	133	A
2014	48,192.0	261.0	185	A

29. Sect Twp Rng or Other	FSA Farm/ Tract/Field #
29 140N054W	9838

30. Date Signed 11/12/2014

31. Prior Yield	32. Approved Yield	33. Adj Yld	34. SA Yld
156	162.0 TA	152.0	

Trend Adjusted Yield (TA)

7. Crop CORN **8. Farm Name**
9. Plan RP **10. Map Area** **11. T-Yield** 159.0
12. Unit 0001-0003-000 **13. Area Class**
14. Type GRAIN **15. Record Type****
16. Practice NIRR **17. Insurability** I **18.** ☐ New Prod*
19. Multi Crop Year Reporting Reason *** **20.** ☐ CRP/USDA ☐ NB ☐ NS
21. Estimated Share 1.000
22. Shareholder[LLT]
23. Remarks
Added Land

24. Year	25. Production	26. Acres	27. Yield	28. Desc.
2005	0.0	0.0	0	Z
2006	0.0	0.0	0	Z
2007	0.0	0.0	0	Z
2008	0.0	0.0	0	Z
2009	0.0	0.0	0	Z
2010	0.0	0.0	159	L
2011	0.0	0.0	159	L
2012	18,759.0	117.6	160	A
2013	13,165.8	117.6	112	A
2014	0.0	0.0	0	Z

29. Sect Twp Rng or Other	FSA Farm/ Tract/Field #
27 140N054W	7295

30. Date Signed 11/12/2014

31. Prior Yield	32. Approved Yield	33. Adj Yld	34. SA Yld
148	149.0 TA	148.0	

Trend Adjusted Yield (TA)

**Record Type 1. Production Sold / Commercial Storage 2. Farm Stored Measured by Insured 3. Pick / Daily Sales Record 4. Automated Yield Monitoring System 5. Farm-Stored Measured by Authorized Representative 6. Livestock Feeding Records 7. Claim for Indemnity 8. Appraisal (non-loss) 9. Field Harvest Records 10. Other

***** Please see Instructions for Reporting Reason codes

Please do not write over this section.

10. B. LAND APPLICATION CALCULATIONS

1. Calculating the Available Manure and Nutrients for Animal Feeding Operations
2. Nutrient Management Planner for ND Livestock Operations
3. Phosphorus Index
4. RUSLE 2 Calculations
5. Average County Yields

Corn, Grain Yield

USDA Ag Statistics - Oliver County

Commodity	Practice	Year	State	County	Yield	Yield_unit
Corn, Grain	Total	2010	North Dakota	Cass	143.4	bushel/acre
Corn, Grain	Total	2011	North Dakota	Cass	101.6	bushel/acre
Corn, Grain	Total	2012	North Dakota	Cass	129.7	bushel/acre
Corn, Grain	Total	2013	North Dakota	Cass	126.2	bushel/acre
Corn, Grain	Total	2014	North Dakota	Cass	138.9	bushel/acre
5-Year Average					**128.0 bushel**	
5-Year Average + 10%					**140.8 bushel**	

Soybeans Yield

USDA Ag Statistics -Cass County

Commodity	Practice	Year	State	County	Yield	Yield_unit
Soybeans	Total	2010	North Dakota	Cass	35.5	bushel/acre
Soybeans	Total	2011	North Dakota	Cass	27.0	bushel/acre
Soybeans	Total	2012	North Dakota	Cass	34.0	bushel/acre
Soybeans	Total	2013	North Dakota	Cass	32.5	bushel/acre
Soybeans	Total	2014	North Dakota	Cass	38.0	bushel/acre
5-Year Average					**33.4**	**bushel/acre**
5-Year Average + 10%					**36.7**	**bushel/acre**

Edible Beans Yield

USDA Ag Statistics -Cass County

Commodity	Practice	Year	State	County	Yield	Yield_unit
Edible Beans	Total	2010	North Dakota	Cass	1650.0	lb/acre
Edible Beans	Total	2011	North Dakota	Cass	910.0	lb/acre
Edible Beans	Total	2012	North Dakota	Cass	1300.0	lb/acre
Edible Beans	Total	2013	North Dakota	Cass	1300.0	lb/acre
Edible Beans	Total	2014	North Dakota	Cass	1550.0	lb/acre
5-Year Average					**1342.0**	lb/acre
5-Year Average + 10%					**1476.2**	lb/acre

APH and Liability Worksheet

Name: Tim Berntson - Cass
Crop Yr: 2015
Company: RCIS Policy # 971957
Policy Liability: $ -

					Wheat - EU							Corn - EU							Soybeans - EU						
					Plan: RP	Cov Lvl: 70%	Projected Price: $5.85	Harvest Price	PP Factor: 60%		Guarantees at 100% Share	Plan: RP	Cov Lvl: 70%	Projected Price: $4.15	Harvest Price	PP Factor: 60%		Guarantees at 100% Share	Plan: RP	Cov Lvl: 70%	Projected Price: $9.73	Harvest Price	PP Factor: 60%		Guarantees at 100% Share
Unit	Section	Township	Range	Map Area	APH Yld	Bushel Guar.	Liability if Complete Loss	Prevent Plant Liability	Acres	Bushel Guarantee	Total Liability if Complete Loss	APH Yld w/ TA	Bushel Guar.	Liability if Complete Loss	Prevent Plant Liability	Acres	Bushel Guarantee	Total Liability if Complete Loss	APH Yld w/ TA	Bushel Guar.	Liability if Complete Loss	Prevent Plant Liability	Acres	Bushel Guarantee	Total Liability if Complete Loss	APH Yld
0101	29	140	54	2	41	28.7	$167.90	$100.74				162	113.4	$470.61	$282.37				39	27.3	$265.63	$159.38				152
0102	32	140	54	2	49	34.3	$200.66	$120.39				156	109.2	$453.18	$271.91				39	27.3	$265.63	$159.38				
0103	27	140	54									149	104.3	$432.85	$259.71				41	28.7	$279.25	$167.55				
TOTALS					45	115% of avg. yld. = 52			-	-	$ -	156	115% of avg. yld. = 179			-	-	$ -	40	115% of avg. yld. = 46			-	-	$ -	152
								Enterprise Unit Guarantee							Enterprise Unit Guarantee							Enterprise Unit Guarantee			

EU Bushel Guarantee Per Acre = #DIV/0! EU Bushel Guarantee Per Acre = #DIV/0! EU Bushel Guarantee Per Acre = #DIV/0!

Case Copy of (L_Wrishts-MP_Cust(1)_b11kvz2.xls 12015 APH Usb

001085

10B.1 Land Application Calculations

Rolling Green Family Farms RE, LLP
02-Dec-15

1. Estimate the total nutrients (NPK) in the excreted manure.

Nutrients per storage period = # of animals x weight (lbs) x daily nutrient production (lb/day/1,000 lb) x storage period (days)

		# of Animals	Average Weight (lbs.)	Daily Nutrient Production (lb/day/1,000 lbs)	Storage Period	Total Nutrients
Nitrogen						
	Farrowing Sows	1,344	400	0.45	365	88,301
	Breeding/Gestation	5,312	400	0.16	365	124,088
	Boars	0	500	0.14	365	0
	Nursery Pigs	800	45	0.92	365	12,089
	Finisher Pigs	1,600	150	0.54	365	47,304
Total Nitrogen		9,056				271,782
Phosphorus						
	Farrowing Sows	1,344	400	0.13	365	25,509
	Breeding/Gestation	5,312	400	0.05	365	38,778
	Boars	0	500	0.05	365	0
	Nursery Pigs	800	45	0.15	365	1,971
	Finisher Pigs	1,600	150	0.09	365	7,884
Total Phosphorus		9,056				74,142
Potassium	Lactating Sows	1,344	400	0.28	365	54,943
	Breeding/Gestation	5,312	400	0.11	365	85,311
	Boars	0	500	0.09	365	0
	Nursery Pigs	800	45	0.35	365	4,599
	Finisher Pigs	1,600	150	0.24	365	21,024
Total Potassium		9,056				165,876

2. Add nutrients contained in wastewater.

Nutrients in the wastewater = Number of animals x daily wastewater production (gal./day/cow) x da

		# of Animals	Daily Wastewater Production (gal./day/cow)	Daily Nutrient Production (lb/day/1,000 gal)	Storage Period	Total Nutrients
Nitrogen						
	Farrowing Sows	1,344	0	0	365	0
	Breeding/Gestation	5,312	0	0	365	0
	Boars	0	0	0	365	0
	Nursery Pigs	800	0	0	365	0
	Finisher Pigs	1,600	0	0	365	0
Total Nitrogen		9,056				0
Phosphorus						
	Farrowing Sows	1,344	0	0	365	0
	Breeding/Gestation	5,312	0	0	365	0
	Boars	0	0	0	365	0
	Nursery Pigs	800	0	0	365	0
	Finisher Pigs	1,600	0	0	365	0
Total Phosphorus		9,056				0
Potassium	Farrowing Sows	1,344	0	0	365	0
	Breeding/Gestation	5,312	0	0	365	0
	Boars	0	0	0	365	0
	Nursery Pigs	800	0	0	365	0
	Finisher Pigs	1,600	0	0	365	0
Total Potassium		9,056				0

Total Nutrients Produced

Total N	271,782	lbs
Total P	74,142	lbs
Total K	165,876	lbs

Convert to Fertilizer Form

Total N	271,782	lbs
Total P_2O_5	169,785	lbs
Total K_2O	200,710	lbs

3. Subtract nutrients lost during storage

Nutrients after storage losses = Total nutrients produced x fraction retained = Amount for land application

Solids (assume 0% of nutrients retained in solids)

Item	Nutrients (lbs)	Percent of Orig.	Available for Land Application (lbs)
Total N	0	0.65	0
Total P_2O_5	0	0.80	0
Total K_2O	0	0.80	0

Liquids (assume 100% of nutrients retained in liquids)

Item	Nutrients (lbs)	Percent of Orig.	Available for Land Application (lbs)
Total N	271,782	0.78	210,631
Total P_2O_5	169,785	0.93	157,051

Total K_2O	200,710	0.93	185,657

4. Determine the plant available nutrients

Estimate the amount of nutrients that will be available each year after the third consecutive year of application
Plant available nutrients = Amount applied x fraction available

Solids (assume 0% of nutrients retained in solids)

Item	Nutrients (lbs)	Percent Avail.	Available for Land Application (lbs)
Total N	0	0.73	0
Total P_2O_5	0	0.90	0
Total K_2O	0	0.93	0

Liquids (assume 100% of nutrients retained in liquids)

Item	Nutrients (lbs)	Percent Avail.	Available for Land Application (lbs)
Total N	210,631	0.73	153,761
Total P_2O_5	157,051	0.90	141,346
Total K_2O	185,657	0.93	172,661

HELP

Name: Melvin Family RE LLLP
County: Cass

Tract / Field(s) Field 1
Acres: 204 9

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information: 148 — BARNES-BUSE LOAMS, 3 TO 6 PERCENT SLOPES

NA	Surface Water Risk	NA
NA	Ground Water Risk	NA

The potential for runoff and leaching is not a concern for this soil map unit. Complete the Phosphorous Index below if agricultural waste will be applied to this field

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
0	greater than 1000 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

4 **Low** Phosphorous Index Rating

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

10. B. LAND APPLICATION CALCULATIONS

1. Calculating the Available Manure and Nutrients for Animal Feeding Operations
2. Nutrient Management Planner for ND Livestock Operations
3. Phosphorus Index
4. RUSLE 2 Calculations
5. Average County Yields

ND-CPA-343e(a)
Revised 1/04

HELP

Name: Melvin Family RE LLLP | Tract / Field Number(s): Field 1 | Date: 06/30/15

County: Cass | Acres: 204.9 | Assisted By:

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	146	bushels	175.2	102.2	170.2
Soybeans	37	bushels	0.0	57.4	81.4
Edible Beans	1476	pounds	73.8	34.1	51.1
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
14B	BARNES-BUSE LOAMS, 3 TO 6 PERCENT SLOPES	NA	NA

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	mmho / cm E.C.
Field 1	24	2	182	8	3.1	1.9

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	greater than 1000 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX

Low

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 180 lbs./ac [redacted] **Phosphorous:** Maximum accumulation of P 150ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

See management statements above.

Additional Planning Remarks

Technical Service Provider — Date — Producer — Date — NRCS — Date

This worksheet is intended to provide nutrient and resource assessments. This worksheet is NOT intended to provide crop / fertilizer recommendations. The Natural Resources Conservation Service assumes no liability for any use of this worksheet outside of the intended purpose.

HELP

Name: Melvin Family RE LLLP
County: Cass

Tract / Field(s) Field 2
Acres: 75.6

August 28, 2015

Leaching and Soil Surface Runoff Potential

Soil Information: 50 — HAMERLY-TONKA LOAMS, 0 TO 3 PERCENT SLOPES

NA	Surface Water Risk	NA
Moderate	Ground Water Risk	Wetness

See "Management Considerations to Address Soil Surface Runoff or Leaching Concerns" on the "Nutrient Management Planner" sheet by clicking on the "Nutrient Management Planner" tab below. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index.

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
0	greater than 1000 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

4 **Low** Phosphorous Index Rating

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

Name:	Melvin Family RE LLLP	Tract / Field Number(s):	Field 2	Date:	06/30/15
HELP County:	Cass	Acres:	75.6	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	146	bushels	175.2	102.2	170.2
Soybeans	37	bushels	0.0	57.4	81.4
Edible Beans	1476	pounds	73.8	34.1	51.1
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
50	HAMERLY-TONKA LOAMS, 0 TO 3 PERCENT SLOPES	NA	Moderate

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	mmho / cm E.C.
Field 2	41	2	150	8	3.5	2.39

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	greater than 1000 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX	
Low	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 150 lbs./ac — **Phosphorous:** Maximum accumulation of P 125 ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

Consider split nitrogen applications to include a preplant application and later application during early vegetative growth.

Additional Planning Remarks

Technical Service Provider — Date — Producer — Date — NRCS — Date

This worksheet is intended to provide nutrient and resource assessments. This worksheet is NOT intended to provide crop / fertilizer recommendations. The Natural Resources Conservation Service assumes no liability for any use of this worksheet outside of the intended purpose.

HELP

Name: Melvin Family RE LLLP
County: Cass

Tract / Field(s) Field 3
Acres: 156.4

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	148	BARNES-BUSE LOAMS, 3 TO 6 PERCENT SLOPES	
NA	Surface Water Risk	NA	
NA	Ground Water Risk	NA	

The potential for runoff and leaching is not a concern for this soil map unit. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index.

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
0	greater than 1000 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0	Best Management Practice Credit Total	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.
4	LOW — Phosphorous Index Rating	

Name:	Melvin Family RE LLLP	Tract / Field Number(s):	Field 3	Date:	06/30/15
County:	Cass	Acres:	156.4	Assisted By:	

HELP

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	141	bushels	169.2	98.7	164.4
Soybeans	37	bushels	0.0	57.4	81.4
Edible Beans	1476	pounds	73.8	34.1	51.1
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
14B	BARNES-BUSE LOAMS, 3 TO 6 PERCENT SLOPES	NA	NA

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	mmho / cm E.C.
Field 3	35	3	132	8.1	3	1.88

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	greater than 1000 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX	
Low	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 180 lbs./ac — **Phosphorous:** Maximum accumulation of P 150ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO_3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

See management statements above.

Additional Planning Remarks

Technical Service Provider — Date — Producer — Date — NRCS — Date

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HELP

Name: Melvin Family RE LLLP
County: Cass

Tract / Field(s) Field 4
Acres: 39.3

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	66	WYARD-HAMERLY LOAMS, 1 TO 3 PERCENT SLOPES	
NA	Surface Water Risk	NA	
NA	Ground Water Risk	NA	

The potential for runoff and leaching is not a concern for this soil map unit. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
0	greater than 1000 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

4 **Low** Phosphorous Index Rating

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

ND-CPA-343e(a)
Revised 1/04

HELP

Name:	Melvin Family RE LLLP	Tract / Field Number(s):	Field 4	Date:	06/30/15
County:	Cass	Acres:	39.3	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	147	bushels	176.4	102.9	171.4
Soybeans	37	bushels	0.0	57.4	81.4
Edible Beans	1476	pounds	73.8	34.1	51.1
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
66	WYARD-HAMERLY LOAMS, 1 TO 3 PERCENT SLOPES	NA	NA

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in K_2O	pH	O.M.%	mmho / cm E.C.
Field 4	27	6	176	7.9	3.1	0.79

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	greater than 1000 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX

Low

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 180 lbs./ac — **Phosphorous:** Maximum accumulation of P 150ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO_3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

See management statements above.

Additional Planning Remarks

Technical Service Provider _____ Date _____ Producer _____ Date _____ NRCS _____ Date _____

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HELP

Name: Melvin Family RE LLLP
County: Cass

Tract / Field(s) Field 5
Acres: 243.5

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information: 66 — WYARD-HAMERLY LOAMS, 1 TO 3 PERCENT SLOPES

NA	Surface Water Risk	NA
NA	Ground Water Risk	NA

The potential for runoff and leaching is not a concern for this soil map unit. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, and soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or > 30 ppm Bray) and runoff water reaches surface water, complete the Phosphorous Index.

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
0	greater than 1000 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

4 LOW Phosphorous Index Rating

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

Name:	Melvin Family RE LLLP	Tract / Field Number(s):	Field 5	Date:	06/30/15
HELP County:	Cass	Acres:	243.5	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	147	bushels	176.4	102.9	171.4
Soybeans	37	bushels	0.0	57.4	81.4
Edible Beans	1476	pounds	73.8	34.1	51.1
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
66	WYARD-HAMERLY LOAMS, 1 TO 3 PERCENT SLOPES	NA	NA

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	mmho / cm E.C.
Field 4	27	6	176	7.9	3.1	0.79

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	greater than 1000 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX	
Low	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 180 lbs./ac — **Phosphorous:** Maximum accumulation of P 150ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO_3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

See management statements above.

Additional Planning Remarks

Technical Service Provider — Date — Producer — Date — NRCS — Date

This worksheet is intended to provide nutrient and resource assessments. This worksheet is NOT intended to provide crop / fertilizer recommendations. The Natural Resources Conservation Service assumes no liability for any use of this worksheet outside of the intended purpose.

HELP

Name: Melvin Family RE LLLP
County: Cass

Tract / Field(s) Field 6
Acres: 78

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	50	HAMERLY-TONKA LOAMS, 0 TO 3 PERCENT SLOPES	
NA	Surface Water Risk	NA	
Moderate	Ground Water Risk	Wetness	

See "Management Considerations to Address Soil Surface Runoff or Leaching Concerns" on the "Nutrient Management Planner" sheet by clicking on the "Nutrient Management Planner" tab below. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index.

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
2	100-200 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

6 LOW Phosphorous Index Rating

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

HELP

Name:	Melvin Family RE LLLP	Tract / Field Number(s):	Field 6	Date:	06/30/15
County:	Cass	Acres:	78	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	141	bushels	169.2	98.7	164.4
Soybeans	37	bushels	0.0	57.4	81.4
Edible Beans	1476	pounds	73.8	34.1	51.1
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
50	HAMERLY-TONKA LOAMS, 0 TO 3 PERCENT SLOPES	NA	Moderate

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	mmho / cm E.C.
Field 6	28	4	166	8.1	2.3	1.2

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	100-200 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX	
Low	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 150 lbs./ac — **Phosphorous:** Maximum accumulation of P 125 ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO_3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

Consider split nitrogen applications to include a preplant application and later application during early vegetative growth.

Additional Planning Remarks

Technical Service Provider — Date — Producer — Date — NRCS — Date

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001100

HELP

Name: Eldwyn Van Bruggen
County: Cass

Tract / Field(s) Field 7 & 8
Acres: 141.2

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	51	HAMERLY LOAM, SALINE, 0 TO 3 PERCENT SLOPES	
NA	Surface Water Risk	NA	
Moderate	Ground Water Risk	Wetness	

See "Management Considerations to Address Soil Surface Runoff or Leaching Concerns" on the "Nutrient Management Planner" sheet by clicking on the "Nutrient Management Planner" tab below. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index.

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
2	100-200 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

6 **Low** Phosphorous Index Rating

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

ND-CPA-343e(a)
Revised 1/04

Name:	Eldwyn Van Bruggen	Tract / Field Number(s):	Field 7 & 8	Date:	06/30/15
HELP County:	Cass	Acres:	141.2	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	141	bushels	169.2	98.7	164.4
Soybeans	37	bushels	0.0	57.4	81.4
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
5t	HAMERLY LOAM, SALINE, 0 TO 3 PERCENT SLOPES	NA	Moderate

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	E.C.
Field 7 & 8	37	6	278	8		

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	100-200 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX	
Low	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 150 lbs./ac — **Phosphorous:** Maximum accumulation of P 125 ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

Consider split nitrogen applications to include a preplant application and later application during early vegetative growth.

Additional Planning Remarks

Technical Service Provider — Date — Producer — Date — NRCS — Date

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Nutrient Management Planner

001102

HELP

Name: Eldwyn Van Bruggen
County: Cass

Tract / Field(s) Field 9
Acres: 150.1

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information: 51 — HAMERLY LOAM, SALINE, 0 TO 3 PERCENT SLOPES

NA	Surface Water Risk	NA
Moderate	Ground Water Risk	Wetness

See "Management Considerations to Address Soil Surface Runoff or Leaching Concerns" on the "Nutrient Management Planner" sheet by clicking on the "Nutrient Management Planner" tab below. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index.

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen < 20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
2	100-200 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

6 **Low** Phosphorous Index Rating

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

ND-CPA-343e(a)
Revised 1/04

HELP

Name: Eldwyn Van Bruggen | Tract / Field Number(s): Field 9 | Date: 06/30/15

County: Cass | Acres: 150.1 | Assisted By:

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	141	bushels	169.2	98.7	164.4
Edible Beans	1476	pounds	73.8	34.1	51.1
Soybeans	37	bushels	0.0	57.4	81.4
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
51	HAMERLY LOAM, SALINE, 0 TO 3 PERCENT SLOPES	NA	Moderate

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-8 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	E.C.
Field 9	45	5	238	8		

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	100-200 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX

Low

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 150 lbs./ac — **Phosphorous:** Maximum accumulation of P 125 ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

Consider split nitrogen applications to include a preplant application and later application during early vegetative growth.

Additional Planning Remarks

Technical Service Provider — Date — Producer — Date — NRCS — Date

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HELP

Name: Joseph Harbeke
County: Cass

Tract / Field(s) Field 10
Acres: 140.2

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	178	BARNES-SVEA LOAMS, 2 TO 5 PERCENT SLOPES	
NA	Surface Water Risk	NA	
NA	Ground Water Risk	NA	

The potential for runoff and leaching is not a concern for this soil map unit. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
0	greater than 1000 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0	Best Management Practice Credit Total	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.
4	Low — Phosphorous Index Rating	

ND-CPA-343e(a)
Revised 1/04

Name: Joseph Harbeke | Tract / Field Number(s): Field 10 | Date: 07/16/15

HELP County: Cass | Acres: 140.2 | Assisted By:

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	141	bushels	169.2	98.7	164.4
Edible Beans	1476	pounds	73.8	34.1	51.1
Soybeans	37	bushels	0.0	57.4	81.4
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
17B	BARNES-SVEA LOAMS, 2 TO 5 PERCENT SLOPES	NA	NA

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	greater than 1000 feet
Best Management Practices Planned	

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	E.C.
11/6/2014	28	6	195	8	4.1	1.1
11/20/2013	27	2	202	7.9		1

PHOSPHOROUS INDEX

Low

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 180 lbs./ac — **Phosphorous:** Maximum accumulation of P 150ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO_3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

See management statements above.

Additional Planning Remarks

Technical Service Provider — Date — Producer — Date — NRCS — Date

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Name:	Jonathon Melvin	Tract / Field Number(s):	Field 11	Date:	07/20/15
HELP County:	Cass	Acres:	158	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	141	bushels	169.2	98.7	164.4
Edible Beans	1476	pounds	73.8	34.1	51.1
Soybeans	37	bushels	0.0	57.4	81.4
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
50	HAMERLY-TONKA LOAMS, 0 TO 3 PERCENT SLOPES	NA	Moderate

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	less than 30 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	greater than 1000 feet
Best Management Practices Planned	

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	E.C.
Field 11	12	19	383	8.1	4	1.47

PHOSPHOROUS INDEX

Low

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 150 lbs./ac — **Phosphorous:** Maximum accumulation of P 125 ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO_3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

Consider split nitrogen applications to include a preplant application and later application during early vegetative growth.

Additional Planning Remarks

Technical Service Provider — Date — Producer — Date — NRCS — Date

This worksheet is intended to provide nutrient and resource assessments. This worksheet is NOT intended to provide crop / fertilizer recommendations. The Natural Resources Conservation Service assumes no liability for any use of this worksheet outside of the intended purpose.

HELP

Name: Jonathon Melvin
County: Cass

Tract / Field(s) Field 11
Acres: 158

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	50	HAMERLY-TONKA LOAMS, 0 TO 3 PERCENT SLOPES	
NA	Surface Water Risk	NA	
Moderate	Ground Water Risk	Wetness	

See "Management Considerations to Address Soil Surface Runoff or Leaching Concerns" on the "Nutrient Management Planner" sheet by clicking on the "Nutrient Management Planner" tab below. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index.

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
1	less than 30 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
0	greater than 1000 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

3 **Low** Phosphorous Index Rating

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

HELP

Name: Jonathon Melvin
County: Cass

Tract / Field(s) Field 12
Acres: 112.3

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	178	BARNES-SVEA LOAMS, 2 TO 5 PERCENT SLOPES	
NA	Surface Water Risk	NA	
NA	Ground Water Risk	NA	

The potential for runoff and leaching is not a concern for this soil map unit. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index.

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
3	20-100 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

7 **Low** Phosphorous Index Rating

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

Natural Resources Conservation Service

ND-CPA-343e(a)
Revised 1/04

Name:	Jonathon Melvin	Tract / Field Number(s):	Field 12	Date:	07/20/15
HELP County:	Cass	Acres:	112.3	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	141	bushels	169.2	98.7	184.4
Edible Beans	1476	pounds	73.8	34.1	51.1
Soybeans	37	bushels	0.0	57.4	81.4
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
178	BARNES-SVEA LOAMS, 2 TO 5 PERCENT SLOPES	NA	NA

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	E.C.
10/27/2014	44	6	242	7.3	4.4	1.09
11/4/2013	31	5	212	7.5	3.6	1.01

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	20-100 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX	
Low	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 180 lbs./ac — **Phosphorous:** Maximum accumulation of P 150ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

See management statements above.

Additional Planning Remarks

Technical Service Provider — Date — Producer — Date — NRCS — Date

This worksheet is intended to provide nutrient and resource assessments. This worksheet is NOT intended to provide crop / fertilizer recommendations. The Natural Resources Conservation Service assumes no liability for any use of this worksheet outside of the intended purpose.

HELP

Name: Randy Melvin
County: Cass

Tract / Field(s) Field 13
Acres: 376.3

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	178	BARNES-SVEA LOAMS, 2 TO 5 PERCENT SLOPES	
NA	Surface Water Risk	NA	
NA	Ground Water Risk	NA	

The potential for runoff and leaching is not a concern for this soil map unit. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff/water reaches surface water, complete the Phosphorous Index.

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
3	20-100 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

7 LOW Phosphorous Index Rating

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

ND-CPA-343e(a)
Revised 1/04

HELP

Name:	Randy Melvin	Tract / Field Number(s):	Field 13	Date:	06/30/15
County:	Cass	Acres:	376.3	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	141	bushels	169.2	98.7	164.4
Edible Beans	1476	pounds	73.8	34.1	51.1
Soybeans	37	bushels	0.0	57.4	81.4
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
17B	BARNES-SVEA LOAMS, 2 TO 5 PERCENT SLOPES	NA	NA

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	mmho / cm E.C.
Field 13	37	5	205	7.7	3	1.4

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	20-100 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX	
Low	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 180 lbs./ac — **Phosphorous:** Maximum accumulation of P 150ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO_3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potentially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

See management statements above.

Additional Planning Remarks

Technical Service Provider — Date — Producer — Date — NRCS — Date

This worksheet is intended to provide nutrient and resource assessments. This worksheet is NOT intended to provide crop / fertilizer recommendations. The Natural Resources Conservation Service assumes no liability for any use of this worksheet outside of the intended purpose.

001112

HELP

Name: Randy Melvin
County: Cass

Tract / Field(s) Field 14
Acres: 70.9

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information: 178 — BARNES-SVEA LOAMS, 2 TO 5 PERCENT SLOPES

NA	Surface Water Risk	NA
NA	Ground Water Risk	NA

The potential for runoff and leaching is not a concern for this soil map unit. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (pH > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index.

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
3	20-100 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

7 **Low** Phosphorous Index Rating

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

United States Dept. of Agriculture
Natural Resources Conservation Service

ND-CPA-343e(a)
Revised 1/04

HELP

Name:	Randy Melvin	Tract / Field Number(s):	Field 14	Date:	06/30/15
County:	Cass	Acres:	70.9	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	141	bushels	169.2	98.7	164.4
Edible Beans	1476	pounds	73.8	34.1	51.1
Soybeans	37	bushels	0.0	57.4	81.4
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
17B	BARNES-SVEA LOAMS, 2 TO 5 PERCENT SLOPES	NA	NA

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	mmho / cm E.C.
Field 14	73	5	174	7.8	3.4	0.9

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-80 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	20-100 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX

Low

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 180 lbs./ac — **Phosphorous:** Maximum accumulation of P 150ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

See management statements above.

Additional Planning Remarks

Technical Service Provider — Date — Producer — Date — NRCS — Date

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001114

HELP

Name: Randy Melvin
County: Cass

Tract / Field(s) Field 15
Acres: 41.2

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information: 27 — DIVIDE LOAM

NA	Surface Water Risk	NA
High	Ground Water Risk	Poor Filter

See "Management Considerations to Address Soil Surface Runoff or Leaching Concerns" on the "Nutrient Management Planner" sheet by clicking on the "Nutrient Management Planner" tab below. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index.

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
3	20-100 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

7 **Low** Phosphorous Index Rating

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

United States Dept. of Agriculture
Natural Resources Conservation Service

ND-CPA-343e(a)
Revised 1/04

Name:	Randy Melvin	Tract / Field Number(s):	Field 15	Date:	06/30/15
HELP County:	Cass	Acres:	41.2	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	141	bushels	169.2	98.7	164.4
Edible Beans	1476	pounds	73.8	34.1	51.1
Soybeans	37	bushels	0.0	57.4	81.4
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
27	DIVIDE LOAM	NA	High

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	20-100 feet
Best Management Practices Planned	

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	mmho / cm E.C.
Field 15	81	8	239	7.9	5.1	2.5

PHOSPHOROUS INDEX

Low

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 100 lbs./ac [redacted] **Phosphorous:** Maximum accumulation of P 100 ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO_3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

Fall application not recommended.
Spring application should be delayed until after the soil is completely thawed. Consider split nitrogen applications to include a preplant application and later application during early vegetative growth.

Additional Planning Remarks

Technical Service Provider _____ Date _____

Producer _____ Date _____

NRCS _____ Date _____

This worksheet is intended to provide nutrient and resource assessments. This worksheet is NOT intended to provide crop / fertilizer recommendations. The Natural Resources Conservation Service assumes no liability for any use of this worksheet outside of the intended purpose.

001116

ND-CPA-343e(a)
Revised 1/04

HELP

Name:	Joseph Harbeke	Tract / Field Number(s):	Field 10	Date:	07/16/15
County:	Cass	Acres:	140.2	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	141	bushels	169.2	98.7	164.4
Edible Beans	1476	pounds	73.8	34.1	51.1
Soybeans	37	bushels	0.0	57.4	81.4
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
17B	BARNES-SVEA LOAMS, 2 TO 6 PERCENT SLOPES	NA	NA

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	E.C.
11/6/2014	28	6	195	8	4.1	1.1
11/20/2013	27	2	202	7.9		1

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	greater than 1000 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.
Low	

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 180 lbs./ac — **Phosphorous:** Maximum accumulation of P 150ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO_3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

See management statements above.

Additional Planning Remarks

Technical Service Provider — Date — Producer — Date — NRCS — Date

This worksheet is intended to provide nutrient and resource assessments. This worksheet is NOT intended to provide crop / fertilizer recommendations. The Natural Resources Conservation Service assumes no liability for any use of this worksheet outside of the intended purpose.

Name:	Eldwyn Van Bruggen	Tract / Field Number(s):	Field 9	Date:	06/30/15
County:	Cass	Acres:	150.1	Assisted By:	

HELP

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	141	bushels	169.2	98.7	164.4
Edible Beans	1476	pounds	73.8	34.1	51.1
Soybeans	37	bushels	0.0	57.4	81.4
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
51	HAMERLY LOAM, SALINE, 0 TO 3 PERCENT SLOPES	NA	Moderate

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	E.C.
Field 9	45	5	238	8		

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	100-200 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX	
Low	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 150 lbs./ac [redacted] **Phosphorous:** Maximum accumulation of P 125 ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potentially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

Consider split nitrogen applications to include a preplant application and later application during early vegetative growth.

Additional Planning Remarks

Technical Service Provider — Date — Producer — Date — NRCS — Date

This worksheet is intended to provide nutrient and resource assessments. This worksheet is NOT intended to provide crop / fertilizer recommendations. The Natural Resources Conservation Service assumes no liability for any use of this worksheet outside of the intended purpose.

HELP

Name: Joseph Harbeke
County: Cass

Tract / Field(s) Field 10
Acres: 140.2

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information: 178 — BARNES-SVEA LOAMS, 2 TO 5 PERCENT SLOPES

NA	Surface Water Risk	NA
NA	Ground Water Risk	NA

The potential for runoff and leaching is not a concern for this soil map unit. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index.

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30 90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
0	greater than 1000 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

4 **Low** Phosphorous Index Rating

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

HELP

Name: Randy Melvin
County: Cass

Tract / Field(s) Field 16
Acres: 63.8

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information: 66 — WYARD-HAMERLY LOAMS, 1 TO 3 PERCENT SLOPES

NA	Surface Water Risk	NA
NA	Ground Water Risk	NA

The potential for runoff and leaching is not a concern for this soil map unit. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index.

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
1	200-1000 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

5 **Low** Phosphorous Index Rating

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

United States Dept. of Agriculture
Natural Resources Conservation Service

ND-CPA-343e(a)
Revised 1/04

Name:	Randy Melvin	Tract / Field Number(s):	Field 16	Date:	06/30/15
HELP County:	Cass	Acres:	63.8	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	148	bushels	177.6	103.6	172.6
Edible Beans	1476	pounds	73.8	34.1	51.1
Soybeans	37	bushels	0.0	57.4	81.4
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
66	WYARD-HAMERLY LOAMS, 1 TO 3 PERCENT SLOPES	NA	NA

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	E.C.
Field 16	15	4	199	8		

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	200-1000 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX

Low

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 180 lbs./ac — **Phosphorous:** Maximum accumulation of P 150ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potentially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

See management statements above.

Additional Planning Remarks

Technical Service Provider _____ Date _____

Producer _____ Date _____

NRCS _____ Date _____

This worksheet is intended to provide nutrient and resource assessments. This worksheet is NOT intended to provide crop / fertilizer recommendations. The Natural Resources Conservation Service assumes no liability for any use of this worksheet outside of the intended purpose.

001121

HELP

Name: Randy Melvin
County: Cass

Tract / Field(s) Field 17
Acres: 83.1

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	148	BARNES-BUSE LOAMS, 3 TO 6 PERCENT SLOPES	
NA	Surface Water Risk	NA	
NA	Ground Water Risk	NA	

The potential for runoff and leaching is not a concern for this soil map unit. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
2	100-200 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

6 **Low** Phosphorous Index Rating

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

United States Dept. of Agriculture
Natural Resources Conservation Service

ND-CPA-343e(a)
Revised 1/04

Name:	Randy Melvin	Tract / Field Number(s):	Field 17	Date:	06/30/15
HELP County:	Cass	Acres:	83.1	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	148	bushels	177.6	103.6	172.6
Edible Beans	1476	pounds	73.8	34.1	51.1
Soybeans	37	bushels	0.0	57.4	81.4
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
14B	BARNES-BUSE LOAMS, 3 TO 6 PERCENT SLOPES	NA	NA

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	E.C.
Field 17	42	8	239	7.7		

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	100-200 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX	
Low	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 180 lbs./ac [redacted] **Phosphorous:** Maximum accumulation of P 150ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO_3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

See management statements above.

Additional Planning Remarks

Technical Service Provider Date

Producer Date

NRCS Date

This worksheet is intended to provide nutrient and resource assessments. This worksheet is NOT intended to provide crop / fertilizer recommendations. The Natural Resources Conservation Service assumes no liability for any use of this worksheet outside of the intended purpose.

001123

HELP

Name: Randy Melvin
County: Cass

Tract / Field(s) Field 18
Acres: 155.8

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	50	HAMERLY-TONKA LOAMS, 0 TO 3 PERCENT SLOPES	
NA	Surface Water Risk	NA	
Moderate	Ground Water Risk	Wetness	

See "Management Considerations to Address Soil Surface Runoff or Leaching Concerns" on the "Nutrient Management Planner" sheet by clicking on the "Nutrient Management Planner" tab below. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, and soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) and runoff water reaches surface water, complete the Phosphorous Index.

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
0	greater than 1000 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

4 **Low** Phosphorous Index Rating

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

Name:	Randy Melvin	Tract / Field Number(s):	Field 18	Date:	06/30/15
HELP County:	Cass	Acres:	155.8	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	141	bushels	169.2	98.7	164.4
Edible Beans	1476	pounds	73.8	34.1	51.1
Soybeans	37	bushels	0.0	57.4	81.4
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
50	HAMERLY-TONKA LOAMS, 0 TO 3 PERCENT SLOPES	NA	Moderate

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	E.C.
Field 18	46	4	196	8	3	1

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	greater than 1000 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX	
Low	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 150 lbs./ac — **Phosphorous:** Maximum accumulation of P 125 ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

Consider split nitrogen applications to include a preplant application and later application during early vegetative growth.

Additional Planning Remarks

Technical Service Provider Date Producer Date NRCS Date

This worksheet is intended to provide nutrient and resource assessments. This worksheet is NOT intended to provide crop / fertilizer recommendations. The Natural Resources Conservation Service assumes no liability for any use of this worksheet outside of the intended purpose.

001125

HELP

Name: Randy Melvin
County: Cass

Tract / Field(s) Field 19
Acres: 148.8

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	50	HAMERLY-TONKA LOAMS, 0 TO 3 PERCENT SLOPES	
NA	Surface Water Risk	NA	
Moderate	Ground Water Risk	Wetness	

See "Management Considerations to Address Soil Surface Runoff or Leaching Concerns" on the "Nutrient Management Planner" sheet by clicking on the "Nutrient Management Planner" tab below. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index.

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
0	greater than 1000 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

4 **Low** Phosphorous Index Rating

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

Name:	Randy Melvin	Tract / Field Number(s):	Field 19	Date:	06/30/15
HELP County:	Cass	Acres:	148.8	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	141	bushels	169.2	98.7	164.4
Edible Beans	1476	pounds	73.8	34.1	51.1
Soybeans	37	bushels	0.0	57.4	81.4
	0		0.0	0.0	0.0
	0		0.0	0.0	0.0
	0		0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
50	HAMERLY-TONKA LOAMS, 0 TO 3 PERCENT SLOPES	NA	Moderate

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	mmho / cm E.C.
Field 19	36	10	231	8	3.9	1.9

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	greater than 1000 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX	
Low	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 150 lbs./ac — **Phosphorous:** Maximum accumulation of P 125 ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

Consider split nitrogen applications to include a preplant application and later application during early vegetative growth.

Additional Planning Remarks

Technical Service Provider — Date — Producer — Date — NRCS — Date

This worksheet is intended to provide nutrient and resource assessments. This worksheet is NOT intended to provide crop / fertilizer recommendations. The Natural Resources Conservation Service assumes no liability for any use of this worksheet outside of the intended purpose.

001127

HELP

Name: Randy Melvin
County: Cass

Tract / Field(s) Field 20
Acres: 57.6

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	66	**WYARD-HAMERLY LOAMS, 1 TO 3 PERCENT SLOPES**	
NA	**Surface Water Risk**	**NA**	
NA	**Ground Water Risk**	**NA**	

The potential for runoff and leaching is not a concern for this soil map unit. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index.

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
3	20-100 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

7 **Low** **Phosphorous Index Rating**

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

Name:	Randy Melvin	Tract / Field Number(s):	Field 20	Date:	06/30/15
HELP County:	Cass	Acres:	57.6	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	141	bushels	169.2	98.7	164.4
Edible Beans	1476	pounds	73.8	34.1	51.1
Soybeans	37	bushels	0.0	57.4	81.4
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
66	WYARD-HAMERLY LOAMS, 1 TO 3 PERCENT SLOPES	NA	NA

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	20-100 feet
Best Management Practices Planned	

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	mmho / cm E.C.
Field 20	10	3	170	8	2.7	1.75

PHOSPHOROUS INDEX	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.
Low	

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 180 lbs./ac — **Phosphorous:** Maximum accumulation of P 150ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potentially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

See management statements above.

Additional Planning Remarks

Technical Service Provider Date | Producer Date | NRCS Date

This worksheet is intended to provide nutrient and resource assessments. This worksheet is NOT intended to provide crop / fertilizer recommendations. The Natural Resources Conservation Service assumes no liability for any use of this worksheet outside of the intended purpose.

001129

HELP

Name: Randy Melvin
County: Cass

Tract / Field(s) Field 21
Acres: 107.7

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information: 148 — BARNES-BUSE LOAMS, 3 TO 6 PERCENT SLOPES

NA	Surface Water Risk	NA
NA	Ground Water Risk	NA

The potential for runoff and leaching is not a concern for this soil map unit. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff water reaches a nearby water, complete the Phosphorous Index.

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
3	20-100 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

7 LOW Phosphorous Index Rating

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

United States Dept. of Agriculture
Natural Resources Conservation Service

ND-CPA-343e(a)
Revised 1/04

001131

Name:	Randy Melvin	Tract / Field Number(s):	Field 21	Date:	06/30/15
HELP County:	Cass	Acres:	107.7	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	141	bushels	169.2	98.7	164.4
Edible Beans	1476	pounds	73.8	34.1	51.1
Soybeans	37	bushels	0.0	57.4	81.4
	0		0.0	0.0	0.0
	0		0.0	0.0	0.0
	0		0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
14B	BARNES-BUSE LOAMS, 3 TO 6 PERCENT SLOPES	NA	NA

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	E.C.
Field 21	28	4	166	7.9	2.2	1.5

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	20-100 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX	
Low	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 180 lbs./ac — **Phosphorous:** Maximum accumulation of P 150ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO_3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

See management statements above.

Additional Planning Remarks

Technical Service Provider — Date — Producer — Date — NRCS — Date

This worksheet is intended to provide nutrient and resource assessments. This worksheet is NOT intended to provide crop / fertilizer recommendations. The Natural Resources Conservation Service assumes no liability for any use of this worksheet outside of the intended purpose.

HELP

Name: Tim Bernston
County: Cass

Tract / Field(s) Field 22
Acres: 268.8

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	148	BARNES-BUSE LOAMS, 3 TO 6 PERCENT SLOPES	
NA		Surface Water Risk	NA
NA		Ground Water Risk	NA

The potential for runoff and leaching is not a concern for this soil map unit. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and/or* runoff water reaches surface water, complete the Phosphorous Index

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
0	greater than 1000 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

4 Low Phosphorous Index Rating

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

Name:	Tim Bernston	Tract / Field Number(s):	Field 22	Date:	06/30/15
HELP County:	Cass	Acres:	268.8	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	162	bushels	194.4	113.4	188.9
Soybeans	37	bushels	0.0	57.4	81.4
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
14B	BARNES-BUSE LOAMS, 3 TO 6 PERCENT SLOPES	NA	NA

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in K_2O	pH	O.M.%	mmho / cm E.C.
Field 22	42	10	125	7.8	3.8	1.25

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	greater than 1000 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX	
Low	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 180 lbs./ac [redacted] **Phosphorous:** Maximum accumulation of P 150ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

See management statements above.

Additional Planning Remarks

Technical Service Provider Date Producer Date NRCS Date

This worksheet is intended to provide nutrient and resource assessments. This worksheet is NOT intended to provide crop / fertilizer recommendations. The Natural Resources Conservation Service assumes no liability for any use of this worksheet outside of the intended purpose.

HELP

Name: Tim Bernston
County: Cass

Tract / Field(s) Field 23
Acres: 261.9

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information: 178 — BARNES-SVEA LOAMS, 2 TO 5 PERCENT SLOPES

NA	Surface Water Risk	NA	
NA	Ground Water Risk	NA	

The potential for runoff and leaching is not a concern for this soil map unit. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index.

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
0	greater than 1000 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

4 **Low** Phosphorous Index Rating

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

Name:	Tim Bernston	Tract / Field Number(s):	Field 23	Date:	06/30/15
HELP County:	Cass	Acres:	261.9	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	162	bushels	194.4	113.4	188.9
Soybeans	37	bushels	0.0	57.4	81.4
Edible Beans	1476	pounds	73.8	34.1	51.1
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
178	BARNES-SVEA LOAMS, 2 TO 5 PERCENT SLOPES	NA	NA

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	mmho / cm E.C.
Field 23	29	7	141	8	3.2	1.12

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	greater than 1000 feet
Best Management Practices Planned	

PHOSPHOROUS INDEX	
Low	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 180 lbs./ac — **Phosphorous:** Maximum accumulation of P 150ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

See management statements above.

Additional Planning Remarks

Technical Service Provider — Date — Producer — Date — NRCS — Date

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HELP

Name: Tim Bernston
County: Cass

Tract / Field(s) Field 24
Acres: 27

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	66	WYARD-HAMERLY LOAMS, 1 TO 3 PERCENT SLOPES	
NA		Surface Water Risk	NA
NA		Ground Water Risk	NA

The potential for runoff and leaching is not a concern for this soil map unit. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit, *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, >30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index.

Phosphorous Index

HELP

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Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
0	greater than 1000 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply:

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

4 **Low** Phosphorous Index Rating

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

Name:	Tim Bernston	Tract / Field Number(s):	Field 24	Date:	06/30/15
HELP County:	Cass	Acres:	27	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	140	bushels	168.0	98.0	163.2
Soybeans	37	bushels	0.0	57.4	81.4
Corn, Grain	162	bushels	194.4	113.4	188.9
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
66	WYARD-HAMERLY LOAMS, 1 TO 3 PERCENT SLOPES	NA	NA

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	greater than 1000 feet
Best Management Practices Planned	

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in K_2O	pH	O.M.%	mmho / cm E.C
Field 24	30	10	144	8	3	1.33

PHOSPHOROUS INDEX

Low

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 180 lbs./ac [redacted] **Phosphorous:** Maximum accumulation of P 150ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO_3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

See management statements above.

Additional Planning Remarks

Technical Service Provider — Date — Producer — Date — NRCS — Date

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001137

HELP

Name: Tim Bernston
County: Cass

Tract / Field(s) Field 25
Acres: 150

August 26, 2015

Leaching and Soil Surface Runoff Potential

Soil Information	148	BARNES-BUSE LOAMS, 3 TO 6 PERCENT SLOPES	
NA	Surface Water Risk	NA	
NA	Ground Water Risk	NA	

The potential for runoff and leaching is not a concern for this soil map unit. Complete the Phosphorous Index below if agricultural waste will be applied to this field.

Phosphorus Risk Screening Tool

If agricultural waste will be applied to this soil map unit *and* soil test Phosphorous is > 20 ppm Olsen (or > 20 ppm Mehlich 3 or, > 30 ppm Bray) *and* runoff water reaches surface water, complete the Phosphorous Index.

Phosphorous Index

HELP

THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES.

Score	Inputs	
0	less than 2 tons/acre/year	Soil Erosion by Wind and Water in (tons/acre/year)
0	NA	Surface Water Risk
1	Olsen <20 ppm	Soil Test Phosphorous (STP)
2	30-90 pounds/acre	Phosphorous Fertilizer Application Rate (pounds P_2O_5/acre) from all Sources
1	Injected or Subsurface Applied	Phosphorous Fertilizer / Manure Application Method
0	greater than 1000 feet	Distance to Permanent Surface Water or Water Course

Check all Best Management Practices that apply

- ☐ Cover or Green Manure Crop
- ☐ Filter Strips
- ☐ Contour Buffer Strips
- ☐ Established No-till System

0 Best Management Practice Credit Total

4 **Low** Phosphorous Index Rating

This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

Name:	Tim Bernston	Tract / Field Number(s):	Field 25	Date:	06/30/15
HELP County:	Cass	Acres:	150	Assisted By:	

Establish realistic yield goals before attempting to use this spreadsheet. Nutrient requirements of a crop depend on the total production of that crop.

CROPS & YIELDS

Rotation / Crops	Yield Goal	Units	Required Nutrients for Yield Goal N	P_2O_5	K_2O
Corn, Grain	150	bushels	180.0	105.0	174.9
Soybeans	37	bushels	0.0	57.4	81.4
Corn, Grain	156	bushels	187.2	109.2	181.9
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0
		0	0.0	0.0	0.0

SOIL MAPPING UNIT INFORMATION

Soil Map Unit	Soil Map Unit Name	Surface Water Risk	Ground Water Risk
14B	BARNES-BUSE LOAMS, 3 TO 6 PERCENT SLOPES	NA	NA

NUTRIENT RISK ASSESSMENT INFORMATION

Soil Erosion by wind and water (tons/acre/year)	less than 2 tons/acre/year
Soil Test Phosphorous (P) ppm	Olsen <20 ppm
Phosphorous fertilizer application rate (pounds P_2O_5/acre)	30-90 pounds/acre
Phosphorous fertilizer application method	Injected or Subsurface Applied
Distance to Surface Water (feet)	greater than 1000 feet
Best Management Practices Planned	

HELP

SOIL TEST INFORMATION

Soil Test Date or Field Number	Lbs./acre 0-24 in. depth N	ppm (Olsen) 0-6 in. P	Optional Information for Documentation Only ppm 0-6 in. K_2O	pH	O.M.%	mmho / cm E.C.
Field 25	57	8	152	8	3	1.5

PHOSPHOROUS INDEX	
Low	This field has a LOW potential for off-site P movement. Organic nutrient application rates may be calculated according to crop nitrogen requirements.

MANAGEMENT CONSIDERATIONS

Nutrient Thresholds — **Nitrogen:** Maximum accumulation of N 180 lbs./ac [redacted] **Phosphorous:** Maximum accumulation of P 150ppm

General Management Statements

- Soil testing should be completed at least every other year to monitor nitrogen and at least once every five years to monitor phosphorus levels. Soil samples should be taken to the rooting depth of each crop in the rotation to reduce the risk of leaching nitrate nitrogen out of the root zone.
- Fall application of anhydrous ammonia and urea should be delayed until soil temperature is less than 45 degrees Fahrenheit. When soil temperatures are above 45 degrees Fahrenheit, microbial activity increases, converting ammonia to nitrate-nitrogen (NO_3). Nitrate-nitrogen is a very mobile form of nitrogen and can leach below the crop root zone.
- Nutrient application should avoid areas sensitive to surface and ground water contamination. Follow federal, state and local guidelines for specific setbacks need to minimize impacts to sensitive areas. Schedule manure applications to minimize offsite impacts by potenially offensive odors. Drainage (surface and subsurface) should be considered when evaluating distance to water.

Site Specific Nutrient Management Considerations

See management statements above.

Additional Planning Remarks

Technical Service Provider Date Producer Date NRCS Date

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Concerns Regarding the Nutrient Management Plan for Rolling Green Family Farms Proposed Buffalo, ND Location

Prepared by

Concerned Citizens of Buffalo

For Presentation to

The North Dakota Department of Health

March 17, 2016

CONCERNS

Reviewing the Rolling Green Family Farms nutrient management plan has resulted in several areas of concern. Items identified in the text of this document will be summarized and presented as concerns and concerned questions. The identified items are:

1) Land easement application forms are incomplete

2) Legal descriptions and acreage errors on the Water Quality Risk Assessment Maps

3) Crop rotations were not listed making it difficult to determine nutrient needs

4) Soil test levels of Phosphorus should be used to determine manure application rates

5) Available acreages appear to be overstated --- township setbacks are not on maps and land for the facility are included as eligible acres

6) NRCS waste management soil ratings were not addressed

7) Pollution from the manure application will ultimately end up in the Maple River which feeds into the Red River

8) Hamerly-Tonka soils are rated "very limited" for application of manure and food processing wastes --- they account for 1,408.6 acres of the total listed for manure application

9) Application of liquid manure on tiled land --- what is the policy in other states

10) Who is going to monitor and enforce the nutrient management plan?

    ----over application

    -----setbacks

    ------water pollution

Nutrient Management Using Liquid Hog Manure

A large confined animal feeding operation (CAFO) produces vast amounts of animal wastes. The hog CAFO proposed for the Buffalo, ND area will have storage pits with a holding capacity of 10.2 million gallons. Estimating the gallons of liquid manure produced annually is dependent on the number of hogs, their weight, whether it is a gestating sow or a sow with a litter, and the amount of water used for cleanup, etc. For a facility the size of the one proposed in the Buffalo area an estimated 7.0 million gallons of liquid hog manure will be produced per year. Disposing of this quantity of manure is a significant problem, and using it as fertilizer for grain crops is essentially the only solution.

Using liquid hog manure as a crop fertilizer does present problems. Manure fertilizer is not a plant nutrient balanced product. In other words, the ratio of nitrogen (N) to phosphorus (P) is such that applying enough N for crop nutrient requirements will result in excess P being added to the soil. It is possible for P to reach levels high enough to cause it to move off-site and get into surface water. Accordingly, Linderman (2012) recommended North Dakota producers apply enough manure to meet the P requirements of the crop and use commercial fertilizer to bring the N to desired levels. Similar recommendations have been made for Minnesota (Schmitt and Rehm 1992) with application rates based on soil tests for P. Although the soil tests submitted as part of the Nutrient Management Plan (Appendix D) indicated a "low" phosphorus risk, environmental concerns would suggest using the University recommenctions for nutrient management. Liquid hog manure also contains potassium (K). Nutrient content for commercial and manure fertilizer are measured differently. For example, a common commercial fertilizer is 11-52-0. This fertilizer contains 11 percent N, 52 percent P, and no K. A ton (2,000 pounds) of this fertilizer has 220 pounds of N, 1,040 pounds of P, and no K. Liquid hog manure is typically expressed as pounds of N, P_2O_5, and K_2O per 1,000 gallons.

Nutrient content of liquid hog manure varies greatly with pounds of N per 1,000 gallons ranging from 15 to 50, pounds of P ranging from 8 to 20, and pounds of K ranging from 8 to 20 (Saskatchewan Soil Conservation Association 1997). Numerous studies have estimated the nutrient value of liquid hog manure. Table 1 presents the estimates for two studies from North Dakota State University and one from the University of Minnesota. The nutrient content for N, P_2O_5, and K_2O reported in the Linderman study was used for this analysis. Nitrogen in the liquid hog manure contains both inorganic and organic matter. The inorganic form of nitrogen in manure is found as ammonium nitrogen (NH_4-N) which is immediately available to plants. The relationship between the inorganic and organic content of the liquid hog manure can vary greatly, but Schmitt and Rehm (1998) estimated that 50 percent of the nitrogen would be available in the first year, 35 percent in the second and third years, and 15 percent would be lost. (All supporting documents referenced and relating to this analysis are presented in Appendix C.)

Table 1. Pounds of Nitrogen, Phosphorus, and Potassium Estimated by Selected Studies, and Values Used for this Analysis

Source	N	P_2O_5	K_2O
	----------Pounds per 1,000 Gallons----------		
Linderman (2002)	27	27	15
Weiderholt et al. (2005)	26	26	20
Schmitt and Rehm (1992)	36	27	22
Selected for Analysis	27	27	15

Obtaining land application easements, soil testing, liquid manure nutrient testing, application of the liquid manure, and a nutrient management plan are the key components of disposing of the animal wastes. A copy of the land easement contracts is presented in Appendix A. Based on the incomplete information provided on five of the six contracts, it is difficult to determine what crops are to be grown and possible crop rotations. Acres reported on the land easement agreement appear to be total cropland acres or Farm Service Agency cropland acres. Without the listing of the crops to be planted on the contracted actress, it is difficult to determine how much liquid manure can be used beyond year one.

Water quality risk assessment maps for each of the fields contracted for liquid hog manure application are presented in Appendix B. These maps show the boundaries for each parcel and indicate the total cropland acres. Setbacks are included but only include water ways and noncropland areas such as permanent wet areas, shelterbelts, and farmsteads. No setbacks are indicated for compliance with township ordnances. Subtracting the risk assessment reported with from the total cropland acres provided the setback acres (Table 2). Also, acres for the CAFO location (NW ¼-4-139-54) have not been removed from the fertilization application acres. The legal description for fields 18 & 19 are incorrect, causing further confusion. Total acres for field 16 & 17 add up to 207.4 acres. Errors and omissions in this data set complicate the calculation of how many acres are available for liquid manure application.

Appendix D presents the nutrient management plan and associated soil tests. Soil tests indicate the N, P_2O_5, and K_2O nutrient levels in the soil, and realistic yield goal nutrient requirements are presented. The realistic yield goal nutrient requirements are available for corn, soybeans, and edible beans. Soil test results for four selected fields are presented in Table 3. The soil tests indicate that the P_2O_5 levels for the four fields range from "very low" to "medium", and one field has K_2O levels that are "high" and the other three were "very high". Table 4 presents the nutrient levels needed for corn to produce yields of 140 bushels per acre or more. Similar data were available for soybeans and dry edible beans are presented in Tables 5 and 6, respectively.

Table 2. Water Quality Risk Assessment Map Acres, Setback Acres, and Listed Acres for Liquid Manure, 2015

Field Number	Map Acres	Setback Acres	Listed Acres
1 & 2	285.6	5.1	280.5
3	156.4	--	156.4
4 & 5	293.7	10.9	282.8
6	78.9	0.9	78.0
7 & 8 & 9	306.4	15.1	291.3
10	157.7	17.5	140.2
11	158.2	0.2	158.0
12	114.0	1.7	112.3
13 & 14 & 15	498.5	10.1	488.4
16 & 17	151.4	4.5	146.9
18 & 19	301.9	1.2	300.7
20	57.6	--	57.6
21	140.5	32.8	107.7
22 & 23 & 24	566.0	8.3	557.7
25	153.1	3.1	150.0
Total			3,308.5

Table 3. Soil Test Results for Four Selected Fields Contracted for liquid Hog manure Application

Field Number	N	P_2O_5[1]	K_2O[2]
	---(lbs)---	---(ppm)---	---(ppm)---
1	24	2	182
6	28	4	166
17	42	8	239
22	42	10	125

[1]Phosphorus (ppm) rankings of 0-3 are in the very low category, 4-7 are low, 8-11 are medium, 12-15 are high, and 16+ are very high (Franzen 2013).

[2]Potassium (ppm) rankings of 0-40 are very low, 41-80 are low, 81-120 are medium, 121-160 are high, and 161+ are very high (Franzen 2013).

Table 4. Required Nutrients for Corn With A 140 Bushel Per Acre or Above Realistic Yield Goal, for Four Selected Fields

Field Number	Yield Goal	N	P_2O_5	K_2O
	---bu/acre---	---lb/acre---	---lb/acre---	---lb/acre---
1	146	175	102	170
6	141	169	98	164
17	148	177	103	172
22	162	194	113	188

Table 5. Required Nutrients for Soybeans With A 37 Bushel Per Acre Realistic Yield Goal, for Four Selected Fields

Field Number	Yield Goal	N	P_2O_5	K_2O
	---bu/acre---	---lb/acre---	---lb/acre---	---lb/acre---
1	37	--	57	81
6	37	--	57	81
17	37	--	57	81
22	37	--	57	81

Table 6. Required Nutrients for Dry Edible Beans With A 1,476 Pounds Per Acre Realistic Yield Goal, for Four Selected Fields

Field Number	Yield Goal	N	P_2O_5	K_2O
	---bu/acre---	---lb/acre---	---lb/acre---	---lb/acre---
1	1,476	74	34	51
6	1,476	74	34	51
17	1,476	74	34	51
14	1,476	74	34	51

Determining the fertilizer application rates requires several calculations. For nitrogen, there could be a credit from the previous crop. Crops such as soybeans, edible beans, peas and lentils, and chick peas typically have a nitrogen credit (Franzen 2013). The nitrogen credit for these crops has been estimated to be 40 pounds of N per acre. Nitrogen required would be the N level necessary for the realistic yield goal less the existing N in the soil less the N credit. This would give the pounds of N required, but as previously stated, about half of the N in liquid hog manure is available the first year. For soil tests with P in the "very low" or "low" category, the full amount of P_2O_5 required could be applied. Application of liquid hog manure results in 80 percent of the P_2O_5 available in the first year.

An example will help illustrate the calculations. In order to obtain a 146 bushel per acre corn yield on field 1, the nutrients required would be 175 pounds per acre of N, 102 pounds per acre of P_2O_5 (because the soil test indicated "very low" parts per million) and no K_2O (because soil levels are already "very high"). Nitrogen required would be 174 pounds less the 24 pounds already in the soil less the 40 pounds soybean credit (assuming the corn is planted on a field that was soybeans the previous year). A total of 111 pounds per acre of N should be added to the soil. As previously stated 50 percent of the N in liquid hog manure is available in the first year, so the 27 pounds of N per 1,000 gallons of manure actually provides 13.5 pounds of N the first year. A total of 8,222 gallons would be needed to be applied to meet the N requirement. The 27 pounds of P_2O_5 in the liquid manure is only 80 percent available to the crop in the first year, so the product has 21.6 pounds of P_2O_5 per 1,000 gallons. A nutrient requirement of 102 pounds of P_2O_5 per acre would require 4,722 gallons to be applied. If the 8,222 gallons of manure necessary to reach the N goal were applied, 178 pounds of P_2O_5 would be added to the soil and be available in first year. This far exceeds the maximum recommended level of 102 pounds per acre. If the

manure were applied using the P soil test to determine the gallons per acre, 1,482 acres would be required to use the 7 million gallons of liquid hog manure produced per year.

If the application of the liquid manure was based on the recommended P level soil tests, the 7 million gallons of liquid manure could be disposed of in year 1, based on the acres available (Table 2). Without knowing what crops are going to be planted and the rotations, it is difficult to guarantee the same result in subsequent years. At a minimum, the manure would have to be applied to the same land every second year based on the available acres. Soils in this area are naturally high in K, so typically no K_2O would need to be applied. The liquid hog manure would add K to soils every other year with this scenario, building K levels to a point where it could contribute to soil salinity. Also, the acres may be overstated because of the plant citing acreage was included and no township setback acres are included in the nutrient management plan.

Another potential problem for the acreages is the National Conservation Resources Service Manure and Food Processing Waste soil ratings. These ratings are based on soil properties that affect absorption, plant growth, microbial activity, and erodibility. The ratings cover manure and food processing waste in solid, slurry, and liquid form. These ratings go from 0.0 to 1.0, with a 1.0 rating being classified as "very limited". The "very limited" category includes soils that have one or more features that make it unfavorable for the specified use. These limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Soil maps showing the "very limited" areas for each field contracted (by quarter section) are presented in Appendix E. For the land that has been contracted for manure application, 1,408.6 acres are classified as 1.0, or "very limited" (Table 7). These soils are classified as Hamerly-Tonka and characterized by slow water movement or ponding. Applying liquid manure to these soils could present serious environmental problems.

A map showing the locations of the land contracted for application indicates manure would have to be hauled as far as 8 miles to the northwest and 6 miles to the south. Also, applying liquid manure to tiled land is currently new to North Dakota. Much of the tilled land identified in the acreage contracts drains directly into the Maple River, which in turn ends up in the Red River. This could become an international problem if nitrogen and phosphorus leach or erode into the local waterways. It is also important to know who will be responsible for monitoring and enforcing sound environmental regulations. Based on the data currently available, it does not appear that the nutrient management plan for this CAFO is sustainable.

Table 7. Field Nutrient Easement Acres Reported, Water Quality Risk Assessment Acres, and National Resources Conservation Service Manure and Food Processing Waste Soil Type Acres Rated Very Limited

Field Number	Legal Description	Land Acres	Water Quality Acres	Very Limited Acres
1 & 2	E ½-9-139-54	284.9	285.6	171.5
3	NW ¼-4-139-54	150.0	156.4	54.5
4 & 5	N ½-36-140-55	293.0	293.7	86.4
6	W ½ SW ¼-12-139-55	78.0	78.9	43.2
7 & 8 & 9	E ½ -32-139-54	308.8	306.4	101.9
10	NE ¼ -14-139-55	157.7	157.7	59.9
11	SE ¼ -10-140-55	158.0	158.2	97.8
12	NW ¼ -14-140-55	114.0	114.0	64.8
13 & 14 & 15	11-140-45	500.0	498.5	281.6
16 & 17	NE ¼ -2-139-55	150.0	151.4	12.4
18 & 19	E ½ -4-139-54	300.7	301.9	215.6
20	S ½ -SE ¼ -11-139-55	60.0	57.6	21.9
21	NW ¼ -12-139-55	120.0	140.5	67.0
22 & 23 & 24	29-140-54	550.0	566.0	93.4
25	NE ¼ -32-140-54	155.0	153.1	36.7
Total				1,408.6

APPENDIX A

Land Application Easements

APPENDIX B

Water Quality Risk Assessment Maps

APPENDIX C

References and Supporting Documentation

APPENDIX D

Nutrient Management Plan

APPENDIX E

NRCS Waste Management Soils Maps

APPENDIX E

NRCS Waste Management Soils Maps

Manure and Food-Processing Waste—Cass County, North Dakota
(NE 1/4 S9 T139 R54W)

Map Scale: 1:6,100 if printed on A landscape (11" x 8.5") sheet.

N

Meters
0 50 100 200 300

Feet
0 250 500 1000 1500

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

001154

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Background
- Aerial Photography

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cass County, North Dakota
Survey Area Data: Version 15, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Aug 27, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

001155

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Tonka (28%)	Slow water movement (1.00)	75.7	55.0%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Wyard (7%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Vallers, moderately saline (7%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cavour (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (46%)	Depth to saturated zone (0.86)	0.4	0.3%
			Balaton (7%)	Depth to saturated zone (0.22)		
			Hamerly, moderately saline (5%)	Depth to saturated zone (0.86)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Salinity (0.50)		
				Sodium content (0.18)		
G144B	Barnes-Buse loams, 3 to 6 percent slopes	Not limited	Barnes (25%)		56.9	41.3%
			Buse (24%)			
			Svea (14%)			
			Balaton (10%)			
			Langhei (4%)			
			Swenoda (3%)			
G639F	Orthents-Aquents-Urban Land, highway complex, 0 to 35 percent slopes	Very limited	Orthents (41%)	Slope (1.00)	1.4	1.0%
				Slow water movement (0.50)		
				Large stones (0.04)		
			Aquents, clayey (16%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Renshaw (6%)	Filtering capacity (1.00)		
				Droughty (0.52)		
			Parnell (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
G680B	Barnes-Sioux complex, 1 to 6 percent slopes	Not limited	Barnes (39%)		3.3	2.4%
			Buse (7%)			
			Svea (7%)			
			Balaton (6%)			
			Swenoda (6%)			
			Langhei (3%)			
Totals for Area of Interest					137.7	100.0%

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Very limited	77.0	56.0%
Not limited	60.3	43.8%
Somewhat limited	0.4	0.3%
Totals for Area of Interest	137.7	100.0%

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Map Scale: 1:5,890 if printed on A portrait (8.5" x 11") sheet.

Meters: 0 50 100 200 300

Feet: 0 250 500 1000 1500

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Background
- Aerial Photography

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

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Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cass County, North Dakota
Survey Area Data: Version 15, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Aug 27, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

001162

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Tonka (28%)	Slow water movement (1.00)	94.4	64.1%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Wyard (7%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Vallers, moderately saline (7%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cavour (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (46%)	Depth to saturated zone (0.86)	3.4	2.3%
			Balaton (7%)	Depth to saturated zone (0.22)		
			Hamerly, moderately saline (5%)	Depth to saturated zone (0.86)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Salinity (0.50)		
				Sodium content (0.18)		
G144B	Barnes-Buse loams, 3 to 6 percent slopes	Not limited	Barnes (25%)		38.3	26.0%
			Buse (24%)			
			Svea (14%)			
			Balaton (10%)			
			Langhei (4%)			
			Swenoda (3%)			
G680B	Barnes-Sioux complex, 1 to 6 percent slopes	Not limited	Barnes (39%)		11.1	7.6%
			Buse (7%)			
			Svea (7%)			
			Balaton (6%)			
			Swenoda (6%)			
			Langhei (3%)			
Totals for Area of Interest					147.3	100.0%

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Very limited	94.4	64.1%
Not limited	49.5	33.6%
Somewhat limited	3.4	2.3%
Totals for Area of Interest	147.3	100.0%

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Manure and Food-Processing Waste—Cass County, North Dakota
(NW 1/4 S4 T139 R54W)

Map Scale: 1:6,860 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 100 200 400 600

Feet: 0 300 600 1200 1800

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

001167

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Background
- Aerial Photography

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cass County, North Dakota
Survey Area Data: Version 15, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Aug 27, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

001168

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G6A	Vallers loam, 0 to 1 percent slopes	Very limited	Vallers (67%)	Depth to saturated zone (1.00)	2.2	1.3%
				Leaching (0.70)		
			Vallers, moderately saline (8%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Tonka (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Parnell (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cresbard (2%)	Slow water movement (1.00)		
				Sodium content (0.32)		
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Tonka (28%)	Slow water movement (1.00)	52.3	31.7%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Wyard (7%)	Ponding (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Depth to saturated zone (0.86)		
			Vallers, moderately saline (7%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cavour (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
G143B	Barnes-Svea loams, 3 to 6 percent slopes	Not limited	Barnes (42%)		8.1	4.9%
			Svea (21%)			
			Buse (9%)			
			Swenoda (3%)			
G144B	Barnes-Buse loams, 3 to 6 percent slopes	Not limited	Barnes (25%)		92.6	56.1%
			Buse (24%)			
			Svea (14%)			
			Balaton (10%)			
			Langhei (4%)			
			Swenoda (3%)			
G680B	Barnes-Sioux complex, 1 to 6 percent slopes	Not limited	Barnes (39%)		9.9	6.0%
			Svea (7%)			
			Buse (7%)			
			Swenoda (6%)			
			Balaton (6%)			
			Langhei (3%)			
Totals for Area of Interest					165.1	100.0%

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Not limited	110.6	67.0%
Very limited	54.5	33.0%
Totals for Area of Interest	**165.1**	**100.0%**

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

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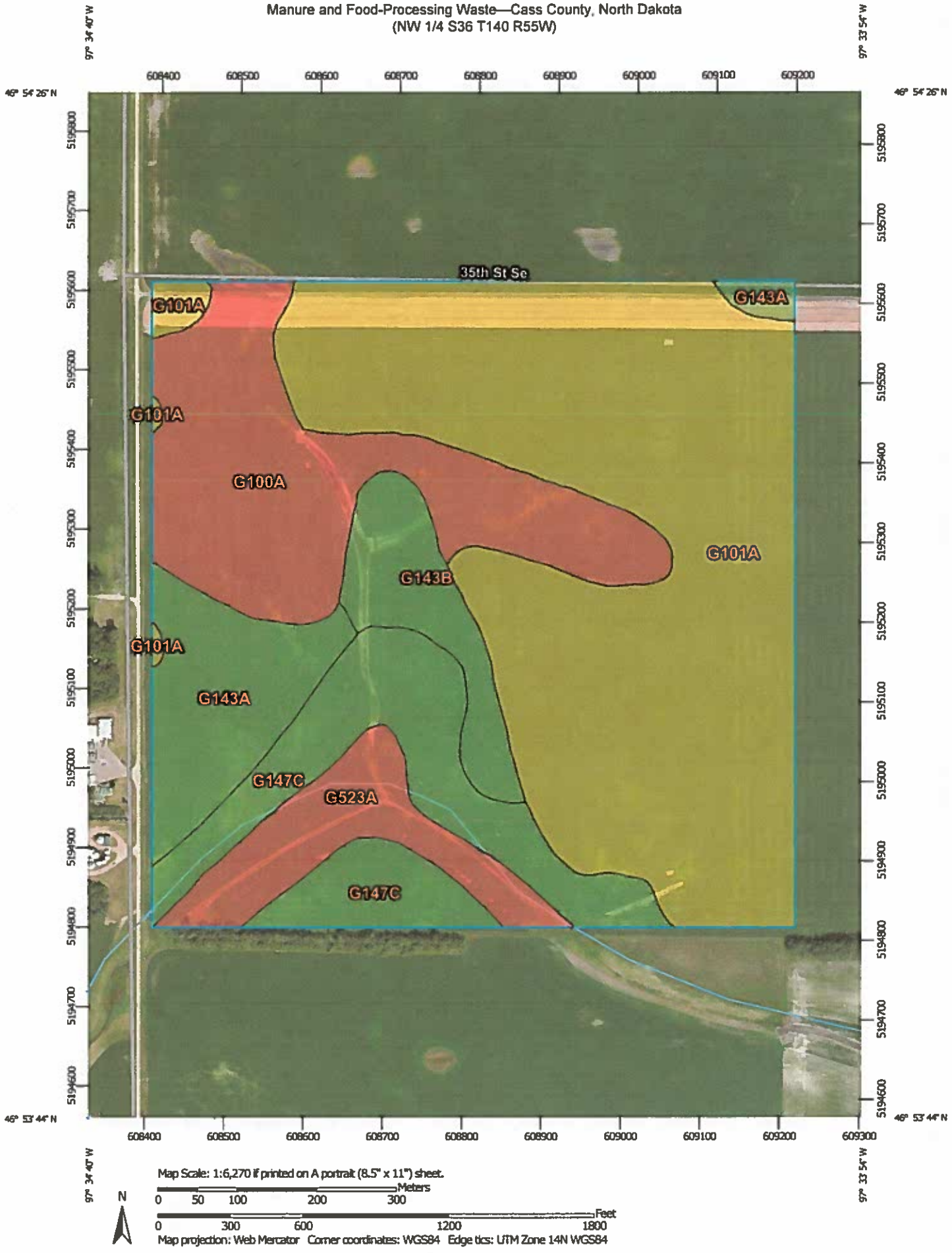
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Manure and Food-Processing Waste—Cass County, North Dakota
(NW 1/4 S36 T140 R55W)



Map Scale: 1:6,270 if printed on A portrait (8.5" x 11") sheet.

N

Meters
0 50 100 200 300

Feet
0 300 600 1200 1800

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Background
- Aerial Photography

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

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Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cass County, North Dakota
Survey Area Data: Version 15, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Aug 27, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

001175

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Tonka (28%)	Slow water movement (1.00)	29.4	18.0%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Wyard (7%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Vallers, moderately saline (7%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cavour (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (46%)	Depth to saturated zone (0.86)	79.8	48.9%
			Balaton (7%)	Depth to saturated zone (0.22)		
			Hamerly, moderately saline (5%)	Depth to saturated zone (0.86)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Salinity (0.50)		
				Sodium content (0.18)		
G143A	Barnes-Svea loams, 0 to 3 percent slopes	Not limited	Barnes (39%)		13.3	8.2%
			Svea (38%)			
			Buse (2%)			
G143B	Barnes-Svea loams, 3 to 6 percent slopes	Not limited	Barnes (42%)		8.6	5.2%
			Svea (21%)			
			Buse (9%)			
			Swenoda (3%)			
G147C	Buse-Barnes-Darnen loams, 3 to 9 percent slopes	Not limited	Buse (28%)		21.7	13.3%
			Barnes (23%)			
			Darnen (22%)			
			Langhei (7%)			
			Swenoda (3%)			
G523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	Very limited	Fluvaquents, channeled, frequently flooded (40%)	Ponding (1.00)	10.5	6.4%
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.90)		
			Lowe, frequently flooded (28%)	Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
			Lowe, moderately saline, frequently flooded (20%)	Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
				Salinity (0.50)		
				Sodium content (0.32)		
			Lowe, very poorly drained, frequently flooded (5%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
Totals for Area of Interest					163.2	100.0%

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Somewhat limited	79.8	48.9%
Not limited	43.6	26.7%
Very limited	39.8	24.4%
Totals for Area of Interest	**163.2**	**100.0%**

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

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Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Manure and Food-Processing Waste—Cass County, North Dakota
(NE 1/4 S36 T140 R55W)

Map Scale: 1:5,950 if printed on A portrait (8.5" x 11") sheet.

Meters: 0 50 100 200 300

Feet: 0 250 500 1000 1500

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Background
- Aerial Photography

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

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Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

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This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cass County, North Dakota
Survey Area Data: Version 15, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Aug 27, 2010

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001182

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Tonka (28%)	Slow water movement (1.00)	44.7	30.1%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Wyard (7%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Vallers, moderately saline (7%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cavour (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (46%)	Depth to saturated zone (0.86)	67.0	45.1%
			Balaton (7%)	Depth to saturated zone (0.22)		
			Hamerly, moderately saline (5%)	Depth to saturated zone (0.86)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Salinity (0.50)		
				Sodium content (0.18)		
G143A	Barnes-Svea loams, 0 to 3 percent slopes	Not limited	Barnes (39%)		36.9	24.9%
			Svea (38%)			
			Buse (2%)			
Totals for Area of Interest					148.6	100.0%

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Somewhat limited	67.0	45.1%
Very limited	44.7	30.1%
Not limited	36.9	24.9%
Totals for Area of Interest	148.6	100.0%

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

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Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Manure and Food-Processing Waste—Cass County, North Dakota
(SW 1/4 WEST 80 S12 T139 R55W)

Map Scale: 1:4,610 if printed on A portrait (8.5" x 11") sheet.

Meters: 0 50 100 200 300

Feet: 0 200 400 800 1200

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

001087

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Background
- Aerial Photography

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cass County, North Dakota
Survey Area Data: Version 15, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Aug 27, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

001188

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G3A	Parnell silty clay loam, 0 to 1 percent slopes	Very limited	Parnell (64%)	Slow water movement (1.00)	13.7	16.8%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Vallers (10%)	Depth to saturated zone (1.00)		
				Leaching (0.70)		
			Vallers, moderately saline (9%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Southam (6%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Tonka (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Ferney (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
				Salinity (0.50)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Tonka (28%)	Slow water movement (1.00)	26.6	32.6%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Wyard (7%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Vallers, moderately saline (7%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cavour (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (46%)	Depth to saturated zone (0.86)	13.9	17.0%
			Balaton (7%)	Depth to saturated zone (0.22)		
			Hamerly, moderately saline (5%)	Depth to saturated zone (0.86)		
				Salinity (0.50)		
				Sodium content (0.18)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G118A	Vallers loam, saline, 0 to 1 percent slopes	Very limited	Vallers, moderately saline (68%)	Depth to saturated zone (1.00)	2.9	3.6%
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Tonka (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cresbard (4%)	Slow water movement (1.00)		
				Sodium content (0.32)		
			Parnell (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Easby (3%)	Depth to saturated zone (1.00)		
				Salinity (1.00)		
				Sodium content (1.00)		
				Droughty (1.00)		
				Slow water movement (0.50)		
G143B	Barnes-Svea loams, 3 to 6 percent slopes	Not limited	Barnes (42%)		8.6	10.6%
			Svea (21%)			
			Buse (9%)			
			Swenoda (3%)			
G144B	Barnes-Buse loams, 3 to 6 percent slopes	Not limited	Barnes (25%)		15.8	19.4%
			Buse (24%)			

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Svea (14%)			
			Balaton (10%)			
			Langhei (4%)			
			Swenoda (3%)			
Totals for Area of Interest					81.4	100.0%

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Very limited	43.1	53.0%
Not limited	24.4	30.0%
Somewhat limited	13.9	17.0%
Totals for Area of Interest	81.4	100.0%

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

97° 31' 32" W
97° 30' 46" W
46° 49' 10" N
46° 48' 31" N
612500
612600
612700
612800
612900
613000
613100
613200
613300
613400
5186100
5186000
5185900
5185800
5185700
5185600
5185500
5185400
5185300
5185200
5185100
5185000
41st St So
G118A
G100A
G6A
G117A
G143A
G125A
G276B
G100A
Map Scale: 1:5,930 if printed on A portrait (8.5" x 11") sheet.
Meters
0 50 100 200 300
N
Feet
0 250 500 1000 1500
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Background
- Aerial Photography

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

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Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

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Soil Survey Area: Cass County, North Dakota
Survey Area Data: Version 15, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Aug 27, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

001196

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G6A	Vallers loam, 0 to 1 percent slopes	Very limited	Vallers (67%)	Depth to saturated zone (1.00)	2.1	1.4%
				Leaching (0.70)		
			Vallers, moderately saline (8%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Tonka (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Parnell (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cresbard (2%)	Slow water movement (1.00)		
				Sodium content (0.32)		
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Tonka (28%)	Slow water movement (1.00)	32.1	21.2%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Vallers, moderately saline (7%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Wyard (7%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Parnell (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cavour (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
G117A	Hamerly loam, saline, 0 to 3 percent slopes	Somewhat limited	Hamerly, moderately saline (55%)	Depth to saturated zone (0.86)	90.7	60.0%
				Salinity (0.50)		
				Sodium content (0.18)		
			Hamerly (8%)	Depth to saturated zone (0.86)		
			Balaton (7%)	Depth to saturated zone (0.22)		
G118A	Vallers loam, saline, 0 to 1 percent slopes	Very limited	Vallers, moderately saline (68%)	Depth to saturated zone (1.00)	4.4	2.9%
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Tonka (5%)	Slow water movement (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cresbard (4%)	Slow water movement (1.00)		
				Sodium content (0.32)		
			Parnell (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Easby (3%)	Depth to saturated zone (1.00)		
				Salinity (1.00)		
				Sodium content (1.00)		
				Droughty (1.00)		
				Slow water movement (0.50)		
G125A	Cavour-Cresbard loams, 0 to 3 percent slopes	Very limited	Cavour (49%)	Slow water movement (1.00)	6.5	4.3%
				Sodium content (1.00)		
			Cresbard (25%)	Slow water movement (1.00)		
				Sodium content (0.18)		
			Ferney (5%)	Slow water movement (1.00)		
				Sodium content (1.00)		
				Salinity (0.50)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Tonka (2%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Vallers, moderately saline (2%)	Depth to saturated zone (1.00)		
				Leaching (0.70)		
				Salinity (0.50)		
				Sodium content (0.32)		
				Droughty (0.03)		
G143A	Barnes-Svea loams, 0 to 3 percent slopes	Not limited	Barnes (39%)		12.6	8.3%
			Svea (38%)			
			Buse (2%)			
G276B	Renshaw-Sioux complex, 2 to 6 percent slopes	Very limited	Renshaw (36%)	Filtering capacity (1.00)	2.7	1.8%
				Droughty (0.52)		
			Sioux (20%)	Filtering capacity (1.00)		
				Leaching (0.45)		
				Droughty (0.18)		
			Fordville (10%)	Filtering capacity (1.00)		
			Sioux (10%)	Filtering capacity (1.00)		
				Leaching (0.45)		
				Droughty (0.15)		
			Osakis (7%)	Filtering capacity (1.00)		
				Droughty (0.90)		
				Leaching (0.45)		
			Warsing (6%)	Filtering capacity (1.00)		
				Droughty (0.01)		
			Arvilla (4%)	Filtering capacity (1.00)		
				Droughty (0.98)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Leaching (0.45)		
			Marysland (3%)	Depth to saturated zone (1.00)		
				Leaching (0.70)		
Totals for Area of Interest					151.1	100.0%

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Somewhat limited	90.7	60.0%
Very limited	47.8	31.6%
Not limited	12.6	8.3%
Totals for Area of Interest	151.1	100.0%

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

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Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Manure and Food-Processing Waste—Cass County, North Dakota
(SE 1/4 S32 T139 R54W)

Map Scale: 1:6,040 if printed on A portrait (8.5" x 11") sheet.

Meters: 0 50 100 200 300

Feet: 0 250 500 1000 1500

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Background
- Aerial Photography

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

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001205

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G6A	Vallers loam, 0 to 1 percent slopes	Very limited	Vallers (67%)	Depth to saturated zone (1.00)	7.7	5.1%
				Leaching (0.70)		
			Vallers, moderately saline (8%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Tonka (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Parnell (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cresbard (2%)	Slow water movement (1.00)		
				Sodium content (0.32)		
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (46%)	Depth to saturated zone (0.86)	0.1	0.0%
			Balaton (7%)	Depth to saturated zone (0.22)		
			Hamerly, moderately saline (5%)	Depth to saturated zone (0.86)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Salinity (0.50)		
				Sodium content (0.18)		
G117A	Hamerly loam, saline, 0 to 3 percent slopes	Somewhat limited	Hamerly, moderately saline (55%)	Depth to saturated zone (0.86)	68.4	45.2%
				Salinity (0.50)		
				Sodium content (0.18)		
			Hamerly (8%)	Depth to saturated zone (0.86)		
			Balaton (7%)	Depth to saturated zone (0.22)		
G118A	Vallers loam, saline, 0 to 1 percent slopes	Very limited	Vallers, moderately saline (68%)	Depth to saturated zone (1.00)	7.0	4.6%
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Tonka (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cresbard (4%)	Slow water movement (1.00)		
				Sodium content (0.32)		
			Parnell (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Easby (3%)	Depth to saturated zone (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Salinity (1.00)		
				Sodium content (1.00)		
				Droughty (1.00)		
				Slow water movement (0.50)		
G125A	Cavour-Cresbard loams, 0 to 3 percent slopes	Very limited	Cavour (49%)	Slow water movement (1.00)	11.5	7.6%
				Sodium content (1.00)		
			Cresbard (25%)	Slow water movement (1.00)		
				Sodium content (0.18)		
			Ferney (5%)	Slow water movement (1.00)		
				Sodium content (1.00)		
				Salinity (0.50)		
			Tonka (2%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Vallers, moderately saline (2%)	Depth to saturated zone (1.00)		
				Leaching (0.70)		
				Salinity (0.50)		
				Sodium content (0.32)		
				Droughty (0.03)		
G143A	Barnes-Svea loams, 0 to 3 percent slopes	Not limited	Barnes (39%)		0.1	0.0%
			Svea (38%)			
			Buse (2%)			
G144B	Barnes-Buse loams, 3 to 6 percent slopes	Not limited	Barnes (25%)		5.8	3.8%
			Buse (24%)			

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Svea (14%)			
			Balaton (10%)			
			Langhei (4%)			
			Swenoda (3%)			
G276B	Renshaw-Sioux complex, 2 to 6 percent slopes	Very limited	Renshaw (36%)	Filtering capacity (1.00)	27.9	18.4%
				Droughty (0.52)		
			Sioux (20%)	Filtering capacity (1.00)		
				Leaching (0.45)		
				Droughty (0.18)		
			Fordville (10%)	Filtering capacity (1.00)		
			Sioux (10%)	Filtering capacity (1.00)		
				Leaching (0.45)		
				Droughty (0.15)		
			Osakis (7%)	Filtering capacity (1.00)		
				Droughty (0.90)		
				Leaching (0.45)		
			Warsing (6%)	Filtering capacity (1.00)		
				Droughty (0.01)		
			Arvilla (4%)	Filtering capacity (1.00)		
				Droughty (0.98)		
				Leaching (0.45)		
			Marysland (3%)	Depth to saturated zone (1.00)		
				Leaching (0.70)		
G680B	Barnes-Sioux complex, 1 to 6 percent slopes	Not limited	Barnes (39%)		22.7	15.0%
			Svea (7%)			
			Buse (7%)			
			Swenoda (6%)			
			Balaton (6%)			
			Langhei (3%)			
Totals for Area of Interest					151.2	100.0%

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Somewhat limited	68.5	45.3%
Very limited	54.1	35.8%
Not limited	28.6	18.9%
Totals for Area of Interest	**151.2**	**100.0%**

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Map Scale: 1:6,070 if printed on A portrait (8.5" x 11") sheet.

Meters: 0 50 100 200 300

Feet: 0 250 500 1000 1500

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Background
- Aerial Photography

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cass County, North Dakota
Survey Area Data: Version 15, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Aug 27, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

001214

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G6A	Vallers loam, 0 to 1 percent slopes	Very limited	Vallers (67%)	Depth to saturated zone (1.00)	56.8	36.4%
				Leaching (0.70)		
			Vallers, moderately saline (8%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Tonka (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Parnell (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cresbard (2%)	Slow water movement (1.00)		
				Sodium content (0.32)		
G12A	Vallers, saline-Parnell complex, 0 to 1 percent slopes	Very limited	Vallers, moderately saline (40%)	Depth to saturated zone (1.00)	0.4	0.3%
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Parnell (27%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Tonka (7%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Manfred (5%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Sodium content (1.00)		
				Slow water movement (1.00)		
				Salinity (0.50)		
			Southam (4%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
				Salinity (0.01)		
			Wyard (3%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Easby (3%)	Depth to saturated zone (1.00)		
				Salinity (1.00)		
				Sodium content (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Droughty (1.00)		
				Slow water movement (0.50)		
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (46%)	Depth to saturated zone (0.86)	8.1	5.2%
			Balaton (7%)	Depth to saturated zone (0.22)		
			Hamerly, moderately saline (5%)	Depth to saturated zone (0.86)		
				Salinity (0.50)		
				Sodium content (0.18)		
G118A	Vallers loam, saline, 0 to 1 percent slopes	Very limited	Vallers, moderately saline (68%)	Depth to saturated zone (1.00)	2.7	1.7%
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Tonka (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cresbard (4%)	Slow water movement (1.00)		
				Sodium content (0.32)		
			Parnell (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Easby (3%)	Depth to saturated zone (1.00)		
				Salinity (1.00)		
				Sodium content (1.00)		
				Droughty (1.00)		
				Slow water movement (0.50)		
G143A	Barnes-Svea loams, 0 to 3 percent slopes	Not limited	Barnes (39%)		18.4	11.8%
			Svea (38%)			
			Buse (2%)			
G143B	Barnes-Svea loams, 3 to 6 percent slopes	Not limited	Barnes (42%)		58.4	37.4%
			Svea (21%)			
			Buse (9%)			
			Swenoda (3%)			
G144B	Barnes-Buse loams, 3 to 6 percent slopes	Not limited	Barnes (25%)		11.3	7.2%
			Buse (24%)			
			Svea (14%)			
			Balaton (10%)			
			Langhei (4%)			
			Swenoda (3%)			
Totals for Area of Interest					156.1	100.0%

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Not limited	88.1	56.4%
Very limited	59.9	38.4%
Somewhat limited	8.1	5.2%
Totals for Area of Interest	156.1	100.0%

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

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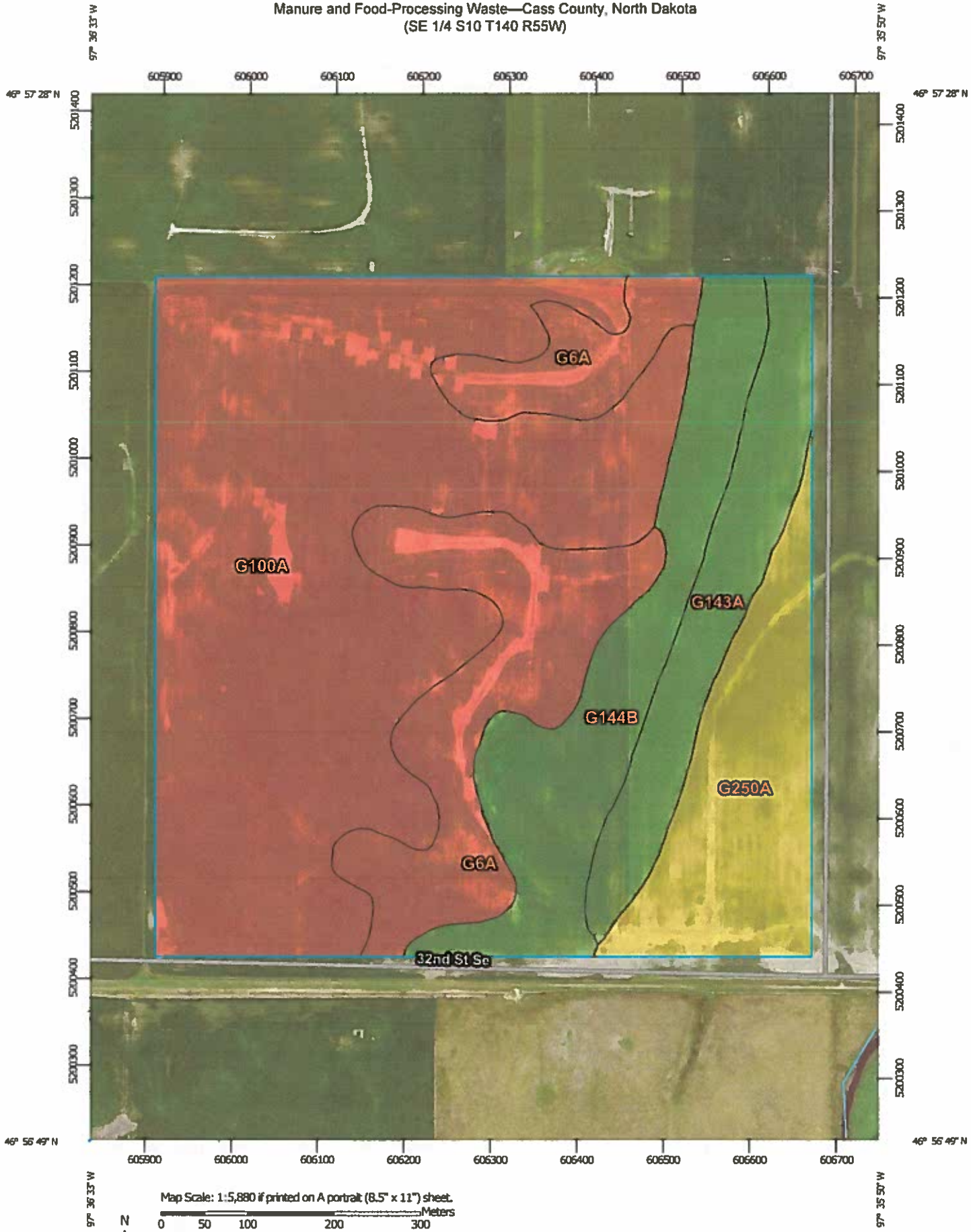
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Manure and Food-Processing Waste—Cass County, North Dakota
(SE 1/4 S10 T140 R55W)



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cass County, North Dakota
Survey Area Data: Version 15, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Aug 27, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

001222

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G6A	Vallers loam, 0 to 1 percent slopes	Very limited	Vallers (67%)	Depth to saturated zone (1.00)	25.8	17.5%
				Leaching (0.70)		
			Vallers, moderately saline (8%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Tonka (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Parnell (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cresbard (2%)	Slow water movement (1.00)		
				Sodium content (0.32)		
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Tonka (28%)	Slow water movement (1.00)	72.9	49.3%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Wyard (7%)	Ponding (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Depth to saturated zone (0.86)		
			Vallers, moderately saline (7%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cavour (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
G143A	Barnes-Svea loams, 0 to 3 percent slopes	Not limited	Barnes (39%)		12.9	8.7%
			Svea (38%)			
			Buse (2%)			
G144B	Barnes-Buse loams, 3 to 6 percent slopes	Not limited	Barnes (25%)		19.2	13.0%
			Buse (24%)			
			Svea (14%)			
			Balaton (10%)			
			Langhei (4%)			
			Swenoda (3%)			
G250A	Divide loam, 0 to 2 percent slopes	Somewhat limited	Divide (70%)	Depth to saturated zone (0.86)	16.9	11.4%
			Wyrene (4%)	Depth to saturated zone (0.86)		
				Droughty (0.31)		
Totals for Area of Interest					147.8	100.0%

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Very limited	98.7	66.8%
Not limited	32.2	21.8%
Somewhat limited	16.9	11.4%
Totals for Area of Interest	**147.8**	**100.0%**

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Manure and Food-Processing Waste—Cass County, North Dakota
(NW 1/4 S14 T140 R55W)

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Background
- Aerial Photography

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cass County, North Dakota
Survey Area Data: Version 15, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Aug 27, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

001229

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Tonka (28%)	Slow water movement (1.00)	32.4	20.6%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Wyard (7%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Vallers, moderately saline (7%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cavour (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
G143B	Barnes-Svea loams, 3 to 6 percent slopes	Not limited	Barnes (42%)		75.4	47.9%
			Svea (21%)			
			Buse (9%)			
			Swenoda (3%)			
G250A	Divide loam, 0 to 2 percent slopes	Somewhat limited	Divide (70%)	Depth to saturated zone (0.86)	17.1	10.8%

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Wyrene (4%)	Depth to saturated zone (0.86)		
				Droughty (0.31)		
G523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	Very limited	Fluvaquents, channeled, frequently flooded (40%)	Ponding (1.00)	29.4	18.7%
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.90)		
			Lowe, frequently flooded (28%)	Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
			Lowe, moderately saline, frequently flooded (20%)	Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
				Salinity (0.50)		
				Sodium content (0.32)		
			Lowe, very poorly drained, frequently flooded (5%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
G546A	Lowe loam, saline, 0 to 1 percent slopes, occasionally flooded	Very limited	Lowe, moderately saline, occasionally flooded (78%)	Depth to saturated zone (1.00)	3.0	1.9%
				Leaching (0.70)		
				Flooding (0.60)		
				Salinity (0.50)		
				Sodium content (0.32)		
			Lowe, very poorly drained, frequently flooded (8%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Lowe, occasionally flooded (5%)	Depth to saturated zone (1.00)		
				Leaching (0.70)		
				Flooding (0.60)		
			Harriet, occasionally flooded (4%)	Slow water movement (1.00)		
				Depth to saturated zone (1.00)		
				Sodium content (1.00)		
				Salinity (0.78)		
				Flooding (0.60)		
Totals for Area of Interest					157.4	100.0%

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Not limited	75.4	47.9%
Very limited	64.8	41.2%
Somewhat limited	17.1	10.8%
Totals for Area of Interest	157.4	100.0%

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

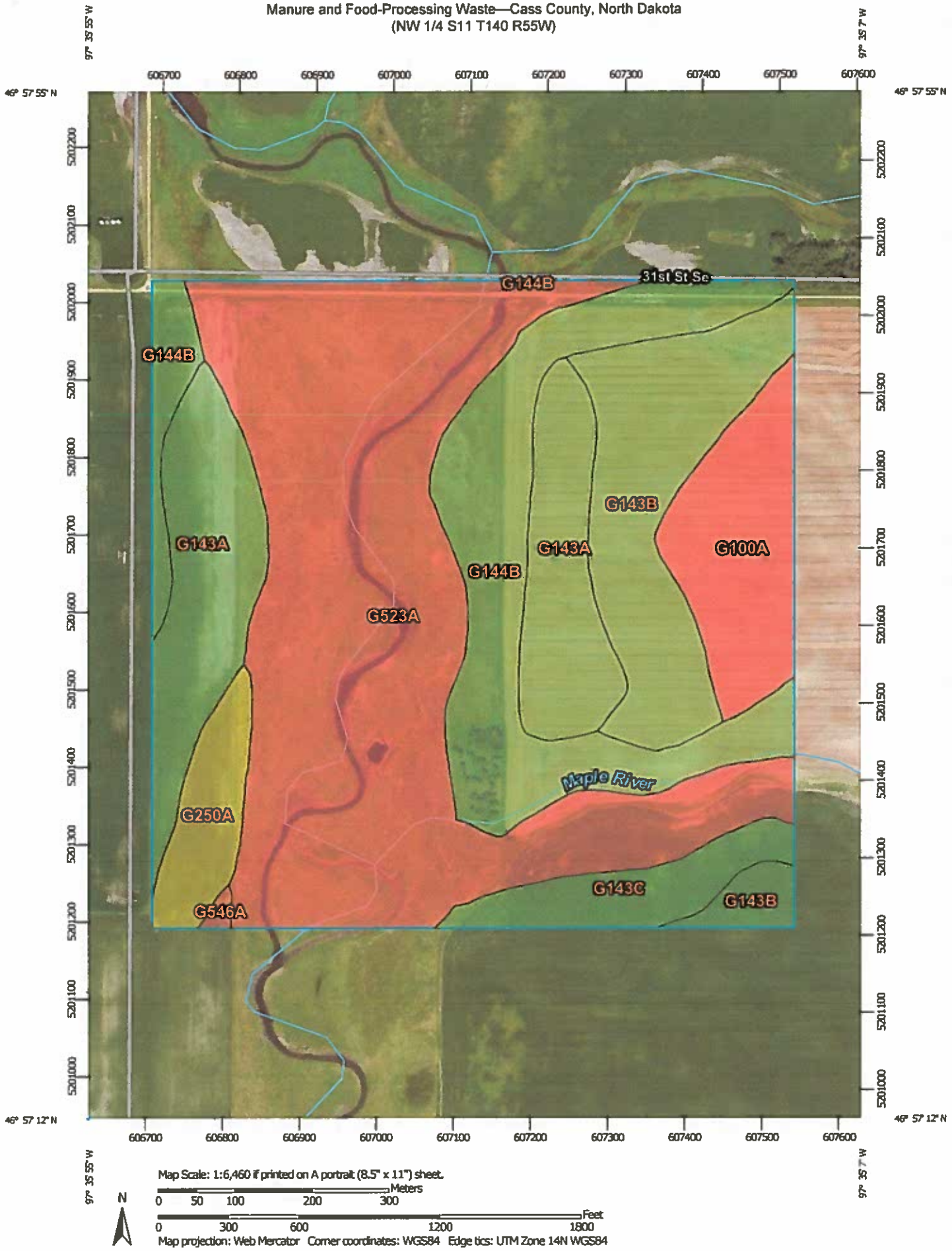
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Manure and Food-Processing Waste—Cass County, North Dakota
(NW 1/4 S11 T140 R55W)



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Background
- Aerial Photography

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cass County, North Dakota
Survey Area Data: Version 15, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Aug 27, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

001236

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Tonka (28%)	Slow water movement (1.00)	13.1	7.6%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Wyard (7%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Vallers, moderately saline (7%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cavour (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
G143A	Barnes-Svea loams, 0 to 3 percent slopes	Not limited	Barnes (39%)		24.7	14.3%
			Svea (38%)			
			Buse (2%)			
G143B	Barnes-Svea loams, 3 to 6 percent slopes	Not limited	Barnes (42%)		21.7	12.5%
			Svea (21%)			
			Buse (9%)			
			Swenoda (3%)			

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G143C	Barnes-Buse-Langhei loams, 6 to 9 percent slopes	Not limited	Barnes (24%)		7.0	4.0%
			Buse (23%)			
			Langhei (18%)			
			Svea (14%)			
			Balaton (3%)			
			Lanona (3%)			
G144B	Barnes-Buse loams, 3 to 6 percent slopes	Not limited	Barnes (25%)		29.3	16.9%
			Buse (24%)			
			Svea (14%)			
			Balaton (10%)			
			Langhei (4%)			
			Swenoda (3%)			
G250A	Divide loam, 0 to 2 percent slopes	Somewhat limited	Divide (70%)	Depth to saturated zone (0.86)	6.1	3.5%
			Wyrene (4%)	Depth to saturated zone (0.86)		
				Droughty (0.31)		
G523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	Very limited	Fluvaquents, channeled, frequently flooded (40%)	Ponding (1.00)	70.7	40.9%
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.90)		
			Lowe, frequently flooded (28%)	Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
			Lowe, moderately saline, frequently flooded (20%)	Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
				Salinity (0.50)		
				Sodium content (0.32)		
			Lowe, very poorly drained, frequently flooded (5%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Flooding (1.00)		
				Leaching (0.70)		
G546A	Lowe loam, saline, 0 to 1 percent slopes, occasionally flooded	Very limited	Lowe, moderately saline, occasionally flooded (78%)	Depth to saturated zone (1.00)	0.3	0.2%
				Leaching (0.70)		
				Flooding (0.60)		
				Salinity (0.50)		
				Sodium content (0.32)		
			Lowe, very poorly drained, frequently flooded (8%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
			Lowe, occasionally flooded (5%)	Depth to saturated zone (1.00)		
				Leaching (0.70)		
				Flooding (0.60)		
			Harriet, occasionally flooded (4%)	Slow water movement (1.00)		
				Depth to saturated zone (1.00)		
				Sodium content (1.00)		
				Salinity (0.78)		
				Flooding (0.60)		
Totals for Area of Interest					172.9	100.0%

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Very limited	84.1	48.6%
Not limited	82.7	47.8%
Somewhat limited	6.1	3.5%
Totals for Area of Interest	172.9	100.0%

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

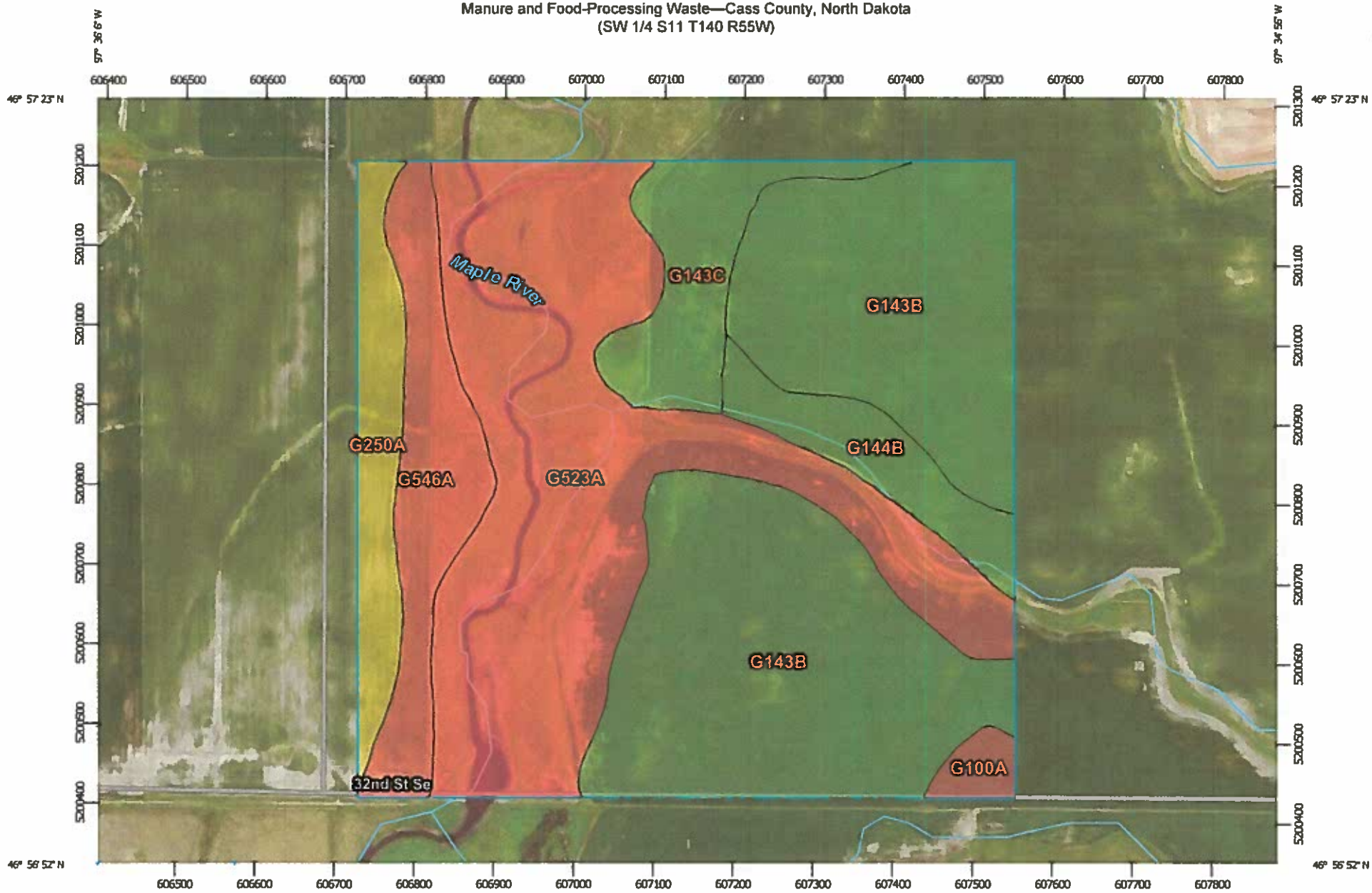
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Manure and Food-Processing Waste—Cass County, North Dakota
(SW 1/4 S11 T140 R55W)



Map Scale: 1:6,760 if printed on A landscape (11" x 8.5") sheet.

N

Meters
0 100 200 400 600

Feet
0 300 600 1200 1800

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

001242

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Background
- Aerial Photography

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cass County, North Dakota
Survey Area Data: Version 15, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Aug 27, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

001243

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Tonka (28%)	Slow water movement (1.00)	1.8	1.1%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Wyard (7%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Vallers, moderately saline (7%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cavour (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
G143B	Barnes-Svea loams, 3 to 6 percent slopes	Not limited	Barnes (42%)		65.7	40.2%
			Svea (21%)			
			Buse (9%)			
			Swenoda (3%)			
G143C	Barnes-Buse-Langhei loams, 6 to 9 percent slopes	Not limited	Barnes (24%)		10.7	6.5%
			Buse (23%)			
			Langhei (18%)			

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Svea (14%)			
			Balaton (3%)			
			Lanona (3%)			
G144B	Barnes-Buse loams, 3 to 6 percent slopes	Not limited	Barnes (25%)		7.9	4.8%
			Buse (24%)			
			Svea (14%)			
			Balaton (10%)			
			Langhei (4%)			
			Swenoda (3%)			
G250A	Divide loam, 0 to 2 percent slopes	Somewhat limited	Divide (70%)	Depth to saturated zone (0.86)	9.2	5.6%
			Wyrene (4%)	Depth to saturated zone (0.86)		
				Droughty (0.31)		
G523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	Very limited	Fluvaquents, channeled, frequently flooded (40%)	Ponding (1.00)	54.4	33.3%
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.90)		
			Lowe, frequently flooded (28%)	Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
			Lowe, moderately saline, frequently flooded (20%)	Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
				Salinity (0.50)		
				Sodium content (0.32)		
			Lowe, very poorly drained, frequently flooded (5%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G546A	Lowe loam, saline, 0 to 1 percent slopes, occasionally flooded	Very limited	Lowe, moderately saline, occasionally flooded (78%)	Depth to saturated zone (1.00)	13.8	8.4%
				Leaching (0.70)		
				Flooding (0.60)		
				Salinity (0.50)		
				Sodium content (0.32)		
			Lowe, very poorly drained, frequently flooded (8%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
			Lowe, occasionally flooded (5%)	Depth to saturated zone (1.00)		
				Leaching (0.70)		
				Flooding (0.60)		
			Harriet, occasionally flooded (4%)	Slow water movement (1.00)		
				Depth to saturated zone (1.00)		
				Sodium content (1.00)		
				Salinity (0.78)		
				Flooding (0.60)		
Totals for Area of Interest					163.4	100.0%

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Not limited	84.2	51.5%
Very limited	70.0	42.8%
Somewhat limited	9.2	5.6%
Totals for Area of Interest	163.4	100.0%

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

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Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Manure and Food-Processing Waste—Cass County, North Dakota
(NE 1/4 S11 T140 R55W)

Map Scale: 1:6,130 if printed on A portrait (8.5" x 11") sheet.

Meters: 0 50 100 200 300

Feet: 0 250 500 1000 1500

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Background
- Aerial Photography

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cass County, North Dakota
Survey Area Data: Version 15, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Aug 27, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

001250

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Tonka (28%)	Slow water movement (1.00)	80.8	50.0%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Vallers, moderately saline (7%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Wyard (7%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Parnell (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cavour (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (46%)	Depth to saturated zone (0.86)	5.2	3.2%
			Balaton (7%)	Depth to saturated zone (0.22)		
			Hamerly, moderately saline (5%)	Depth to saturated zone (0.86)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Salinity (0.50)		
				Sodium content (0.18)		
G143B	Barnes-Svea loams, 3 to 6 percent slopes	Not limited	Barnes (42%)		54.1	33.5%
			Svea (21%)			
			Buse (9%)			
			Swenoda (3%)			
G143C	Barnes-Buse-Langhei loams, 6 to 9 percent slopes	Not limited	Barnes (24%)		3.9	2.4%
			Buse (23%)			
			Langhei (18%)			
			Svea (14%)			
			Balaton (3%)			
			Lanona (3%)			
G144B	Barnes-Buse loams, 3 to 6 percent slopes	Not limited	Barnes (25%)		11.2	7.0%
			Buse (24%)			
			Svea (14%)			
			Balaton (10%)			
			Langhei (4%)			
			Swenoda (3%)			
G523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	Very limited	Fluvaquents, channeled, frequently flooded (40%)	Ponding (1.00)	6.2	3.8%
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.90)		
			Lowe, frequently flooded (28%)	Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
			Lowe, moderately saline, frequently flooded (20%)	Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
				Salinity (0.50)		
				Sodium content (0.32)		
			Lowe, very poorly drained,	Ponding (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			frequently flooded (5%)	Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
Totals for Area of Interest					161.5	100.0%

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Very limited	87.0	53.9%
Not limited	69.2	42.9%
Somewhat limited	5.2	3.2%
Totals for Area of Interest	161.5	100.0%

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

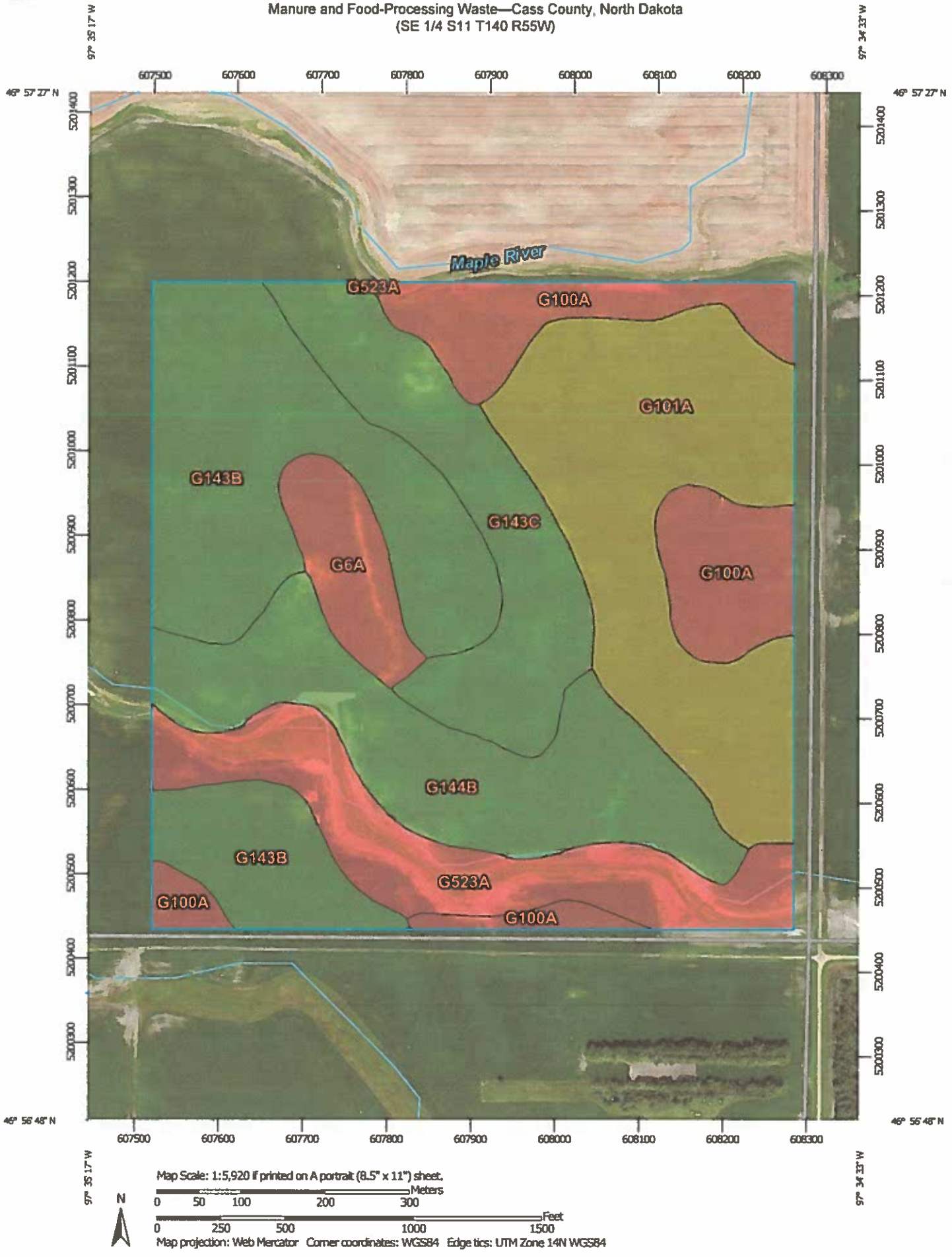
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Manure and Food-Processing Waste—Cass County, North Dakota
(SE 1/4 S11 T140 R55W)



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cass County, North Dakota
Survey Area Data: Version 15, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Aug 27, 2010

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001257

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G6A	Vallers loam, 0 to 1 percent slopes	Very limited	Vallers (67%)	Depth to saturated zone (1.00)	6.0	4.2%
				Leaching (0.70)		
			Vallers, moderately saline (8%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Tonka (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Parnell (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cresbard (2%)	Slow water movement (1.00)		
				Sodium content (0.32)		
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Tonka (28%)	Slow water movement (1.00)	17.9	12.3%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Wyard (7%)	Ponding (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Depth to saturated zone (0.86)		
			Vallers, moderately saline (7%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cavour (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (46%)	Depth to saturated zone (0.86)	30.9	21.3%
			Balaton (7%)	Depth to saturated zone (0.22)		
			Hamerly, moderately saline (5%)	Depth to saturated zone (0.86)		
				Salinity (0.50)		
				Sodium content (0.18)		
G143B	Barnes-Svea loams, 3 to 6 percent slopes	Not limited	Barnes (42%)		33.7	23.2%
			Svea (21%)			
			Buse (9%)			
			Swenoda (3%)			
G143C	Barnes-Buse-Langhei loams, 6 to 9 percent slopes	Not limited	Barnes (24%)		17.6	12.1%
			Buse (23%)			
			Langhei (18%)			
			Svea (14%)			
			Balaton (3%)			

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Lanona (3%)			
G144B	Barnes-Buse loams, 3 to 6 percent slopes	Not limited	Barnes (25%)		22.5	15.5%
			Buse (24%)			
			Svea (14%)			
			Balaton (10%)			
			Langhei (4%)			
			Swenoda (3%)			
G523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	Very limited	Fluvaquents, channeled, frequently flooded (40%)	Ponding (1.00)	16.6	11.4%
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.90)		
			Lowe, frequently flooded (28%)	Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
			Lowe, moderately saline, frequently flooded (20%)	Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
				Salinity (0.50)		
				Sodium content (0.32)		
			Lowe, very poorly drained, frequently flooded (5%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
Totals for Area of Interest					145.3	100.0%

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Not limited	73.8	50.8%
Very limited	40.5	27.9%
Somewhat limited	30.9	21.3%
Totals for Area of Interest	145.3	100.0%

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

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The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

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Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Manure and Food-Processing Waste—Cass County, North Dakota
(NE 1/4 S2 T139 R55W)

Map Scale: 1:6,150 if printed on A portrait (8.5" x 11") sheet.

Meters: 0 50 100 200 300

Feet: 0 250 500 1000 1500

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

001266

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Background
- Aerial Photography

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

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Soil Survey Area: Cass County, North Dakota
Survey Area Data: Version 15, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Aug 27, 2010

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001264

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Tonka (28%)	Slow water movement (1.00)	7.7	4.9%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Wyard (7%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Vallers, moderately saline (7%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cavour (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (46%)	Depth to saturated zone (0.86)	39.6	25.0%
			Balaton (7%)	Depth to saturated zone (0.22)		
			Hamerly, moderately saline (5%)	Depth to saturated zone (0.86)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Salinity (0.50)		
				Sodium content (0.18)		
G143A	Barnes-Svea loams, 0 to 3 percent slopes	Not limited	Barnes (39%)		0.4	0.3%
			Svea (38%)			
			Buse (2%)			
G143B	Barnes-Svea loams, 3 to 6 percent slopes	Not limited	Barnes (42%)		0.4	0.2%
			Svea (21%)			
			Buse (9%)			
			Swenoda (3%)			
G143C	Barnes-Buse-Langhei loams, 6 to 9 percent slopes	Not limited	Barnes (24%)		3.8	2.4%
			Buse (23%)			
			Langhei (18%)			
			Svea (14%)			
			Balaton (3%)			
			Lanona (3%)			
G144B	Barnes-Buse loams, 3 to 6 percent slopes	Not limited	Barnes (25%)		78.2	49.3%
			Buse (24%)			
			Svea (14%)			
			Balaton (10%)			
			Langhei (4%)			
			Swenoda (3%)			
G147C	Buse-Barnes-Darnen loams, 3 to 9 percent slopes	Not limited	Buse (28%)		23.9	15.0%
			Barnes (23%)			
			Darnen (22%)			
			Langhei (7%)			
			Swenoda (3%)			
G523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	Very limited	Fluvaquents, channeled, frequently flooded (40%)	Ponding (1.00)	4.7	3.0%
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.90)		
			Lowe, frequently flooded (28%)	Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Lowe, moderately saline, frequently flooded (20%)	Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
				Salinity (0.50)		
				Sodium content (0.32)		
			Lowe, very poorly drained, frequently flooded (5%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
Totals for Area of Interest					158.7	100.0%

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Not limited	106.6	67.2%
Somewhat limited	39.6	25.0%
Very limited	12.4	7.8%
Totals for Area of Interest	158.7	100.0%

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

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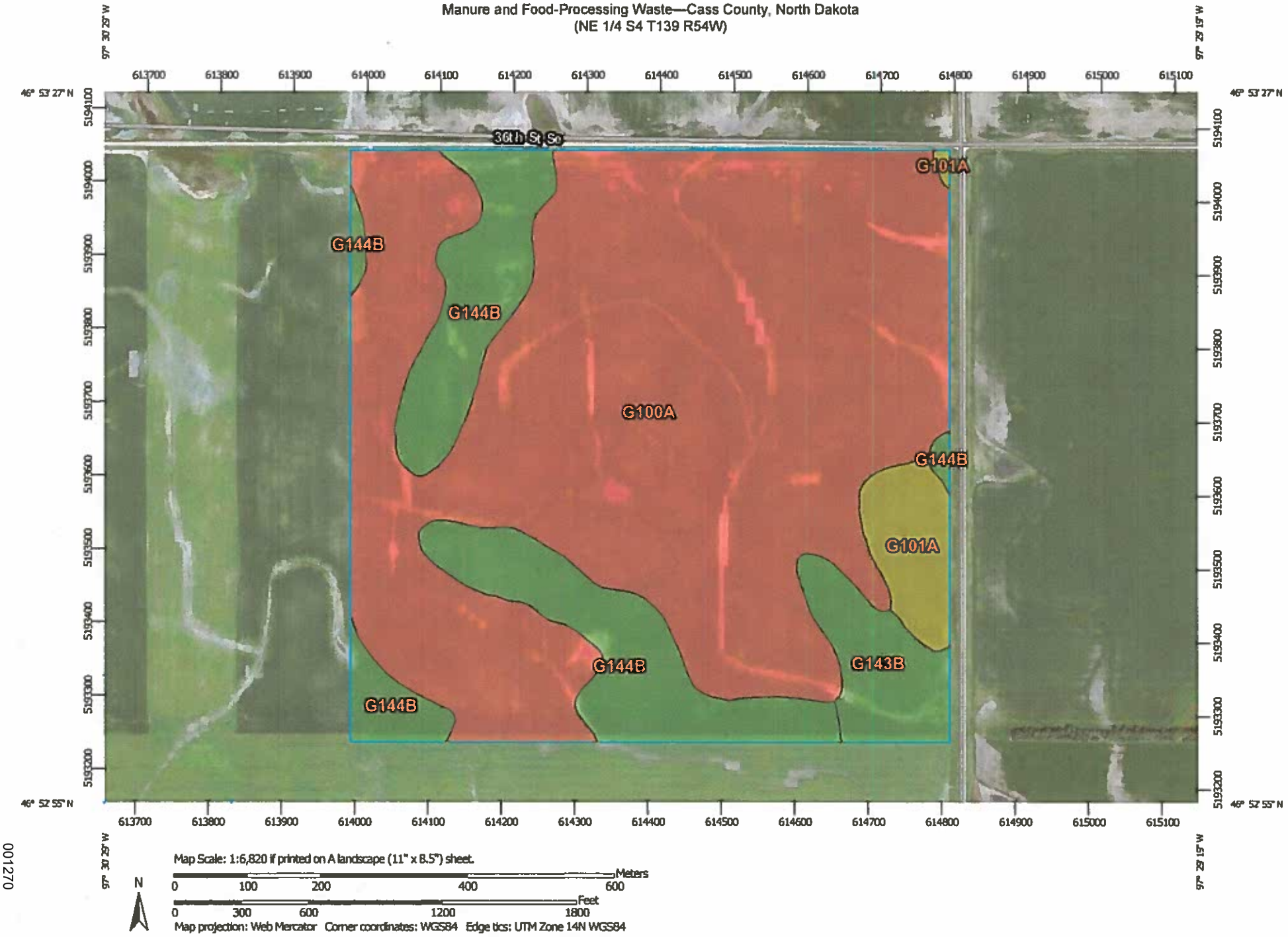
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Manure and Food-Processing Waste—Cass County, North Dakota
(NE 1/4 S4 T139 R54W)



001270

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Background
- Aerial Photography

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cass County, North Dakota
Survey Area Data: Version 15, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Aug 27, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

001271

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Tonka (28%)	Slow water movement (1.00)	120.6	73.9%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Wyard (7%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Vallers, moderately saline (7%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cavour (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (46%)	Depth to saturated zone (0.86)	6.0	3.7%
			Balaton (7%)	Depth to saturated zone (0.22)		
			Hamerly, moderately saline (5%)	Depth to saturated zone (0.86)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Salinity (0.50)		
				Sodium content (0.18)		
G143B	Barnes-Svea loams, 3 to 6 percent slopes	Not limited	Barnes (42%)		7.6	4.6%
			Svea (21%)			
			Buse (9%)			
			Swenoda (3%)			
G144B	Barnes-Buse loams, 3 to 6 percent slopes	Not limited	Barnes (25%)		29.0	17.8%
			Buse (24%)			
			Svea (14%)			
			Balaton (10%)			
			Langhei (4%)			
			Swenoda (3%)			
Totals for Area of Interest					163.2	100.0%

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Very limited	120.6	73.9%
Not limited	36.6	22.4%
Somewhat limited	6.0	3.7%
Totals for Area of Interest	163.2	100.0%

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Manure and Food-Processing Waste—Cass County, North Dakota
(SE 1/4 S4 T139 R54W)

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Background
- Aerial Photography

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

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Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

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This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cass County, North Dakota
Survey Area Data: Version 15, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Aug 27, 2010

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001277

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Tonka (28%)	Slow water movement (1.00)	90.7	60.7%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Wyard (7%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Vallers, moderately saline (7%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cavour (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
G143B	Barnes-Svea loams, 3 to 6 percent slopes	Not limited	Barnes (42%)		2.4	1.6%
			Svea (21%)			
			Buse (9%)			
			Swenoda (3%)			
G144B	Barnes-Buse loams, 3 to 6 percent slopes	Not limited	Barnes (25%)		52.2	34.9%
			Buse (24%)			
			Svea (14%)			

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Balaton (10%)			
			Langhei (4%)			
			Swenoda (3%)			
G639F	Orthents-Aquents-Urban Land, highway complex, 0 to 35 percent slopes	Very limited	Orthents (41%)	Slope (1.00)	4.3	2.9%
				Slow water movement (0.50)		
				Large stones (0.04)		
			Aquents, clayey (16%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Renshaw (6%)	Filtering capacity (1.00)		
				Droughty (0.52)		
			Parnell (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
Totals for Area of Interest					149.6	100.0%

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Very limited	95.0	63.5%
Not limited	54.6	36.5%
Totals for Area of Interest	149.6	100.0%

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

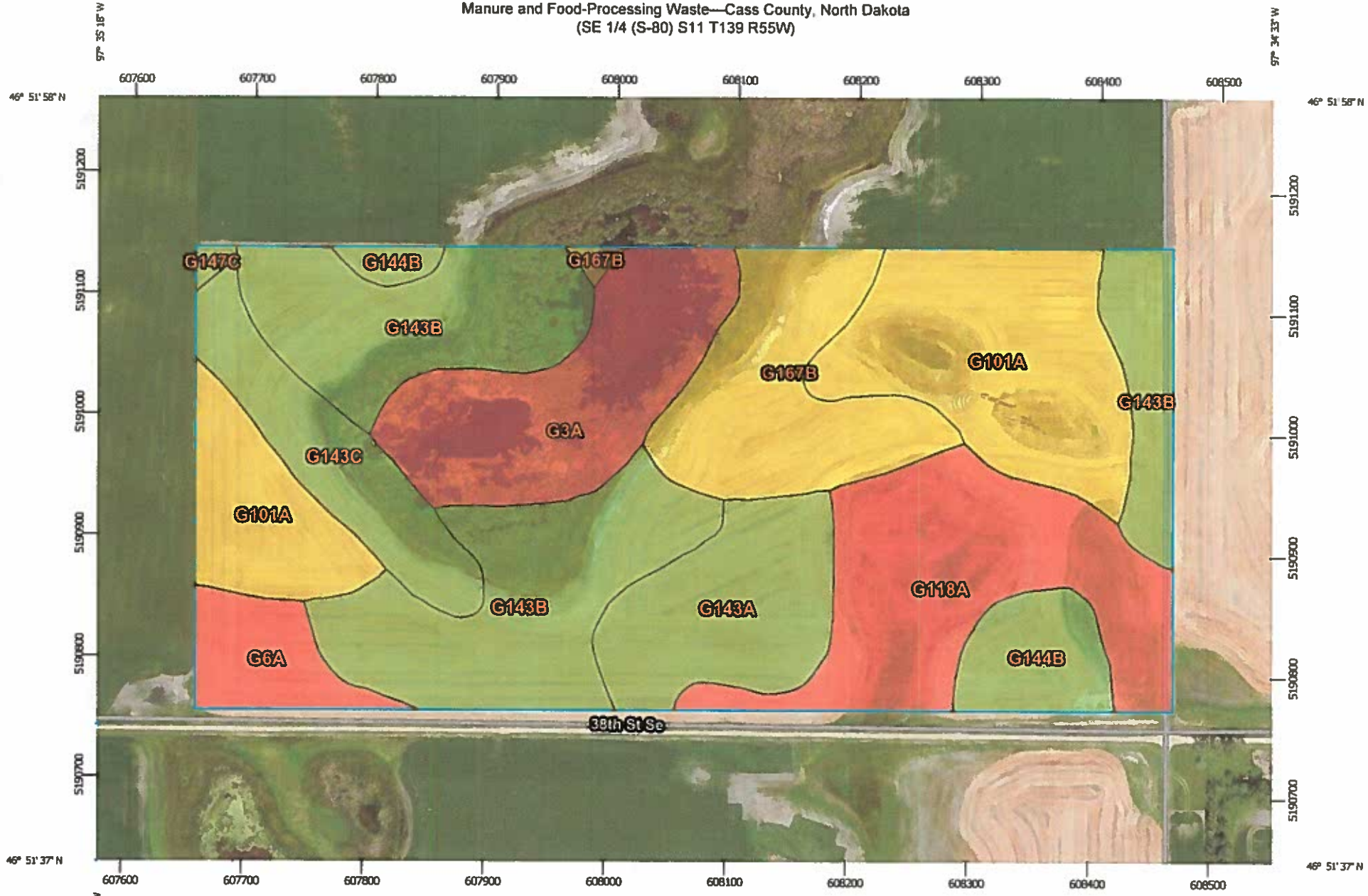
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Manure and Food-Processing Waste—Cass County, North Dakota
(SE 1/4 (S-80) S11 T139 R55W)



Map Scale: 1:4,450 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 50 100 200 300

Feet: 0 200 400 800 1200

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

001282

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

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Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

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This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cass County, North Dakota
Survey Area Data: Version 15, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Aug 27, 2010

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001283

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G3A	Parnell silty clay loam, 0 to 1 percent slopes	Very limited	Parnell (64%)	Slow water movement (1.00)	8.4	11.0%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Vallers (10%)	Depth to saturated zone (1.00)		
				Leaching (0.70)		
			Vallers, moderately saline (9%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Southam (6%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Tonka (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Ferney (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
				Salinity (0.50)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G6A	Vallers loam, 0 to 1 percent slopes	Very limited	Vallers (67%)	Depth to saturated zone (1.00)	2.7	3.5%
				Leaching (0.70)		
			Vallers, moderately saline (8%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Tonka (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Parnell (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cresbard (2%)	Slow water movement (1.00)		
				Sodium content (0.32)		
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (46%)	Depth to saturated zone (0.86)	13.5	17.6%
			Balaton (7%)	Depth to saturated zone (0.22)		
			Hamerly, moderately saline (5%)	Depth to saturated zone (0.86)		
				Salinity (0.50)		
				Sodium content (0.18)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G118A	Vallers loam, saline, 0 to 1 percent slopes	Very limited	Vallers, moderately saline (68%)	Depth to saturated zone (1.00)	10.8	14.0%
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Tonka (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cresbard (4%)	Slow water movement (1.00)		
				Sodium content (0.32)		
			Parnell (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Easby (3%)	Depth to saturated zone (1.00)		
				Salinity (1.00)		
				Sodium content (1.00)		
				Droughty (1.00)		
				Slow water movement (0.50)		
G143A	Barnes-Svea loams, 0 to 3 percent slopes	Not limited	Barnes (39%)		6.3	8.1%
			Svea (38%)			
			Buse (2%)			
G143B	Barnes-Svea loams, 3 to 6 percent slopes	Not limited	Barnes (42%)		19.1	24.8%
			Svea (21%)			
			Buse (9%)			

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Swenoda (3%)			
G143C	Barnes-Buse-Langhei loams, 6 to 9 percent slopes	Not limited	Barnes (24%)		4.9	6.4%
			Buse (23%)			
			Langhei (18%)			
			Svea (14%)			
			Balaton (3%)			
			Lanona (3%)			
G144B	Barnes-Buse loams, 3 to 6 percent slopes	Not limited	Barnes (25%)		3.3	4.3%
			Buse (24%)			
			Svea (14%)			
			Balaton (10%)			
			Langhei (4%)			
			Swenoda (3%)			
G147C	Buse-Barnes-Darnen loams, 3 to 9 percent slopes	Not limited	Buse (28%)		0.2	0.3%
			Barnes (23%)			
			Darnen (22%)			
			Langhei (7%)			
			Swenoda (3%)			
G167B	Balaton-Wyard loams, 0 to 6 percent slopes	Somewhat limited	Balaton (33%)	Depth to saturated zone (0.22)	7.6	10.0%
			Harnerly (9%)	Depth to saturated zone (0.86)		
Totals for Area of Interest					76.8	100.0%

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Not limited	33.7	43.9%
Very limited	21.9	28.5%
Somewhat limited	21.1	27.5%
Totals for Area of Interest	76.8	100.0%

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

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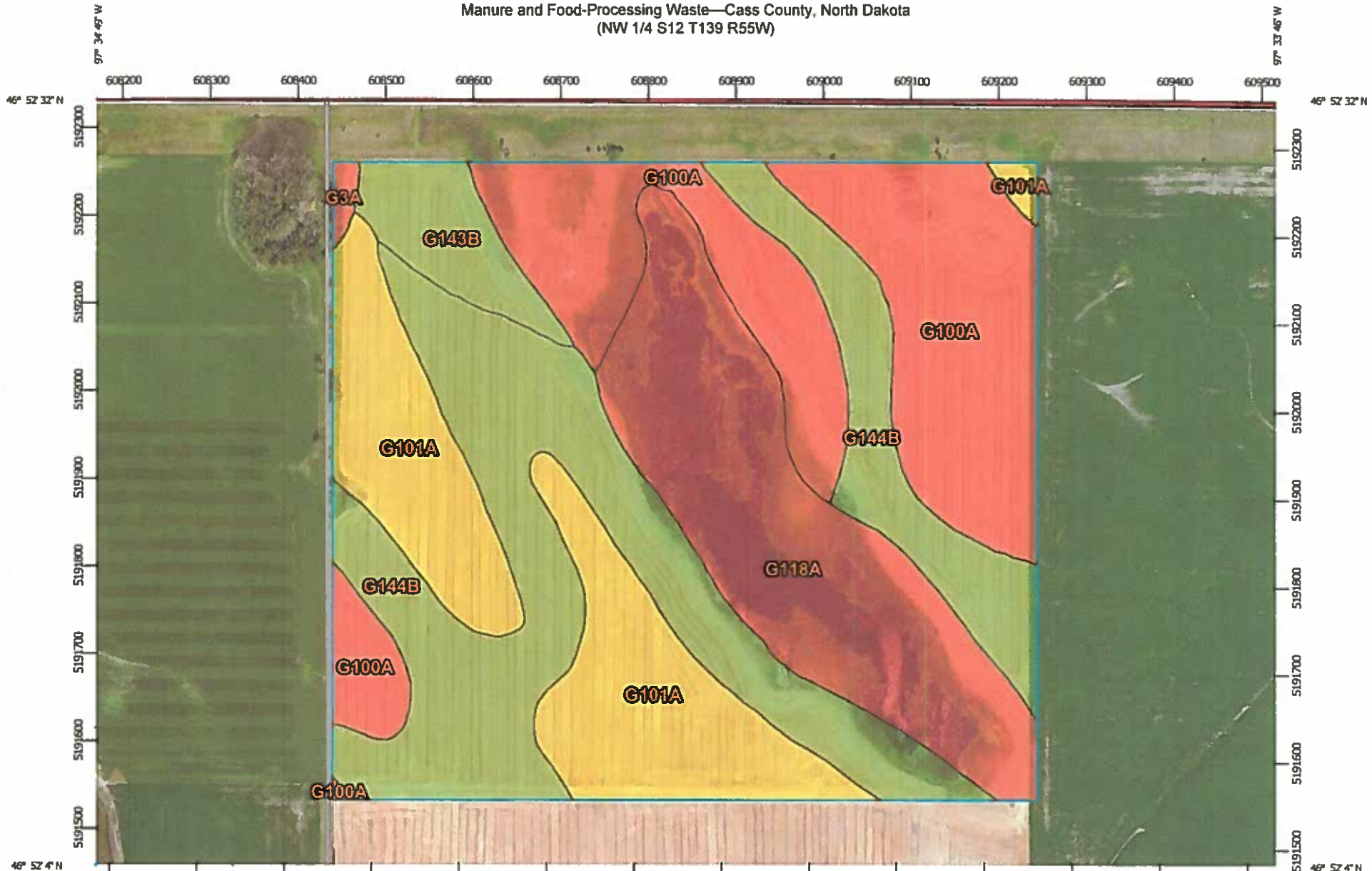
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Manure and Food-Processing Waste—Cass County, North Dakota
(NW 1/4 S12 T139 R55W)



Map Scale: 1:6,160 if printed on A landscape (11" x 8.5") sheet.

N

Meters
0 50 100 200 300

Feet
0 250 500 1000 1500

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

001290

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Background
- Aerial Photography

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cass County, North Dakota
Survey Area Data: Version 15, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Aug 27, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

001291

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G3A	Parnell silty clay loam, 0 to 1 percent slopes	Very limited	Parnell (64%)	Slow water movement (1.00)	0.6	0.4%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Vallers (10%)	Depth to saturated zone (1.00)		
				Leaching (0.70)		
			Vallers, moderately saline (9%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Southam (6%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Tonka (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Ferney (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
				Salinity (0.50)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Tonka (28%)	Slow water movement (1.00)	37.1	25.5%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Wyard (7%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Vallers, moderately saline (7%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cavour (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (46%)	Depth to saturated zone (0.86)	27.0	18.6%
			Balaton (7%)	Depth to saturated zone (0.22)		
			Hamerly, moderately saline (5%)	Depth to saturated zone (0.86)		
				Salinity (0.50)		
				Sodium content (0.18)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G118A	Vallers loam, saline, 0 to 1 percent slopes	Very limited	Vallers, moderately saline (68%)	Depth to saturated zone (1.00)	29.3	20.2%
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Tonka (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cresbard (4%)	Slow water movement (1.00)		
				Sodium content (0.32)		
			Parnell (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Easby (3%)	Depth to saturated zone (1.00)		
				Salinity (1.00)		
				Sodium content (1.00)		
				Droughty (1.00)		
				Slow water movement (0.50)		
G143B	Barnes-Svea loams, 3 to 6 percent slopes	Not limited	Barnes (42%)		5.7	4.0%
			Svea (21%)			
			Buse (9%)			
			Swenoda (3%)			
G144B	Barnes-Buse loams, 3 to 6 percent slopes	Not limited	Barnes (25%)		45.5	31.3%
			Buse (24%)			

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Svea (14%)			
			Balaton (10%)			
			Langhei (4%)			
			Swenoda (3%)			
Totals for Area of Interest					145.2	100.0%

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Very limited	67.0	46.1%
Not limited	51.2	35.3%
Somewhat limited	27.0	18.6%
Totals for Area of Interest	145.2	100.0%

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

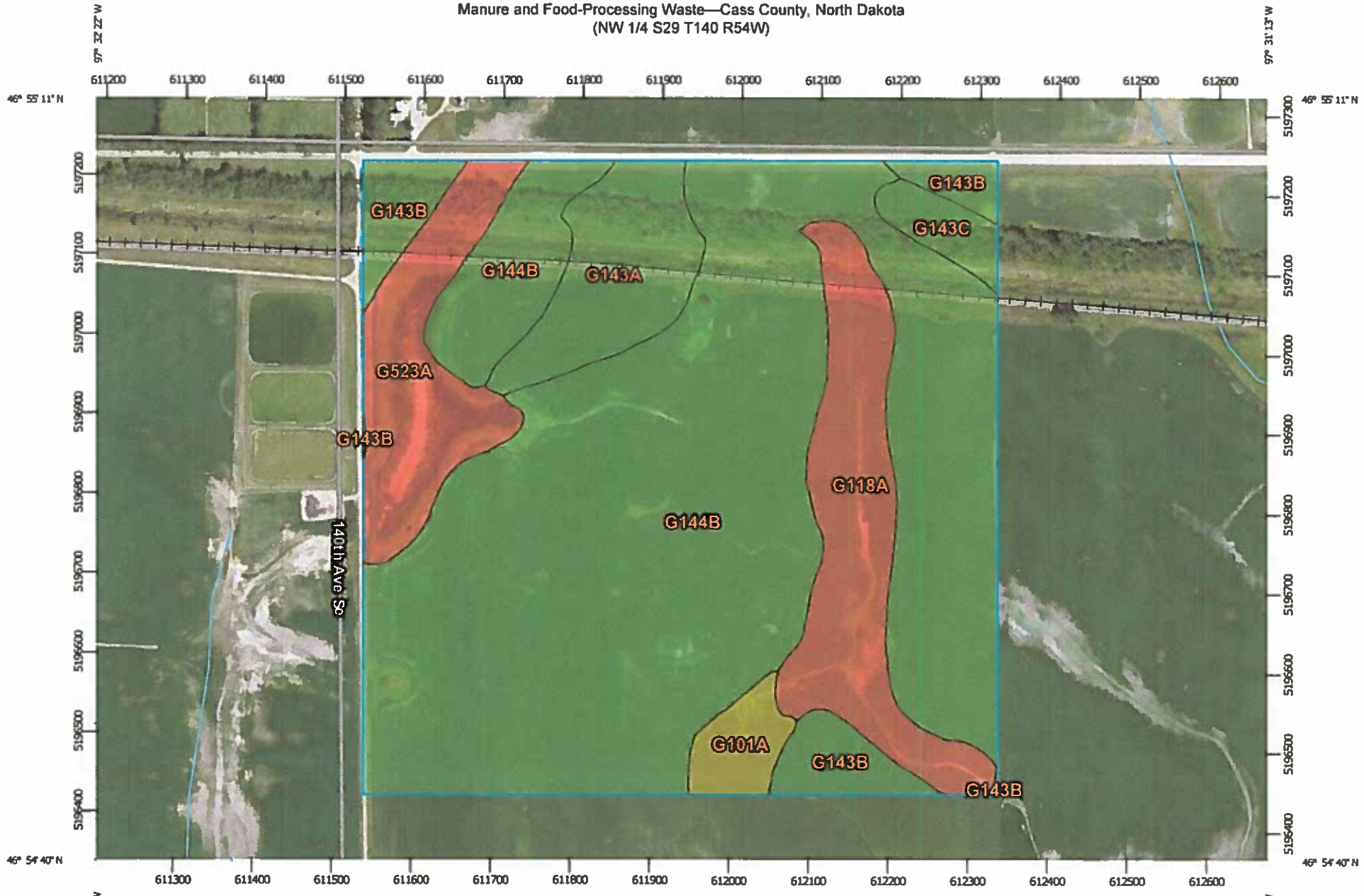
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Manure and Food-Processing Waste—Cass County, North Dakota
(NW 1/4 S29 T140 R54W)



Map Scale: 1:6,740 if printed on A landscape (11" x 8.5") sheet.

N

Meters
0 50 100 200 300

Feet
0 300 600 1200 1800

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

001298

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Background
- Aerial Photography

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

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This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cass County, North Dakota
Survey Area Data: Version 15, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Aug 27, 2010

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001299

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (46%)	Depth to saturated zone (0.86)	3.3	2.1%
			Balaton (7%)	Depth to saturated zone (0.22)		
			Hamerly, moderately saline (5%)	Depth to saturated zone (0.86)		
				Salinity (0.50)		
				Sodium content (0.18)		
G118A	Vallers loam, saline, 0 to 1 percent slopes	Very limited	Vallers, moderately saline (68%)	Depth to saturated zone (1.00)	17.1	10.9%
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Tonka (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cresbard (4%)	Slow water movement (1.00)		
				Sodium content (0.32)		
			Parnell (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Easby (3%)	Depth to saturated zone (1.00)		
				Salinity (1.00)		
				Sodium content (1.00)		
				Droughty (1.00)		
				Slow water movement (0.50)		
G143A	Barnes-Svea loams, 0 to 3 percent slopes	Not limited	Barnes (39%)		10.3	6.6%
			Svea (38%)			
			Buse (2%)			
G143B	Barnes-Svea loams, 3 to 6 percent slopes	Not limited	Barnes (42%)		8.1	5.2%
			Svea (21%)			
			Buse (9%)			
			Swenoda (3%)			
G143C	Barnes-Buse-Langhei loams, 6 to 9 percent slopes	Not limited	Barnes (24%)		2.7	1.7%
			Buse (23%)			
			Langhei (18%)			
			Svea (14%)			
			Balaton (3%)			
			Lanona (3%)			
G144B	Barnes-Buse loams, 3 to 6 percent slopes	Not limited	Barnes (25%)		103.4	65.6%
			Buse (24%)			
			Svea (14%)			
			Balaton (10%)			
			Langhei (4%)			
			Swenoda (3%)			
G523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	Very limited	Fluvaquents, channeled, frequently flooded (40%)	Ponding (1.00)	12.7	8.1%
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.90)		
			Lowe, frequently flooded (28%)	Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Lowe, moderately saline, frequently flooded (20%)	Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
				Salinity (0.50)		
				Sodium content (0.32)		
			Lowe, very poorly drained, frequently flooded (5%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
Totals for Area of Interest					157.7	100.0%

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Not limited	124.6	79.0%
Very limited	29.8	18.9%
Somewhat limited	3.3	2.1%
Totals for Area of Interest	157.7	100.0%

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

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Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Manure and Food-Processing Waste—Cass County, North Dakota
(SW 1/4 S29 T140 R54W)

Map Scale: 1:6,110 if printed on A portrait (8.5" x 11") sheet.

Meters 0 50 100 200 300

Feet 0 250 500 1000 1500

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Background
- Aerial Photography

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

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Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

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This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cass County, North Dakota
Survey Area Data: Version 15, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Aug 27, 2010

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001306

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Tonka (28%)	Slow water movement (1.00)	19.3	12.5%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Vallers, moderately saline (7%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Wyard (7%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Parnell (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cavour (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (46%)	Depth to saturated zone (0.86)	33.7	21.7%
			Balaton (7%)	Depth to saturated zone (0.22)		
			Hamerly, moderately saline (5%)	Depth to saturated zone (0.86)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Salinity (0.50)		
				Sodium content (0.18)		
G118A	Vallers loam, saline, 0 to 1 percent slopes	Very limited	Vallers, moderately saline (68%)	Depth to saturated zone (1.00)	0.2	0.1%
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Tonka (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cresbard (4%)	Slow water movement (1.00)		
				Sodium content (0.32)		
			Parnell (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Easby (3%)	Depth to saturated zone (1.00)		
				Salinity (1.00)		
				Sodium content (1.00)		
				Droughty (1.00)		
				Slow water movement (0.50)		
G143B	Barnes-Svea loams, 3 to 6 percent slopes	Not limited	Barnes (42%)		79.5	51.3%
			Svea (21%)			
			Buse (9%)			
			Swenoda (3%)			

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G143C	Barnes-Buse-Langhei loams, 6 to 9 percent slopes	Not limited	Barnes (24%)		3.1	2.0%
			Buse (23%)			
			Langhei (18%)			
			Svea (14%)			
			Balaton (3%)			
			Lanona (3%)			
G144B	Barnes-Buse loams, 3 to 6 percent slopes	Not limited	Barnes (25%)		19.2	12.4%
			Buse (24%)			
			Svea (14%)			
			Balaton (10%)			
			Langhei (4%)			
			Swenoda (3%)			
Totals for Area of Interest					155.0	100.0%

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Not limited	101.9	65.7%
Somewhat limited	33.7	21.7%
Very limited	19.5	12.6%
Totals for Area of Interest	155.0	100.0%

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

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Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

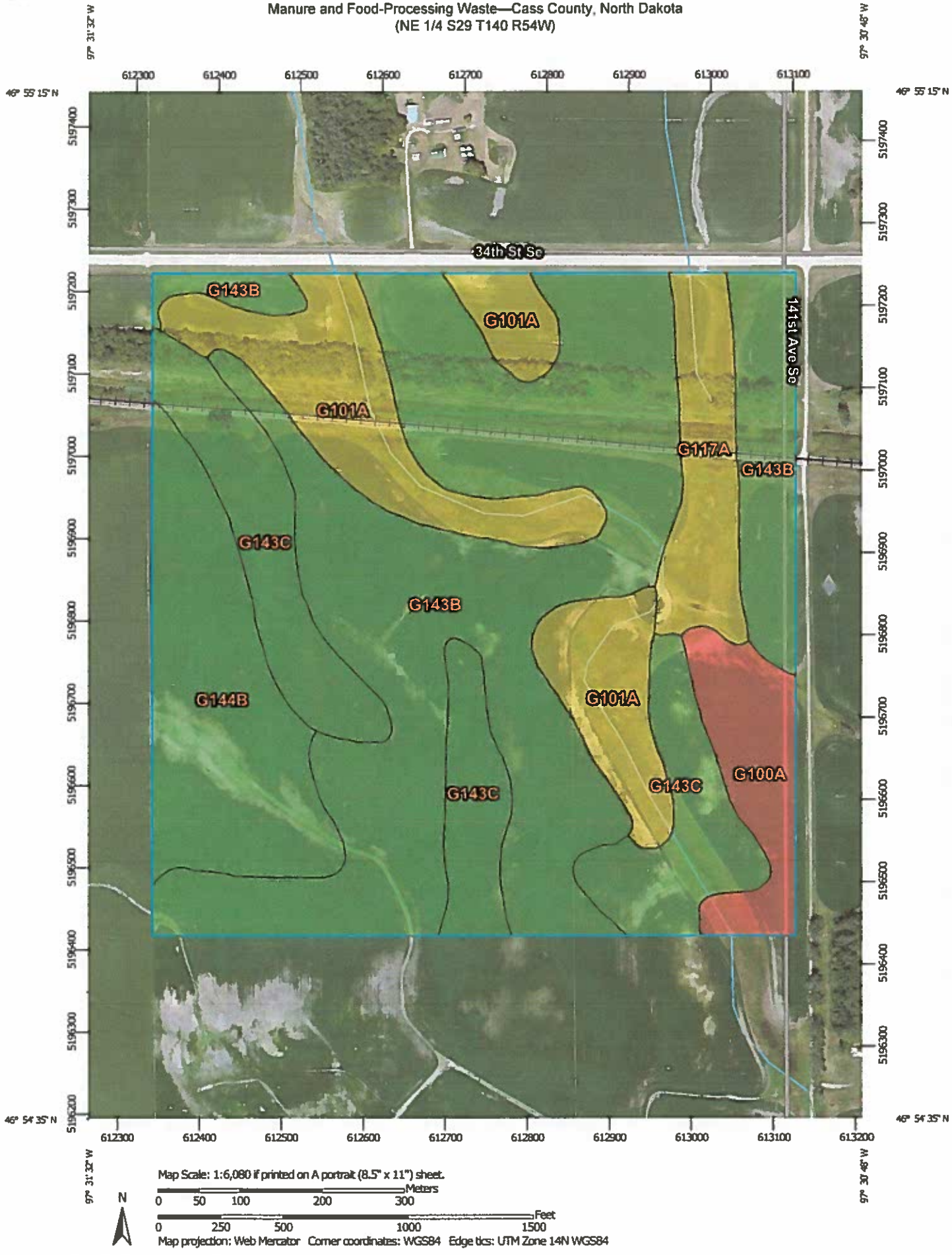
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Manure and Food-Processing Waste—Cass County, North Dakota
(NE 1/4 S29 T140 R54W)



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Background
- Aerial Photography

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cass County, North Dakota
Survey Area Data: Version 15, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Aug 27, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

001313

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Tonka (28%)	Slow water movement (1.00)	8.0	5.1%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Wyard (7%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Vallers, moderately saline (7%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cavour (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (46%)	Depth to saturated zone (0.86)	23.7	15.2%
			Balaton (7%)	Depth to saturated zone (0.22)		
			Hamerly, moderately saline (5%)	Depth to saturated zone (0.86)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Salinity (0.50)		
				Sodium content (0.18)		
G117A	Hamerly loam, saline, 0 to 3 percent slopes	Somewhat limited	Hamerly, moderately saline (55%)	Depth to saturated zone (0.86)	8.6	5.5%
				Salinity (0.50)		
				Sodium content (0.18)		
			Hamerly (8%)	Depth to saturated zone (0.86)		
			Balaton (7%)	Depth to saturated zone (0.22)		
G143B	Barnes-Svea loams, 3 to 6 percent slopes	Not limited	Barnes (42%)		71.8	45.8%
			Svea (21%)			
			Buse (9%)			
			Swenoda (3%)			
G143C	Barnes-Buse-Langhei loams, 6 to 9 percent slopes	Not limited	Barnes (24%)		25.1	16.0%
			Buse (23%)			
			Langhei (18%)			
			Svea (14%)			
			Balaton (3%)			
			Lanona (3%)			
G144B	Barnes-Buse loams, 3 to 6 percent slopes	Not limited	Barnes (25%)		19.5	12.5%
			Buse (24%)			
			Svea (14%)			
			Balaton (10%)			
			Langhei (4%)			
			Swenoda (3%)			
Totals for Area of Interest					156.7	100.0%

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Not limited	116.4	74.3%
Somewhat limited	32.3	20.6%
Very limited	8.0	5.1%
Totals for Area of Interest	156.7	100.0%

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

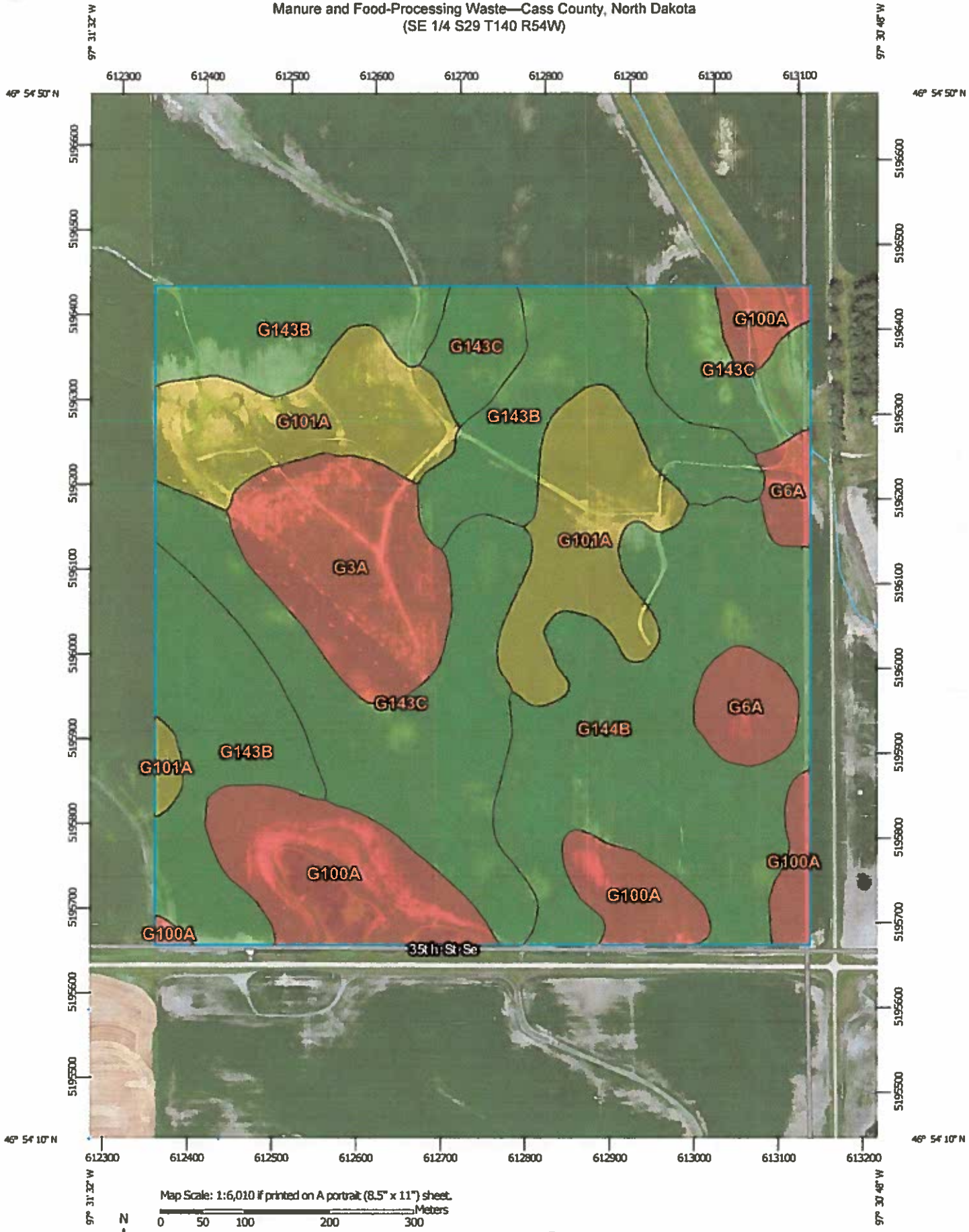
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Manure and Food-Processing Waste—Cass County, North Dakota
(SE 1/4 S29 T140 R54W)



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Background
- Aerial Photography

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

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Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cass County, North Dakota
Survey Area Data: Version 15, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Aug 27, 2010

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001319

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G3A	Parnell silty clay loam, 0 to 1 percent slopes	Very limited	Parnell (64%)	Slow water movement (1.00)	12.9	8.6%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Vallers (10%)	Depth to saturated zone (1.00)		
				Leaching (0.70)		
			Vallers, moderately saline (9%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Southam (6%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Tonka (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Ferney (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
				Salinity (0.50)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G6A	Vallers loam, 0 to 1 percent slopes	Very limited	Vallers (67%)	Depth to saturated zone (1.00)	5.1	3.4%
				Leaching (0.70)		
			Vallers, moderately saline (8%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Tonka (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Parnell (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cresbard (2%)	Slow water movement (1.00)		
				Sodium content (0.32)		
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Tonka (28%)	Slow water movement (1.00)	18.1	12.1%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Wyard (7%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Vallers, moderately saline (7%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cavour (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (46%)	Depth to saturated zone (0.86)	22.0	14.7%
			Balaton (7%)	Depth to saturated zone (0.22)		
			Hamerly, moderately saline (5%)	Depth to saturated zone (0.86)		
				Salinity (0.50)		
				Sodium content (0.18)		
G143B	Barnes-Svea loams, 3 to 6 percent slopes	Not limited	Barnes (42%)		32.5	21.7%
			Svea (21%)			
			Buse (9%)			
			Swenoda (3%)			
G143C	Barnes-Buse-Langhei loams, 6 to 9 percent slopes	Not limited	Barnes (24%)		29.7	19.9%
			Buse (23%)			
			Langhei (18%)			
			Svea (14%)			
			Balaton (3%)			
			Lanona (3%)			

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G144B	Barnes-Buse loams, 3 to 6 percent slopes	Not limited	Barnes (25%)		29.3	19.6%
			Buse (24%)			
			Svea (14%)			
			Balaton (10%)			
			Langhei (4%)			
			Swenoda (3%)			
Totals for Area of Interest					149.6	100.0%

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Not limited	91.5	61.2%
Very limited	36.1	24.1%
Somewhat limited	22.0	14.7%
Totals for Area of Interest	149.6	100.0%

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

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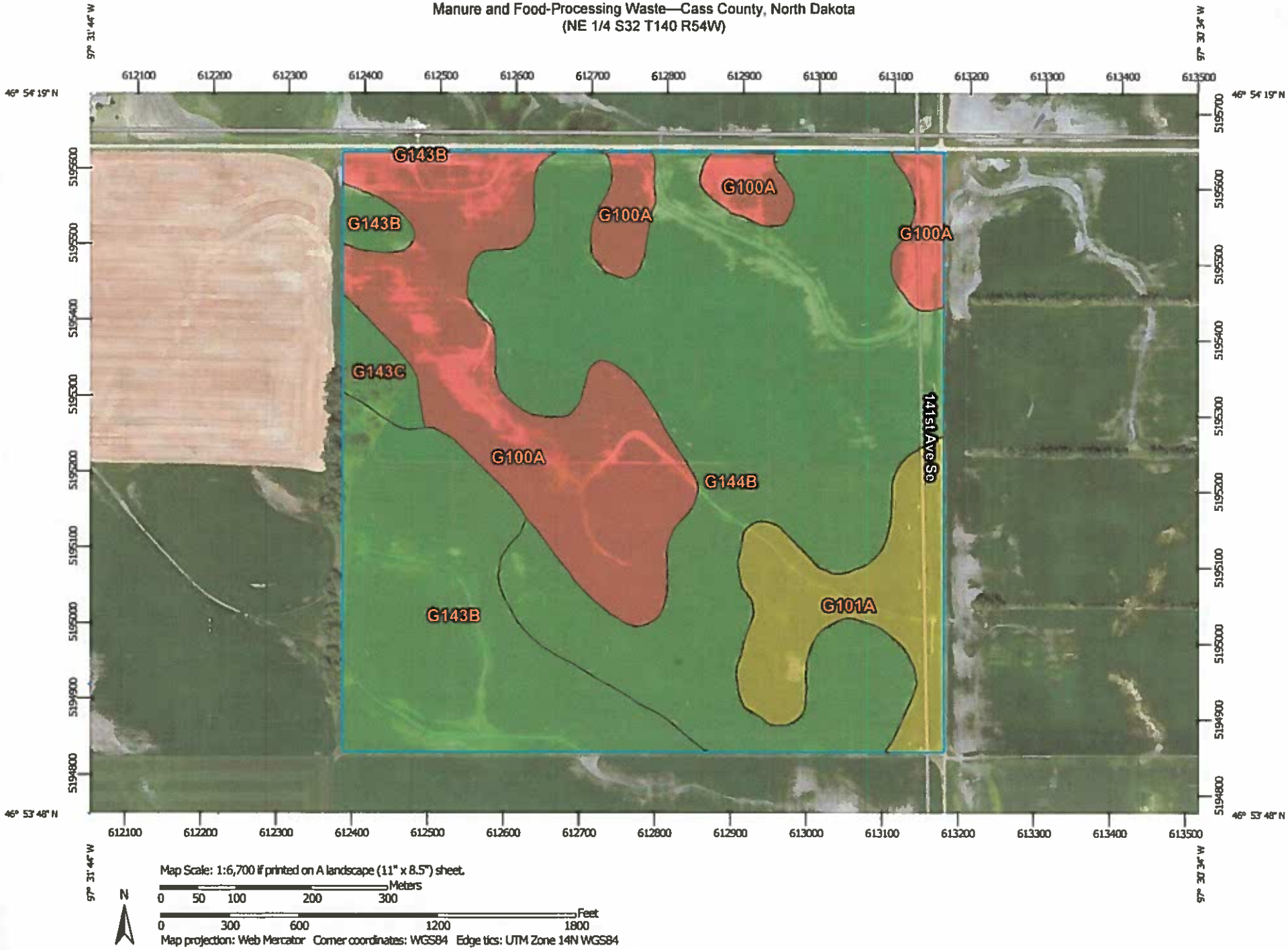
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Manure and Food-Processing Waste—Cass County, North Dakota
(NE 1/4 S32 T140 R54W)



001326

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Background
- Aerial Photography

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

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Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

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Soil Survey Area: Cass County, North Dakota
Survey Area Data: Version 15, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Aug 27, 2010

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001327

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Cass County, North Dakota (ND017)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Tonka (28%)	Slow water movement (1.00)	36.7	23.5%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Wyard (7%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Vallers, moderately saline (7%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cavour (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (46%)	Depth to saturated zone (0.86)	13.6	8.7%
			Balaton (7%)	Depth to saturated zone (0.22)		
			Hamerly, moderately saline (5%)	Depth to saturated zone (0.86)		

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

TO: North Dakota Department of Health

My name is Craig Wendt and I am part of the Concerned Citizens of Buffalo. My wife and I and our two teenage daughters live a few miles straight south of Buffalo. I am not an area farmer. I chose to live in Buffalo because it's my hometown and I prefer the country way of life. My wife and I both work in Fargo and commute. Our daughters are currently attending Maple Valley School where I graduated in 1987.

I am horrified that this out-of-state corporation can build a hog factory 3-1/2 miles from our home and spread manure on 300 acres as close as a half mile from our family. Area farmers and landowners have signed a "Mutual Agreement to Refuse Easements". This agreement states:

"Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste or manure, or (2) to install a pipeline across or upon our land."

There are a total of 46 pages of signed documents which account for 33,083 acres. The number of acres refusing easements speaks volumes. We demand that the ND Health Department denies this illegal permit.

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Gary Christensen — GARY CHRISTENSEN
Signature — Print Name

NW 1/4 - 2 - 139 - 55 — 80 Crop / 160 total
Location (Township-Section-Range) — Number of Acres

Property Owner _____ _____
Signature — Print Name

_____ _____
Location (Township-Section-Range) — Number of Acres

Property Owner _____ _____
Signature — Print Name

_____ _____
Location (Township-Section-Range) — Number of Acres

Property Owner _____ _____
Signature — Print Name

_____ _____
Location (Township-Section-Range) — Number of Acres

Property Owner _____ _____
Signature — Print Name

_____ _____
Location (Township-Section-Range) — Number of Acres

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Missy Poulson by: Brian Poulson — Signature
Missy Poulson — Print Name

138N-54W-5 — Location (Township-Section-Range)
157 ✓ — Number of Acres

Property Owner _____ — Signature
_____ — Print Name

_____ — Location (Township-Section-Range)
_____ — Number of Acres

Property Owner _____ — Signature
_____ — Print Name

_____ — Location (Township-Section-Range)
_____ — Number of Acres

Property Owner _____ — Signature
_____ — Print Name

_____ — Location (Township-Section-Range)
_____ — Number of Acres

Property Owner _____ — Signature
_____ — Print Name

_____ — Location (Township-Section-Range)
_____ — Number of Acres

157

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner William F Grieve William F Grieve
Signature Print Name

Location (Township-Section-Range) 160 Number of Acres

Property Owner Jeannine Wilcox Jeannine Wilcox
Signature Print Name

Ayr Township Section 32 NE 1/4 141N54W
Section 31 141N54W
Location (Township-Section-Range) 160 – 640 Number of Acres 960

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner _____ _____
Signature Print Name

Sec. 5 139-54 — Location (Township-Section-Range)
310 — Number of Acres

Property Owner _____ _____
Signature Print Name

Sec 6 139-54 — Location (Township-Section-Range)
160 — Number of Acres

Property Owner _____ _____
Signature Print Name

Sec 33 139-54 — Location (Township-Section-Range)
158 — Number of Acres
628

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Carol Beilke — Carol Beilke
Signature — Print Name

SE 1/4 32 140-54 — 154 ✓
Location (Township-Section-Range) — Number of Acres

Property Owner Carol Beilke — Carol Beilke
Signature — Print Name

SE 1/4 15 139-54 — 158 ✓
Location (Township-Section-Range) — Number of Acres

Property Owner Carol Beilke — Carol Beilke
Signature — Print Name

SE 1/4 2 138-54 — 158 ✓
Location (Township-Section-Range) — Number of Acres

Property Owner Kent Beilke — Kent Beilke
Signature — Print Name

SE 1/4 16 139-54 — 148 ✓
Location (Township-Section-Range) — Number of Acres

Property Owner Kent Beilke — Kent Beilke
Signature — Print Name

NE 1/4 21 139-54 — 158 ✓
Location (Township-Section-Range) — Number of Acres

776

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner LuElla VonBank LuElla Von Bank
Signature Print Name

NW ¼ of Section 5, 139-54 → Howes Township, Section 5 160 acres
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

160

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner R-Za — Ryan Zaun
Signature — Print Name

139N Howes 31 54W — 153.4 ✓
Location (Township-Section-Range) — Number of Acres
Southwest Qtr.

Property Owner _____ _____
Signature — Print Name

_____ _____
Location (Township-Section-Range) — Number of Acres

Property Owner _____ _____
Signature — Print Name

_____ _____
Location (Township-Section-Range) — Number of Acres

Property Owner _____ _____
Signature — Print Name

_____ _____
Location (Township-Section-Range) — Number of Acres

Property Owner _____ _____
Signature — Print Name

_____ _____
Location (Township-Section-Range) — Number of Acres

153.40

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

Signed:

Property Owner Diane M Reveling DIANE M. REVELING ✓
Signature Print Name

W ½ 139-54 Section 15 316
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

316

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Kent Beilke — Kent Beilke
Signature — Print Name

N 1/2 1 138-54 — 139 ✓
Location (Township-Section-Range) — Number of Acres

Property Owner Kent Beilke — Kent Beilke
Signature — Print Name

N 1/2 2 138-54 — 305 ✓
Location (Township-Section-Range) — Number of Acres

Property Owner [signature] — Keith Andersen
Signature — Print Name

Section 25, SW 1/4 139N 55W — 160 ~~147~~ ✓
Location (Township-Section-Range) — Number of Acres

Property Owner [signature] — Keith Andersen
Signature — Print Name

Section 36, NW 1/4 139N 55W — 160 ~~158~~ ✓
Location (Township-Section-Range) — Number of Acres

764

Property Owner _____ _____
Signature — Print Name

_____ _____
Location (Township-Section-Range) — Number of Acres

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Renee Fiskejon Renee Fiskejon
Signature Print Name

SW ¼ Section 20 139 N. 54 W. 160
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

160

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Lillian VonBank — Lillian VonBank
Signature — Print Name

Section 17 N ½ 139 N 54W — 320 Acres
Location (Township-Section-Range) — Number of Acres

Property Owner Debora Miller — Debora Miller
Signature — Print Name

Section 28 NE ¼ 141 N 54W — ~~320~~ 160 ✓
Location (Township-Section-Range) — Number of Acres

Property Owner Elaine Hagen — ELAINE HagEN
Signature POA Marilyn Rudell — Print Name

NW ¼ 35-140-54 — 160
Location (Township-Section-Range) — Number of Acres

Property Owner Shard Martin — Shard MarTiN
Signature POA Marilyn Rudell — Print Name

NE ¼ 35-140-54 — 160
Location (Township-Section-Range) — Number of Acres

Property Owner Donald Barnby Family Trust — MARilyN Barnby
Signature POA Marilyn Rudell — Print Name

SE ¼ 27-140-54 — 160
Location (Township-Section-Range) — Number of Acres

960

Mutual Agreement to Refuse Easements

Property Owner Bradley D Paul P.O.A for David Paul
Signature Print Name: Bradley D Paul

T-139-N Sec 35 R-55-W — 160 ✓
Location (Township-Section-Range) Number of Acres

Property Owner Bradley D Paul P.O.A. for David Paul
Signature Print Name: Bradley D Paul

T-139-N Sec34 - R-55-W — 149 ✓
Location (Township-Section-Range) Number of Acres

Property Owner Bradley D Paul P.O.A. for David Paul
Signature Print Name: Bradley D Paul

T-139-N Sec27 - R-55-W — 160 ✓
Location (Township-Section-Range) Number of Acres

Property Owner _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

001343

469

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Winston S. Mullen Winston S. Mullen
Signature Print Name

SW/4 14-140-55 160
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Marvin Ries (Signature) MARVIN N. RIES (Print Name)

139N. 54W Section 30 (Location (Township-Section-Range)) 460 (Number of Acres)

Property Owner Scott J. Hansen (Signature) Scott J. Hansen (Print Name)

Howes 32 NW ¼ (80)(80) (Location (Township-Section-Range)) 160ac ✓ (Number of Acres)

Property Owner [signature] (Signature) FRANK D. MULLEN (Print Name)

SE 14 -140 -55 (Location (Township-Section-Range)) 139 (Number of Acres)

Property Owner Scott J. Hansen (Signature) Scott J. Hansen (Print Name)

SE¼ Sec 26 139N 55W (Location (Township-Section-Range)) 150 ✓ (Number of Acres)

Property Owner Scott J. Hansen (Signature) Scott J. Hansen (Print Name)

E½ Sec 35 139N 55W (Location (Township-Section-Range)) 300 ✓ (Number of Acres)

1809

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Gretchen Martin by Peter Baasch POA Peter Baasch
Signature Print Name

Tow NW 1/4 35 140 - 55 80
Location (Township-Section-Range) Number of Acres

Property Owner William Fraase II by Peter Baasch POA Peter Baasch
Signature Print Name

SE 1/4 35 140-55 160
Location (Township-Section-Range) Number of Acres

Property Owner William Fraase by Peter Baasch POA Peter Baasch
Signature Print Name

SW 1/4 35 140-55 160
Location (Township-Section-Range) Number of Acres

Property Owner Scott J. Hansen Scott J. Hansen
Signature Print Name

SW 1/4 Sec 36 139 N 55 W 155 ✓
Location (Township-Section-Range) Number of Acres

555

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Mutual Agreement to Refuse Easements

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SIGNED:

Property Owner _____ Mary K Kruske
Signature Print Name

140N 54W Sec 18 SE 1/4 — 160
Location (Township-Section-Range) Number of Acres

Property Owner _____ Robert A. Pierce
Signature Print Name

139N 54W Sec 12 — 27.65
Location (Township-Section-Range) Number of Acres

Property Owner _____ MARIAN KASOWSKI
Signature Print Name

140 N-54 W Section 32-SW 1/4
140N-54W section 31-SE 1/4 — 120
Location (Township-Section-Range) Number of Acres

Property Owner _____ Betty M. Fraese
Signature Print Name

139N 54W Sect 14 West half
139N 54W Sect 10 N 1/2 half — 640
Location (Township-Section-Range) Number of Acres

Property Owner _____ Corey + Kristi Hovelson
Signature Print Name

139-55 section 4 — 273
Location (Township-Section-Range) Number of Acres

12 20.65

Mutual Agreement to Refuse Easements

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SIGNED:

Property Owner Paul Kasowski — Paul Kasowski
Signature — Print Name

17 NW 40 of NW¼ 140N-53W — 40
Location (Township-Section-Range) — Number of Acres

Property Owner Paul Kasowski — Paul Kasowski
Signature — Print Name

Sec 35 SE 10a SE¼ 140N 54W — 107
Location (Township-Section-Range) — Number of Acres

Property Owner Heidi Baasch — Heidi Baasch
Signature — Print Name

140 N 54W Sec 31 NW Corner — 18
Location (Township-Section-Range) — Number of Acres

Property Owner Randy Kasowski — Randy Kasowski
Signature — Print Name

NE¼ Sec 15 B. Hills 140-54 — 160
Location (Township-Section-Range) — Number of Acres

Property Owner Randy Kasowski — Randy Kasowski
Signature — Print Name

NW NE, & SE¼ Sec. 1 B. Hills 140-54 — 480
Location (Township-Section-Range) — Number of Acres

80

Mutual Agreement to Refuse Easements

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SIGNED:

Property Owner Cheryl Hager — Cheryl Hager
Signature — Print Name

Sec 19 SE quarter 1/4 139 N 54 W — 160
Location (Township-Section-Range) — Number of Acres

Property Owner [signature] — Paul Kasowski
Signature — Print Name

15 SE ¼ 140 N 54W — 160
Location (Township-Section-Range) — Number of Acres

Property Owner [signature] — Paul Kasowski
Signature — Print Name

16 SW ¼ 140 N 54 W — 160
Location (Township-Section-Range) — Number of Acres

Property Owner [signature] — Paul Kasowski
Signature — Print Name

17 SE ¼ 140 N 54W — 160
Location (Township-Section-Range) — Number of Acres

Property Owner [signature] — Paul Kasowski
Signature — Print Name

20 SW ¼ 140 N 53 W — 160
Location (Township-Section-Range) — Number of Acres

80

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner [signature] Harvey L. Coon
Signature Print Name

NE ¼ - 1 - 139 - 55 160
Location (Township-Section-Range) Number of Acres

Property Owner [signature] Harvey L. Coon
Signature Print Name

SE ¼ - 1 - 139 - 55 160
Location (Township-Section-Range) Number of Acres

Property Owner [signature] Richard Smith
Signature Print Name

Sec 22 SW¼
Sec 34 W½ 27 N½ (139-54) 800
Location (Township-Section-Range) Number of Acres

Property Owner [signature] Cecil P Von Bank
Signature Print Name

139 N - 55 W 25 S½ SE ¼ 80
Location (Township-Section-Range) Number of Acres

Property Owner [signature] Janice Diemert
Signature Print Name

Sec 17 NE ¼ 140 N 55 W
Sec 8 SE ¼ 140 N 55 W 320
Location (Township-Section-Range) Number of Acres

(640)

Mutual Agreement to Refuse Easements

Cornell

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Cathy Ernie By Consent CATHY ERNIE
Signature Print Name

NW¼ Sec 30 - 140N-54 42
Location (Township-Section-Range) Number of Acres

Property Owner Edie Nelson By Consent Edie Nelson
Signature Print Name

NW¼ Sec. 30 140N-54 48
Location (Township-Section-Range) Number of Acres

Property Owner
Signature Justin Killam
Print Name

Section 24 S½ 141-55 300
Location (Township-Section-Range) Number of Acres

Property Owner
Signature Justin Killam
Print Name

Buffalo Sec 18+17 140W-54 300
Location (Township-Section-Range) Number of Acres

Property Owner
Signature Justin Killam
Print Name

Buffalo Sec 8 SE¼ 140-54 150
Location (Township-Section-Range) Number of Acres

240

Mutual Agreement to Refuse Easements Cornell

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner [signature] Richard Smith
Signature Print Name

NE¼ Sec 20 (141-55) 160
Location (Township-Section-Range) Number of Acres

Property Owner Judith Von Bank Judith Von Bank
Signature Print Name

Sec 22 SE¼ 141 N 55W 160
Location (Township-Section-Range) Number of Acres

Property Owner Casey Marcks Casey Marcks
Signature Print Name

SE¼ 30 140N 54 155.7
Location (Township-Section-Range) Number of Acres

Property Owner Casey Marcks Casey Marcks
Signature Print Name

NE¼ Sec. 30 140N-54 44
Location (Township-Section-Range) Number of Acres

Property Owner Rodney Marcks By Casey Marcks Rodney Marcks
Signature Print Name

NE¼ Sec. 30 - 140N-54 74
Location (Township-Section-Range) Number of Acres

393.7

001352

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Judith Von Bank — Judith Von Bank
Signature — Print Name

NE ¼ section 6 139 54R — 160
Location (Township-Section-Range) — Number of Acres

Property Owner Randy Coon — Randy Coon
Signature — Print Name

SW¼ - 6 - 139 - 54 — 160
Location (Township-Section-Range) — Number of Acres

Property Owner Randy Coon — Randy Coon
Signature — Print Name

SW¼ - 36 - 140 - 55 — 160
Location (Township-Section-Range) — Number of Acres

Property Owner Randy Coon — Randy Coon
Signature — Print Name

NW¼ - 1 - 139 - 55 — 160
Location (Township-Section-Range) — Number of Acres

Property Owner Marlyn Nudell — MARLYN NUDELL
Signature — Print Name

NW¼ - 26 - 140 - 54
SW¼ - 34 - 140 - 54 — 280
Location (Township-Section-Range) — Number of Acres

920

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Lana F Rakow — Signature

Lana F. Rakow — Print Name

Section 14, NW 1/4, 47 A mWest, 139N, 55W — Location (Township-Section-Range)

47.37 — Number of Acres

Property Owner Jeff Zaun — Signature

Jeff Zaun — Print Name

SW1/4 Sec 2-139-35 — Location (Township-Section-Range)

160.00 — Number of Acres

Property Owner Jeff Zaun — Signature

Jeff Zaun — Print Name

E1/2 Sec 10-139-55 — Location (Township-Section-Range)

320.00 — Number of Acres

Property Owner Jeff Zaun — Signature

Jeff Zaun — Print Name

NW1/4 Sec 11-139-55 — Location (Township-Section-Range)

160 — Number of Acres

Property Owner Jeff Zaun — Signature

Jeff Zaun — Print Name

NW1/4 Sec 14-139-55 — Location (Township-Section-Range)

100 — Number of Acres

987.37

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Gerald D. Marcks — GERALD D. MARCKS
Signature — Print Name

NE ¼ - 31 - 140 - 54 — 160
Location (Township-Section-Range) — Number of Acres

Property Owner Gerald Marcks / x Jacqueline L Marcks — GERALD MARCKS / JACQUELINE MARCKS
Signature — Print Name

N½ of NW¼ 32-140-54 — 80
Location (Township-Section-Range) — Number of Acres

Property Owner x Jacqueline K. Marcks — JACQUELINE MARCKS
Signature — Print Name

SW¼ 28-140-54 — 155.98
Location (Township-Section-Range) — Number of Acres

Property Owner x Jacqueline L. Marcks — JACQUELINE MARCKS
Signature — Print Name

SW¼ - 4 - 139 - 54 — 160
Location (Township-Section-Range) — Number of Acres

Property Owner Jayne Robinson — JAYNE ROBINSON
Signature — By Gerald Marcks Print Name P.O.A.

S½ of NW¼ - 32-140-50 — 80
Location (Township-Section-Range) — Number of Acres

635.98

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner [signature] Signature — Larry Zaun Print Name

Sec 31 - E½ of SE¼ - 140-54 Location (Township-Section-Range) — 80 Number of Acres

Property Owner [signature] Signature — Larry Zaun Print Name

Sec 32 - SW¼ - 140-54 Location (Township-Section-Range) — 80 Number of Acres

Property Owner [signature] Signature — Larry Zaun Print Name

34 - NE¼ - 140-55 Location (Township-Section-Range) — 56 Number of Acres

Property Owner Good Hope Farms by [signature] Signature — Larry Zaun Print Name

SE¼ - 2 - 139-55 — 140

NE¼ - 11 - 139-55 Location (Township-Section-Range) — 140 Number of Acres

Property Owner Good Hope Farms by [signature] Signature — Larry Zaun Print Name

W½ - 13 - 139-55 — 320

NW¼ - 24 - 139-55 Location (Township-Section-Range) — 160 Number of Acres

S½ - NE¼ - 23 - 139-55 — 80

SE¼ - 23 - 139-55 — 160

1216

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Kell Boyd (Signature) — Kelly Boyd (Print Name)

Buffalo 20 140 54 SW Qu. (Location (Township-Section-Range)) — 137.5 (Number of Acres)

Property Owner Kell Boyd (Signature) — Kelly Boyd (Print Name)

~~Buffalo~~ Tower 13 140 55 E½ (Location (Township-Section-Range)) — 140.7 (Number of Acres)

Property Owner Kell Boyd (Signature) — Kelly Boyd (Print Name)

Tower 23 140 55 [redacted] (Location (Township-Section-Range)) — 539.7 (Number of Acres)

Property Owner Kalvin C Boyd Kell Boyd (Signature) — Kalvin Boyd Kelly Boyd (Print Name)

Ayr 33 141 54 NE (Location (Township-Section-Range)) — 161.1 (Number of Acres)

Property Owner Kalvin C Boyd (Signature) — Kalvin Boyd (Print Name)

Ayr 34 141 54 NE (Location (Township-Section-Range)) — 144.1 (Number of Acres)

1183.1

Mutual Agreement to Refuse Easements

Property Owner Lorrie Smith / Lueil Morse — LORRIE SMITH / LUEIL MORSE

Signature By Gerald Marsh POA. — Print Name

SW¼ - 30 - 140 - 54 — Location (Township-Section-Range)

160 — Number of Acres

Property Owner Barbara Phillips ETAL — BARBARA PHILLIPS

Signature Gerald Marsh POA — Print Name

SE¼ - 33 - 140 - 54 — Location (Township-Section-Range)

160 — Number of Acres

320

Property Owner _____ — _____

Signature — Print Name

_____ — Location (Township-Section-Range)

_____ — Number of Acres

Property Owner _____ — _____

Signature — Print Name

_____ — Location (Township-Section-Range)

_____ — Number of Acres

Property Owner _____ — _____

Signature — Print Name

_____ — Location (Township-Section-Range)

_____ — Number of Acres

Property Owner _____ — _____

Signature — Print Name

_____ — Location (Township-Section-Range)

_____ — Number of Acres

Mutual Agreement to Refuse Easements

Property Owner Lorrie Smith / Lucil Morse — LORRIE SMITH / LUCIL MORSE

Signature By Gerald Marsh POA. — Print Name

SW¼ - 30 - 140 - 54 — Location (Township-Section-Range)

160 — Number of Acres

Property Owner Barbara Phillips ETAL — BARBARA PHILLIPS

Signature Gerald Marsh POA — Print Name

SE¼ - 33 - 140 - 54 — Location (Township-Section-Range)

160 — Number of Acres

320

Property Owner _____ _____

Signature — Print Name

_____ _____

Location (Township-Section-Range) — Number of Acres

Property Owner _____ _____

Signature — Print Name

_____ _____

Location (Township-Section-Range) — Number of Acres

Property Owner _____ _____

Signature — Print Name

_____ _____

Location (Township-Section-Range) — Number of Acres

Property Owner _____ _____

Signature — Print Name

_____ _____

Location (Township-Section-Range) — Number of Acres

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Ron K. Fraase — RON K. FRAASE
Signature — Print Name

NE 1/4 5-139-54 — 160
Location (Township-Section-Range) — Number of Acres

Property Owner Ron K. Fraase — RON K. FRAASE
Signature — Print Name

E 1/2 3-139-54 — 320
Location (Township-Section-Range) — Number of Acres

Property Owner Ron K. Fraase — RON K. FRAASE
Signature — Print Name

S 1/2 2-139-54 — 320
Location (Township-Section-Range) — Number of Acres

Property Owner Ron K. Fraase — RON K. FRAASE
Signature — Print Name

NE 1/4 2-139-54 — 160
Location (Township-Section-Range) — Number of Acres

960

Property Owner _____ — _____
Signature — Print Name

_____ — _____
Location (Township-Section-Range) — Number of Acres

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Dan Sheldon — DAN SHELDON
Signature — Print Name

Section 25 W½ 140N 54W — 107
Location (Township-Section-Range) — Number of Acres

Property Owner Agnetha Frueh — Agnetha Frueh
Signature — Print Name

Section 8 NW 10 acres of NW ¼ — 10.3
Location (Township-Section-Range) — Number of Acres
139N 54W

Property Owner Wendy Ruppke — Wendy Ruppke
Signature — Print Name

NE, SE Qtr Section 4
Sec 4, [illegible], N Buffalo 140 54 — 20
Location (Township-Section-Range) — Number of Acres

Property Owner Renee Wilm — Renee Wilm
Signature — Print Name

139N 54 Sec. 26 NE¼ — 10
Location (Township-Section-Range) — Number of Acres

Property Owner Deborah Miller — Deborah Miller
Signature — Print Name

Sec. 26 NW¼ 139N 55W — 160
Location (Township-Section-Range) — Number of Acres

307.3

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Brian Buehr — BRIAN BUEHR
Signature — Print Name

NW1/4 Sec 20-139-54 Howes — 160
Location (Township-Section-Range) — Number of Acres

Property Owner Brian Buehr — BRIAN BUEHR
Signature — Print Name

S1/2 of the NW1/4 Sec. 6-139-54 Howes — 75
Location (Township-Section-Range) — Number of Acres

Property Owner Brian Buehr — BRIAN BUEHR
Signature — Print Name

SE1/4 Sec 15-141-54 Ayr — 160 ✓
Location (Township-Section-Range) — Number of Acres

Property Owner Brian Buehr — BRIAN BUEHR
Signature — Print Name

S1/2 of the NE1/4 19-141-54 Ayr — 80 ✓
Location (Township-Section-Range) — Number of Acres

Property Owner Brian Buehr — BRIAN BUEHR
Signature — Print Name

(475)

Location (Township-Section-Range) — Number of Acres

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Debora Miller — Debora Miller
Signature — Print Name

E1/2 18-139-54 — 320 acres ✓
Location (Township-Section-Range) — Number of Acres

Property Owner Debora Miller — Debora Miller
Signature — Print Name

N1/2 19-139-54 — 320 acres ✓
Location (Township-Section-Range) — Number of Acres

Property Owner Debora Miller — Debora Miller
Signature — Print Name

E1/2 17-139-55 — 320 acres ✓
Location (Township-Section-Range) — Number of Acres

Property Owner Debora Miller — Debora Miller
Signature — Print Name

E1/2 13-139-55 — 320 acres ✓
Location (Township-Section-Range) — Number of Acres

Property Owner Debora Miller — Debora Miller
Signature — Print Name

N1/2 S~~E~~1/4 11-139-55 — 80 ✓
Location (Township-Section-Range) — Number of Acres

1360

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Debora Miller — Debora Miller
Signature — Print Name

SW¼ 23-139-55 — 160 ✓
Location (Township-Section-Range) — Number of Acres

Property Owner — Craig A. Wendt
Signature — Print Name

E½ 21-139-55 — 320
Location (Township-Section-Range) — Number of Acres

Property Owner — Craig A. Wendt
Signature — Print Name

E½ 28-139-55 — 320
Location (Township-Section-Range) — Number of Acres

Property Owner — Craig A. Wendt
Signature — Print Name

S½ 29-139-55 — 320
Location (Township-Section-Range) — Number of Acres

Property Owner — Craig A. Wendt
Signature — Print Name

Section 8 E½ NW¼ 140 N 55W — 80
Location (Township-Section-Range) — Number of Acres

1200

Mutual Agreement to Refuse Easements

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SIGNED:

Property Owner William L Jahraus William L Jahraus
Signature Print Name

SW 1/4 sec 35 Buffalo township 140 54 160
Location (Township-Section-Range) Number of Acres

Property Owner Debora Miller Debora Miller
Signature Print Name

NE 1/4 24-139-55 118
Location (Township-Section-Range) Number of Acres

278

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Kim Walter Jahraus KIM WALTER JAHRAUS
Signature Print Name

MARCH 6, 2016

SE 1/4 SECTION 35, BUFFALO TOWNSHIP 140 NORTH, RANGE 54 — 160
Location (Township-Section-Range) Number of Acres

SAME

Property Owner Yolonda Jane Jahraus YOLONDA JANE JAHRAUS
Signature Print Name

3-6-16

SE 1/4 SECTION 35, BUFFALO TOWNSHIP 140 NORTH, RANGE 54 — 160
Location (Township-Section-Range) Number of Acres

160

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Owen Broadshaug by Pete Baas POA — Peter Baasch
Signature — Print Name

Tower 26 140 55 — 640
Location (Township-Section-Range) — Number of Acres

Property Owner Owen Broadshaug by Pete Baas POA — Peter Baasch
Signature — Print Name

Tower 25 S 1/2 140 55 — 320
Location (Township-Section-Range) — Number of Acres

Property Owner Owen Broadshaug by Pete Baas POA — Peter Baasch
Signature — Print Name

Tower 23 140-55 — 59 Acres
Location (Township-Section-Range) — Number of Acres

Property Owner Pete Baas — Peter Baasch
Signature — Print Name

Tower 35 NE 1/4 140-55 — 160
Location (Township-Section-Range) — Number of Acres

Property Owner Antionette & William Babcock by Pete Baas POA — Peter Baasch
Signature — Print Name

Tower NW 1/4 35 140-55 — 80
Location (Township-Section-Range) — Number of Acres

1259

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner _____ Peter Baasch
Signature — Print Name

Buffalo 31 W 1/2 31 140 N 5 W — 280
Location (Township-Section-Range) — Number of Acres

Property Owner _____ Peter Baasch
Signature — Print Name

Howes S 1/2 10 139 N 5 W — 300
Location (Township-Section-Range) — Number of Acres

Property Owner _____ Peter Baasch
Signature — Print Name

Howes SW 1/4 11 139 N 5 W — 160
Location (Township-Section-Range) — Number of Acres

Property Owner Marilyn Thompson by Peter Baasch POA Peter Baasch
Signature — Print Name

Howes SE 1/4 21 & NE 1/4 28 139 N 5 W — 320
Location (Township-Section-Range) — Number of Acres

Property Owner Mark Evans by Peter Baasch POA Peter Baasch
Signature — Print Name

Howes West 1/2 33 139 N 5 W — 320
Location (Township-Section-Range) — Number of Acres

1380

Mutual Agreement to Refuse Easements

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SIGNED:

Property Owner Gretchen Martin by Peter Baun POA Peter Baasch
Signature Print Name

Bosier NE 1/4 3 Hill 139 55 W — 80
Location (Township-Section-Range) Number of Acres

Property Owner Antionette and William Dubrock by Peter Baun POA Peter Baasch
Signature Print Name

Bosier WE 3 1/4 Hill 139 55 W — 80
Location (Township-Section-Range) Number of Acres

Property Owner Cynthia Waugh by Peter Baun POA Peter Baasch
Signature Print Name

Bosier SE 1/4 3 Hill 139 55 W — 154
Location (Township-Section-Range) Number of Acres

Property Owner Peter Baun ~~SW 1/4 21 Hill 139 55~~ Peter Baasch
Signature Print Name

SW 1/4 21 Hill 139 55W — 160
Location (Township-Section-Range) Number of Acres

Property Owner Peter Baun Peter Baasch
Signature Print Name

NE 1/4 33 Hill 139 55W — 130
NW Location (Township-Section-Range) Number of Acres

604

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Alan + Kim Webster (Signature) Alan + Kim Webster (Print Name)

Sec. 8 N ½ 139 N 54W (Location (Township-Section-Range)) 275.10 (Number of Acres)

Property Owner Brenda Nygard (Signature) Brenda Nygard (Print Name)

Sec 28 NW ¼ 139N 54W (Location (Township-Section-Range)) 160 (Number of Acres)

Property Owner Brenda Nygard (Signature) Brenda Nygard (Print Name)

Sec 26 E ½ 139N 54W (Location (Township-Section-Range)) 180 (Number of Acres)

Property Owner Brenda Nygard (Signature) Brenda Nygard (Print Name)

Sec 25 NW ¼ 139W 54W (Location (Township-Section-Range)) 160 (Number of Acres)

Property Owner Naomi Mougey (Signature) Naomi Mougey (Print Name)

Section 28 SW ¼ 139W 54W (Location (Township-Section-Range)) 160 (Number of Acres)

935.1

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Bradley D Paul — Bradley D Paul
Signature — Print Name

T-139-N Sec 16 R-55-W — 80
Location (Township-Section-Range) — Number of Acres

Property Owner Bradley D Paul — Bradley D Paul
Signature — Print Name

T-139-N Sec 26 - R-55-W — 80
Location (Township-Section-Range) — Number of Acres

Property Owner Bradley D Paul — Bradley D Paul
Signature — Print Name

T-139-N Sec 27 - R-55 W — 11
Location (Township-Section-Range) — Number of Acres

Property Owner _____
Signature — Print Name

_____ — _____
Location (Township-Section-Range) — Number of Acres

001371

17

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Gregory M. Sproul _____ Gregory M. Sproul
Signature Print Name

Property Owner Robin M. Sproul _____ Robin M. Sproul
3-8-2016 Signature Print Name

19 140N 054W — 454.2
Location (Township-Section-Range) Number of Acres

Property Owner Gregory M. Sproul _____ Gregory M. Sproul
Signature Print Name

Property Owner Robin M. Sproul _____ Robin M. Sproul
3-8-2016 Signature Print Name

24 140N 055W — 303.9
Location (Township-Section-Range) Number of Acres

Property Owner Gregory M. Sproul _____ Gregory M. Sproul
Signature Print Name

Property Owner Robin M. Sproul _____ Robin M. Sproul
3-8-2016 Signature Print Name

8 140N 054W — 135.6
Location (Township-Section-Range) Number of Acres

Property Owner Gregory M. Sproul _____ Gregory M. Sproul
Signature Print Name

Property Owner Robin M. Sproul _____ Robin M. Sproul
3-8-2016 Signature Print Name

18 140N 054W — 139.9
Location (Township-Section-Range) Number of Acres

1033.6

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Lee K Fraase — LEE K. FRAASE
Signature — Print Name

W½ sec. 3 139-54 — 320
Location (Township-Section-Range) — Number of Acres

Property Owner Lee K Fraase — LEE K. FRAASE
Signature — Print Name

NW¼ sec. 2 139-54 — 160
Location (Township-Section-Range) — Number of Acres

Property Owner Lee K Fraase — LEE K. FRAASE
Signature — Print Name

SE¼ sec. 34 140-54 — 160
Location (Township-Section-Range) — Number of Acres

Property Owner Lee K Fraase — LEE K. FRAASE
Signature — Print Name

SW¼ sec. 36 140-54 — 160
Location (Township-Section-Range) — Number of Acres

Property Owner Dale Zaun — Dale Zaun
Signature — Print Name

Section 34 SE¼ 139N 55W — 160
Location (Township-Section-Range) — Number of Acres

960

Mutual Agreement to Refuse Easements

Property Owner _____ _____
Signature Print Name

W½ of SE¼ Sec. 6 Whitehall 140-53 — 400
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

N½ Sec 17 less west 40 — 280
Location (Township-Section-Range) Number of Acres
Whitehall Twp 140-53

Property Owner Larry Zaun — Larry Zaun
Signature Print Name

E80 - NW¼ - 30-139-54 — 80
Location (Township-Section-Range) Number of Acres

Property Owner Penny Zaun by Larry Zaun — Larry Zaun
Signature Print Name

NW¼ - 31-139-54 — 160
Location (Township-Section-Range) Number of Acres

Property Owner _____ THOMAS Torgensen
Signature Print Name

Section 32 NW¼ 139N 55W — 160
Location (Township-Section-Range) Number of Acres

Property Owner _____ Thomas Torgensen
Signature Print Name

Section 30 SE¼ 139N 55W — 160
Location (Township-Section-Range) Number of Acres

1240

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Brent Buhr — Signature — Brent Buhr — Print Name

SW 1/4 Sec 32-141-54 Ayr — Location (Township-Section-Range) — 150 ✓ — Number of Acres

Property Owner Brent Buhr — Signature — Brent Buhr — Print Name

NE 1/4 Sec 20-141-54 Ayr — Location (Township-Section-Range) — 160 ✓ — Number of Acres

Property Owner Brent Buhr — Signature — Brent Buhr — Print Name

SW 1/4 Sec 15-141-54 Ayr — Location (Township-Section-Range) — 160 ✓ — Number of Acres

Property Owner Brent Buhr — Signature — Brent Buhr — Print Name

N 1/2 of the NE 1/4 19-141-54 Ayr — Location (Township-Section-Range) — 80 ✓ — Number of Acres

Property Owner Brent Buhr — Signature — Brent Buhr — Print Name

N 1/2 of the NW 1/4 6-139-54 Howes — Location (Township-Section-Range) — 75 — Number of Acres

625

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Darrell Holm — Darrell Holm
Signature — Print Name

Section 25, ½ of NE¼ 139N 55W — 80 A. ✓
Location (Township-Section-Range) — Number of Acres

Property Owner Alfred J. Van Beek — ALFRED VAN BEEK
Signature — Print Name

Section 19 ½ SW¼ 139N 54W — 80 A ✓
Location (Township-Section-Range) — Number of Acres

Property Owner _____ — _____
Signature — Print Name

_____ — _____
Location (Township-Section-Range) — Number of Acres

160

Property Owner _____ — _____
Signature — Print Name

_____ — _____
Location (Township-Section-Range) — Number of Acres

Property Owner _____ — _____
Signature — Print Name

_____ — _____
Location (Township-Section-Range) — Number of Acres

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner _____, Trustee — Camille Schaetzel, Trustee

Signature — Print Name

SW ¼ -1-139-55 — 160

Location (Township-Section-Range) — Number of Acres

Property Owner (County) _____ — _____

Signature — Print Name

NE ¼ -15-139-55 — 160

Location (Township-Section-Range) — Number of Acres

Property Owner (Paul) _____ — _____

Signature — Print Name

W ½ -18-139-54 — 320

Location (Township-Section-Range) — Number of Acres

Property Owner _____ — _____

Signature — Print Name

_____ — _____

Location (Township-Section-Range) — Number of Acres

640

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner_____ _____
Signature Print Name

SW ¼ -1-139-55 160
Location (Township-Section-Range) Number of Acres

Property Owner_____ _____
Signature Print Name

NE ¼ -15-139-55 160
Location (Township-Section-Range) Number of Acres

Property Owner_____ Paul R Schaefer
Signature Print Name

W ½ -18-139-54 320
Location (Township-Section-Range) Number of Acres

Property Owner_____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

4. Water Quality Report

Opening Statement

My concern is the elevation drop, water runoff, and soil contamination and how it will affect our farm. Not only are we downwind but we are also downstream!

Southeast Drainage

The elevation at the proposed site is 1142'. Because of the water table, the bottom of the 8.6 Mgal pit is at the proposed elevation of 1139'. The elevation in the SE corner of this field is 1130'. So there is a 12' drop in this 1/2 mile and that means the field next to the county road is 9' lower than the bottom of this huge pit. Yes, they plan to build a dike around the site but dikes can break. Or worse yet the huge Enviropork farrowing facility at Larimore ND in June 2000, experienced over 20" of rain in 24 hours and in order to keep the pressure off of the dikes, they were forced to pump the manure over the dikes onto the adjacent fields and eventually running into the river. (Photo #1)

If a leak would happen most of it would be coming down I-94 ditches by our farm and down through Lake Agassiz 's second beach line and settling in the flat shore bed of Lake Agassiz. This elevation is 1079'. That's a 63' drop in these 2 1/4 miles. (Photo #2)

This map shows how the water flows SE from the proposed site (see the darker colors, means higher elevation, it does not go south a shallow containment pond is planned to catch runoff water from the site and also drain tile will be placed under and around pits to collect any dirty water which may escape from the pits and pumped into this pond. Where will this water go when the pond is full? There could be times that the pond could be being pumped out 24 -7. My first concern is how Jerry Marcks (who is the first downstream neighbor) will get to the NE corner of his quarter to farm it, plus what will this contaminated overflow water do to his land and my land further downstream. (Photo #3)

This map is more detailed on where the ditches actually go. Water runs downhill, just ask Fargo. If you look close, this small ditch comes from Jerry Marcks SW 1/4 of, and comes into the highway ditch just east of this I-94 culvert. More interesting the main ditch from the proposed site comes into the highway ditch 133' east of this ramp culvert (which is downhill of the culvert). So all of the proposed site water moves quickly to the east and collects

along the county road flowing eastbound, not southbound, like the permit application claimed. (Photo #4)

Air plane photo next. (Photo #5 – Photo #6, not used)

As the water goes east (in between our service road and the north highway ditch) there are 4 culverts and three small dams here that help divert the water to the south highway ditch, but we still get some of this water by our two farm houses and farmyard. When I 94 went through in the fifties they would not move the houses instead they jogged the right of way. So water seepage in these basements has been a problem since then because of the narrow right of way ditch. Now being this water could be contaminated, this is even more of an issue. The water then continues east, dropping over the old Lake Agassiz beachline and settling in to the very flat Lake Agassiz shore bed. This shore bed drops less than 1' per mile as it heads south to the Buffalo Creek. (Photo #7)

This map shows the very flat Lake Agassiz shore bed in our pasture, which contains some wetlands and our stock pond. (Photo #8)

This same flat Lake Agassiz shore bed continues south with very little elevation change and more wetlands. (Photo #9)

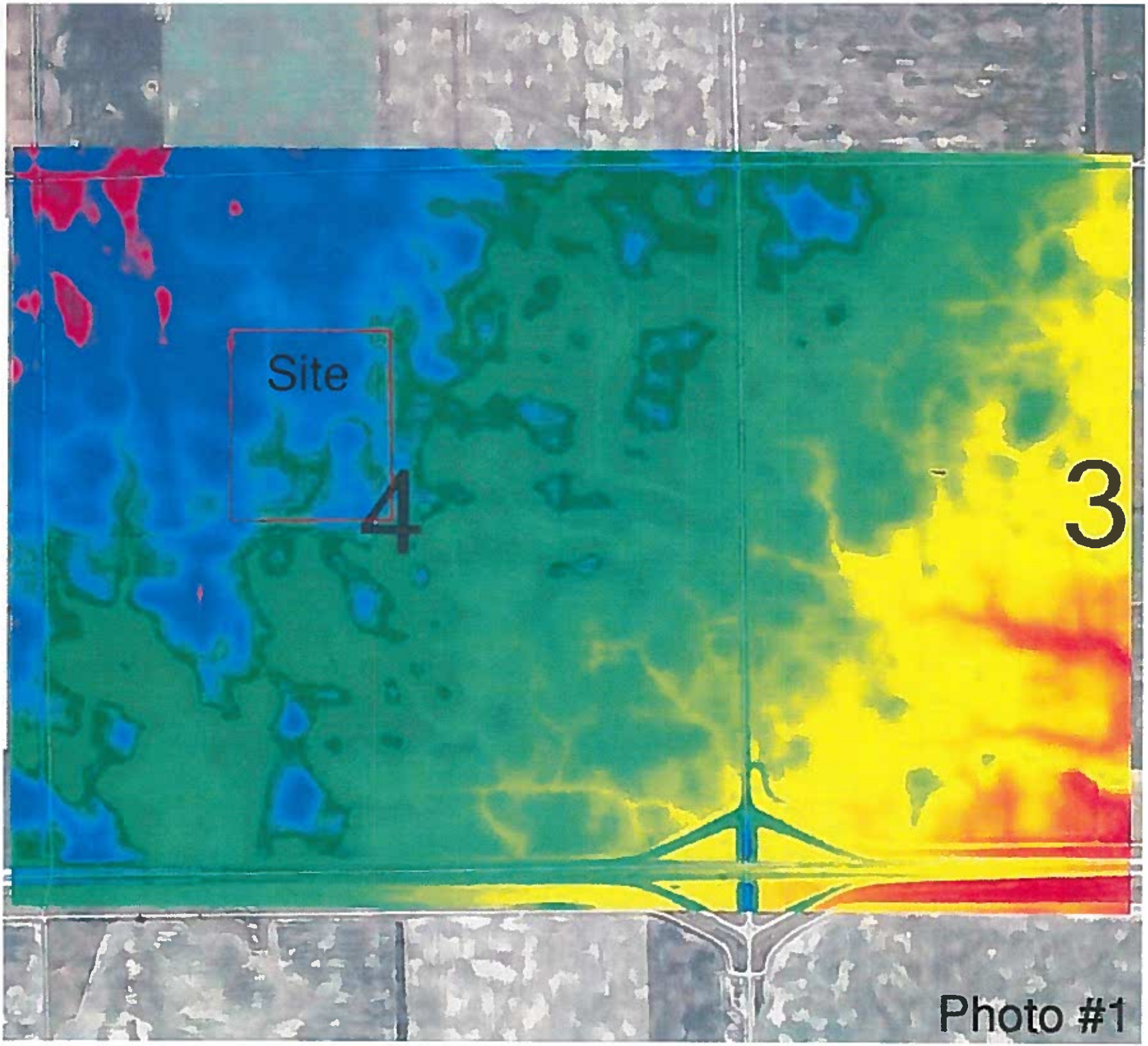
Site
4
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Photo #1

Photo #2
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11
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3
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28
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6

3
Photo #3

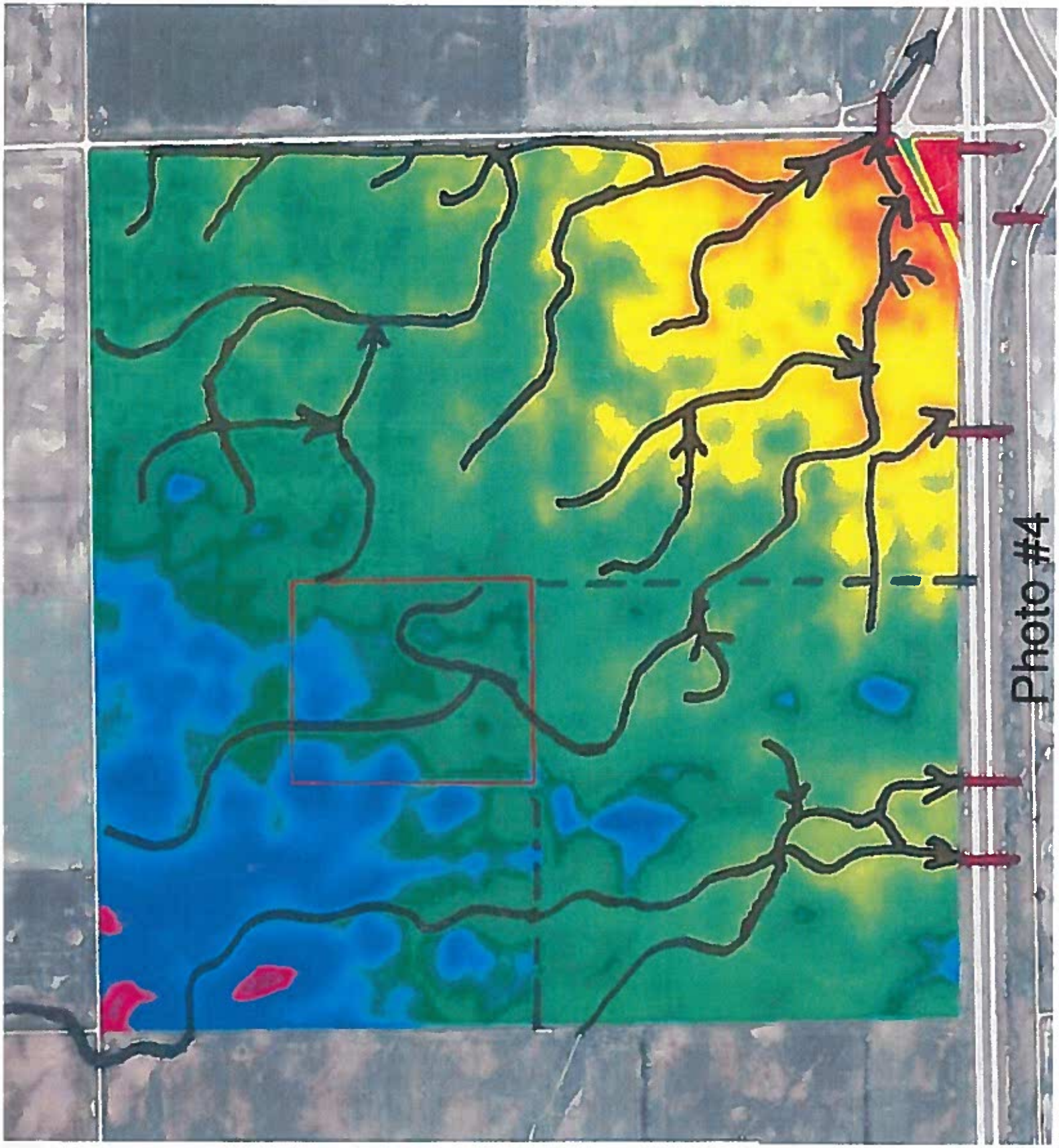
Photo #4

Photo #5

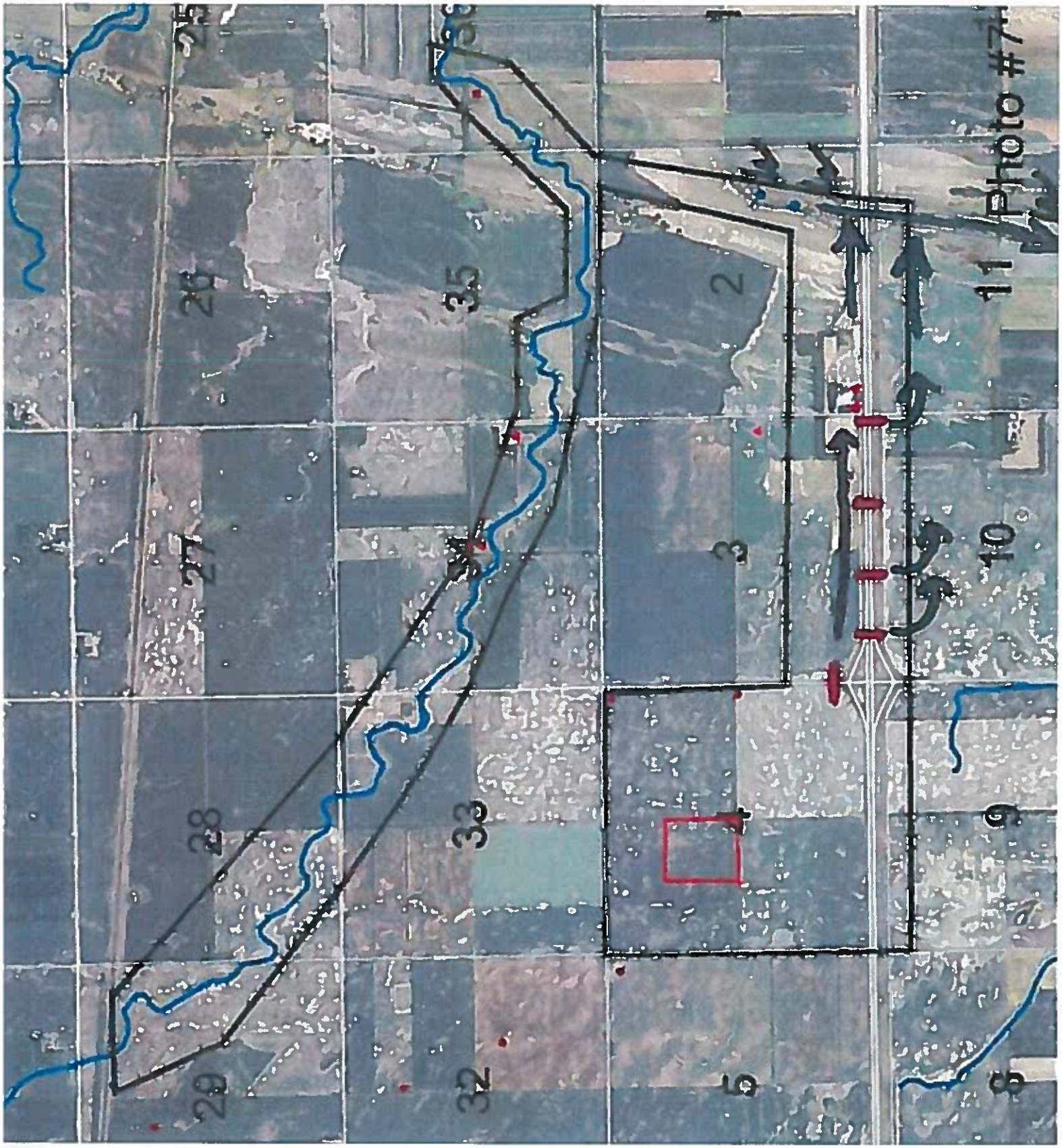
Photo #7
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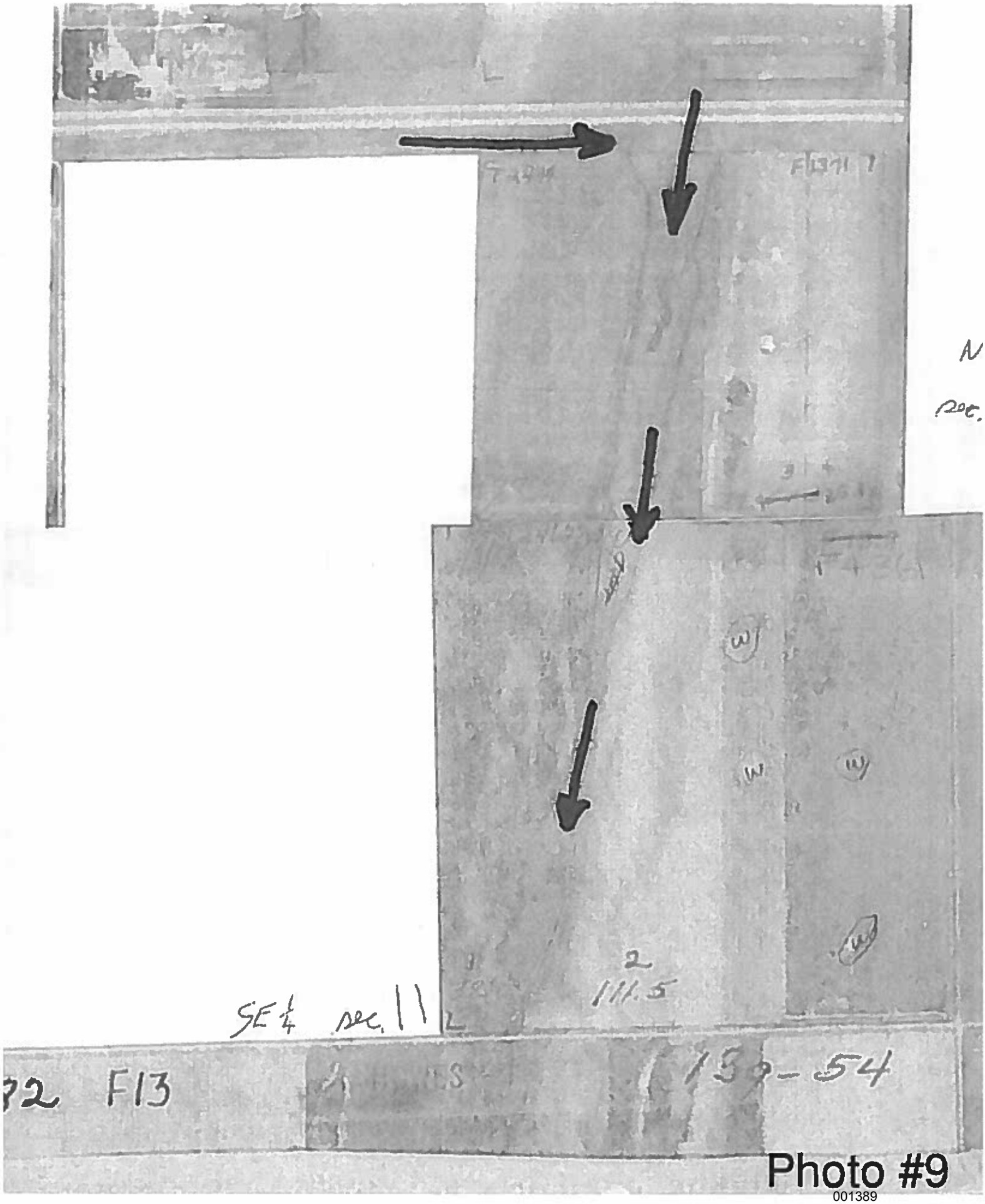
1992
CASS 017
NOT TO SCALE
HOWES
F 28707
STOCK POND
Photo #8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SE¼ sec. 11
72 F13
15?-54
Photo #9
001389

North Intermittent Stream

Also, north of the proposed building site is an intermittent stream (which is a waterway determined by constant flow of water for long periods of time) that flows southeast through my land, across my CRP filter strip, near my house, next to one open running well, and drops down across the old Lake Agassiz beach line and dumps into my stock pond. This land drops 104 feet in four miles. After this drop, this intermittent stream then continues dropping east through my pasture and right by my shallow open well and then flows into Garsteig's dam, which is part of the Buffalo Creek. (Photo #10)

The land in pink (and likely more acres? – outlined in red) are upstream of my land and is signed up to have manure applied to it. Spillage, seepage or just surface runoff (that's how phosphorus moves) will occur especially if applied to the soil surface after an early freeze up. You do mention setbacks. Will you be out there measuring the correct footage on these setbacks? All the applicator has to go by is that white line you drew in? (Photo #11)

This map shows the path the runoff from the site and this intermittent stream come together as part of the Buffalo watershed and both go into the Maple River. (Photo #12)

The shallow open well in my pasture, is from an old farmstead (Con's well), but because it has not been converted to farmland it has not been bulldozed over, like most old farmsteads were. See the 18" culvert and two weeks ago the water level was 8' below the surface. (Photo #13 – Photos #14 & #15, not used)

There are many old farmsteads on the land that is signed up to have the manure applied on it. These old farmsteads had out-buildings which would indicate livestock was being raised, meaning shallow wells were most likely dug and used. These old farmsteads are currently being farmed over and are signed up to have large amounts of manure (8,000 gal/ac) applied over them. Were these shallow wells properly sealed when the farmstead was bulldozed over? A neighbor one and a half miles west from the proposed building site uses their well water to water their garden and flowers. (Photo #16)

There also is a neighbor's farm yard that is located a half of mile away from a field that is signed up to take manure. This neighbor continues to pump his well water into his house for certain uses and also for uses around his farmyard. The Maple River also runs through this field where manure is signed up to be applied to. This location and one other has drain tile installed in it and both drain into the Maple River. (Photo #17)

Note the following aerial photos identifying 4 of the old farmsteads. (Photos #18, #19, #20, #21 & #22)

This map indicates the very unique geological and soil features in this area because of the glacial Lake Agassiz. They are called Eskers, they are significant sandier lens of soil beneath the surface, see here in Sec 29. Sec 29 has a lot of elevation around that 1200' (I have been told this is the highest spot in Cass county). Whatever water/nutrients that enter the soil from above in these areas could enter these soil lens below and move more rapidly downhill eastward towards the intermittent stream. It should be a concern when applying large quantities of liquid manure. (Photo #23)

After talking with three different custom manure applicators, 8,000 gal/ac is the minimum rate that they will apply. This is concerning because as Randy Coon as already mentioned, over 40% of these soils signed up to have manure applied to them are very limited in their ability to handle manure. So, even if the custom applicators agreed to cut the application rate down, more acres would be required. Some of the acres that have been signed up are at unrealistic distances from the proposed hog farm site (**one site over 10 miles away**) and will likely not even be used. It is a known fact the closest land to the site will be over applied. Pumping through hoses is the preferred way but there is a limit how far you can pump this manure, especially when you have to try and cross I-94, state highway 38, BNSF Railroad tracks and the Maple River. Trucking costs a lot more than pumping and over half the fields would need to have it trucked. To put this in perspective, to haul away a qtr. Of harvested corn, you would need around 25 semi loads. To apply a qtr. Of land with this hog manure, you would need around 125 semi loads! Tough on the township roads? So in closing over half of the acres signed up are unrealistic acres and if these acres were applied to, the cost would not be the 60-70% range of commercial fertilizer cost, like we were told.

Photo #10

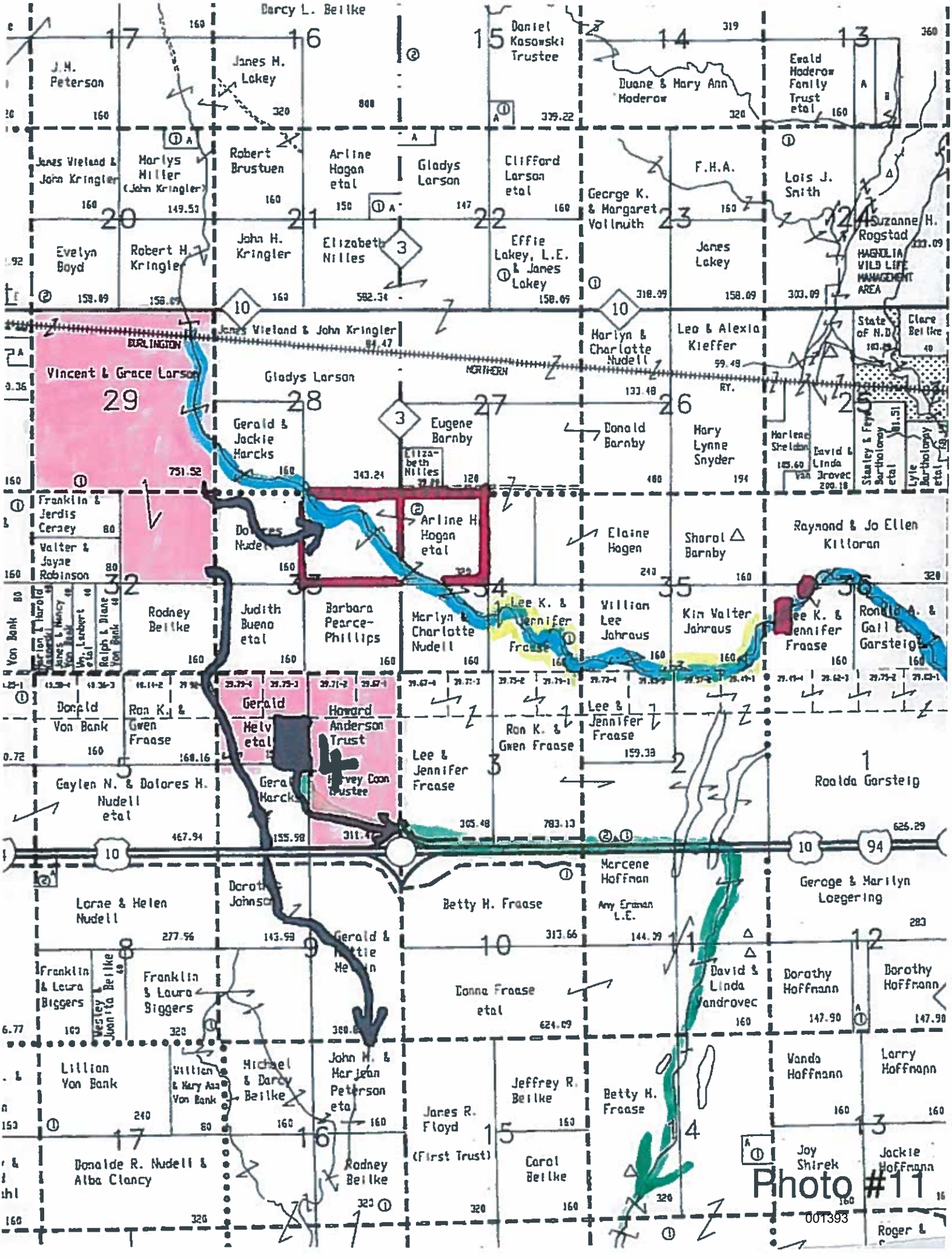
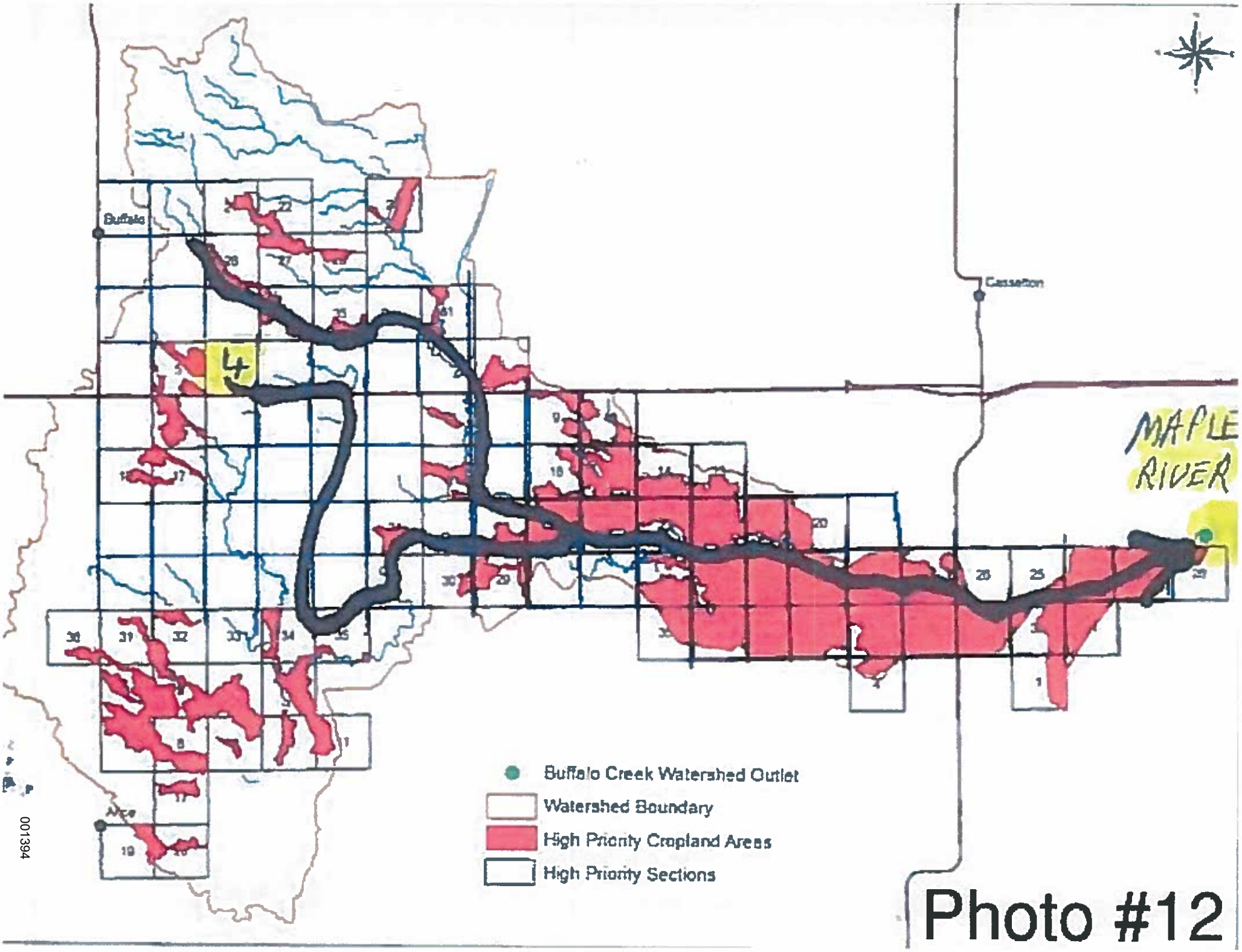


Photo #11

001393


Buffalo
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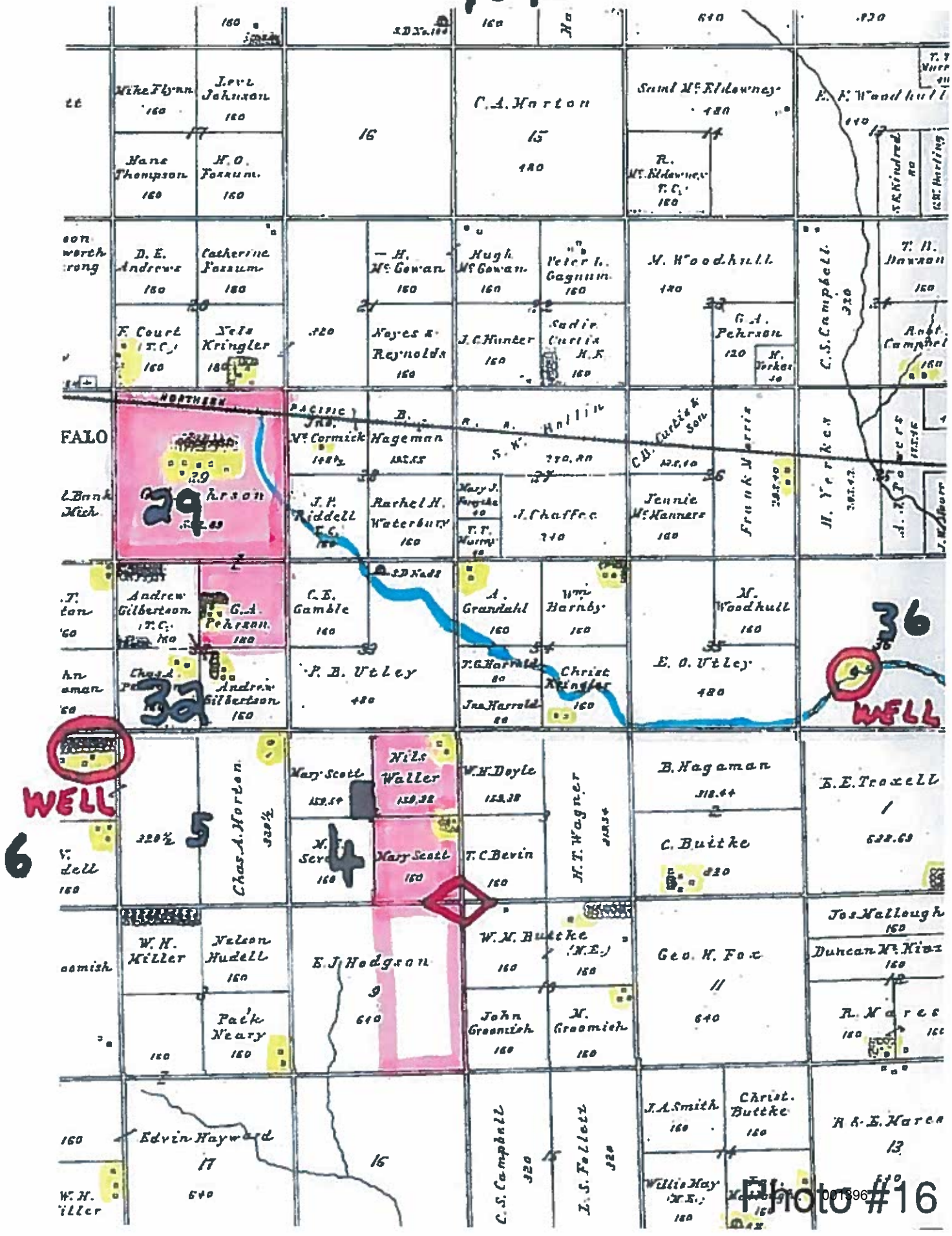
4
MAPLE RIVER
Buffalo Creek Watershed Outlet
Watershed Boundary
High Priority Cropland Areas
High Priority Sections
001394

Photo #12

Photo #13

1893


Mike Flynn
Levi Johnson
C. A. Horton
15
Saml Mc Eldowney
Hans Thompson
H. O. Fossum
16
R. Mc Eldowney
D. E. Andrews
Catherine Fossum
Hugh Mc Gowan
Peter L. Gagnum
M. Woodhull
C. S. Campbell
T. H. Dawson
F. Court
Nels Kringler
Hayes & Reynolds
J. C. Hunter
Sadie Curtis
G. A. Peterson
Northern Pacific R.R.
Wm Cormick
Hageman
R. R. Hollin
Curtis & Son
Frank Harris
H. Yerkes
Andrew Gilbertson
G. A. Peterson
C. E. Gamble
P. B. Utley
A. Grandahl
Wm Barnby
Christ Kringler
E. O. Utley
WELL
Mary Scott
Nils Waller
W. H. Doyle
H. T. Wagner
B. Hagaman
E. E. Troxell
Chas A. Horton
T. C. Bevin
C. Buttke
W. H. Miller
Nelson Hudell
E. J. Hodgson
W. M. Buttke
Geo. H. Fox
Jos Halloughs
Duncan Mc Kinz
Park Neary
John Greenwich
M. Greenwich
Edwin Hayward
17
640
C. S. Campbell
I. S. Follett
J. A. Smith
Christ. Buttke
Willis Hay
Photo #16

Township 140 Range 55

1893

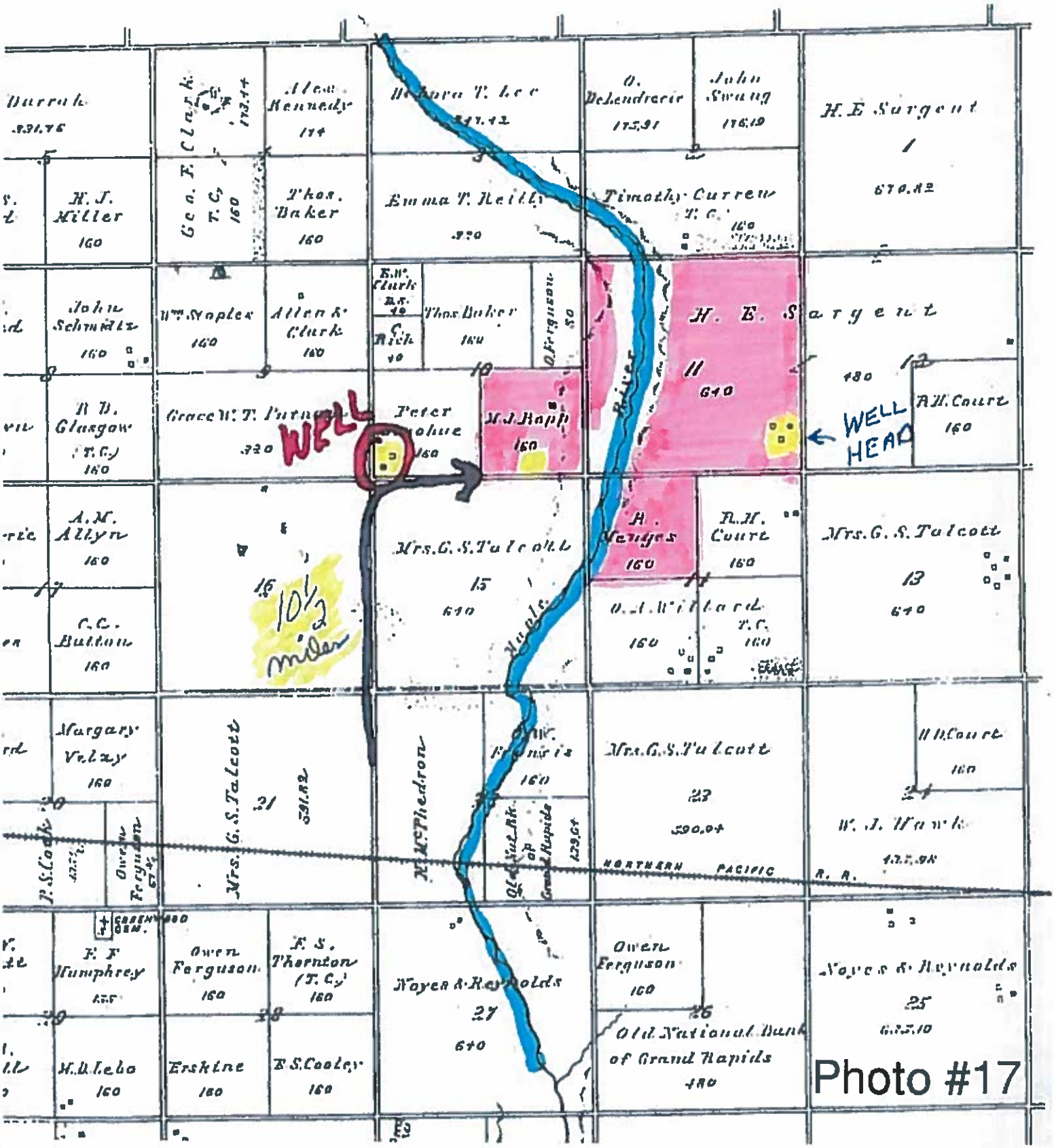
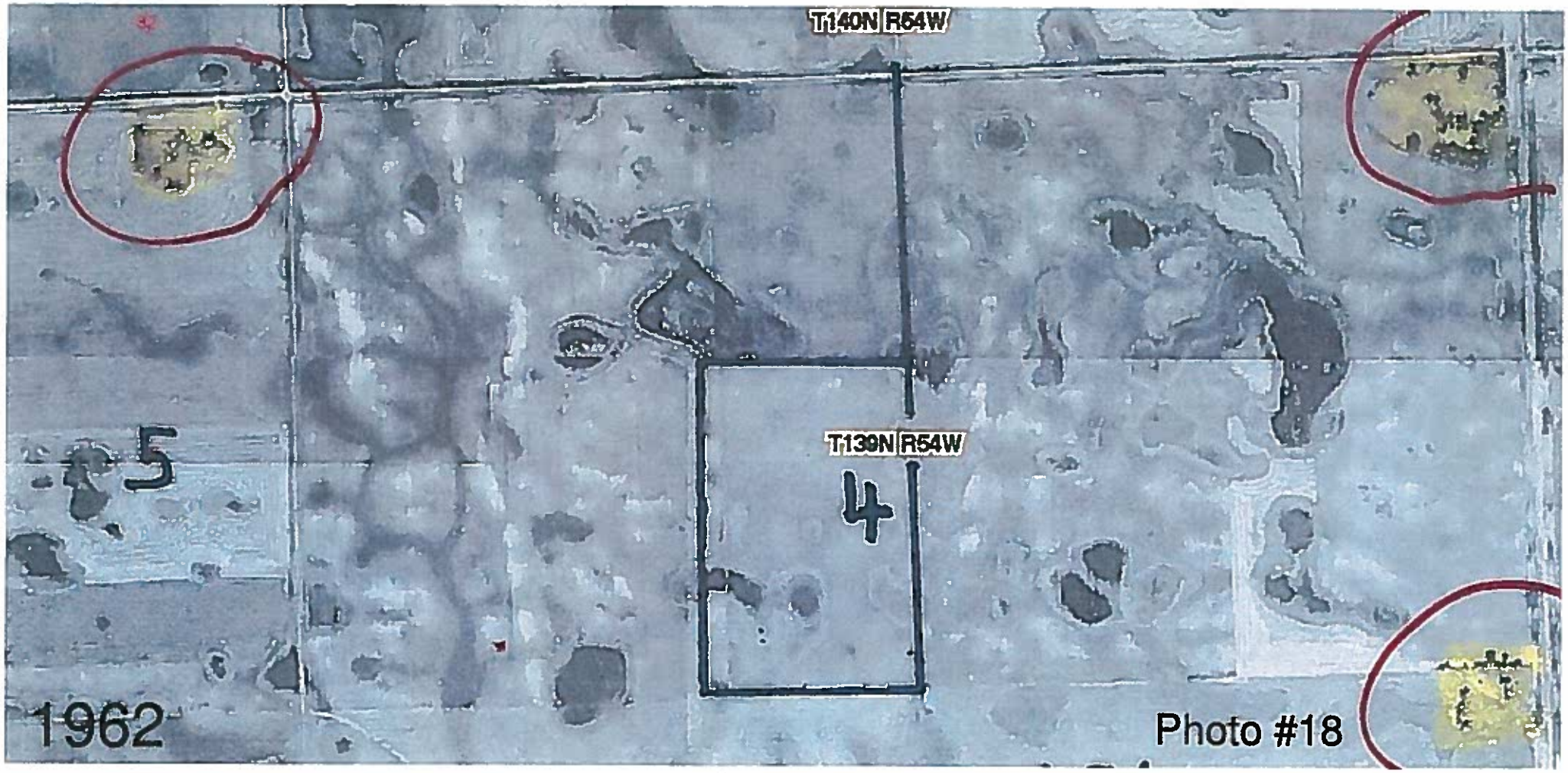


Photo #17

001397


T140N R54W
T139N R54W
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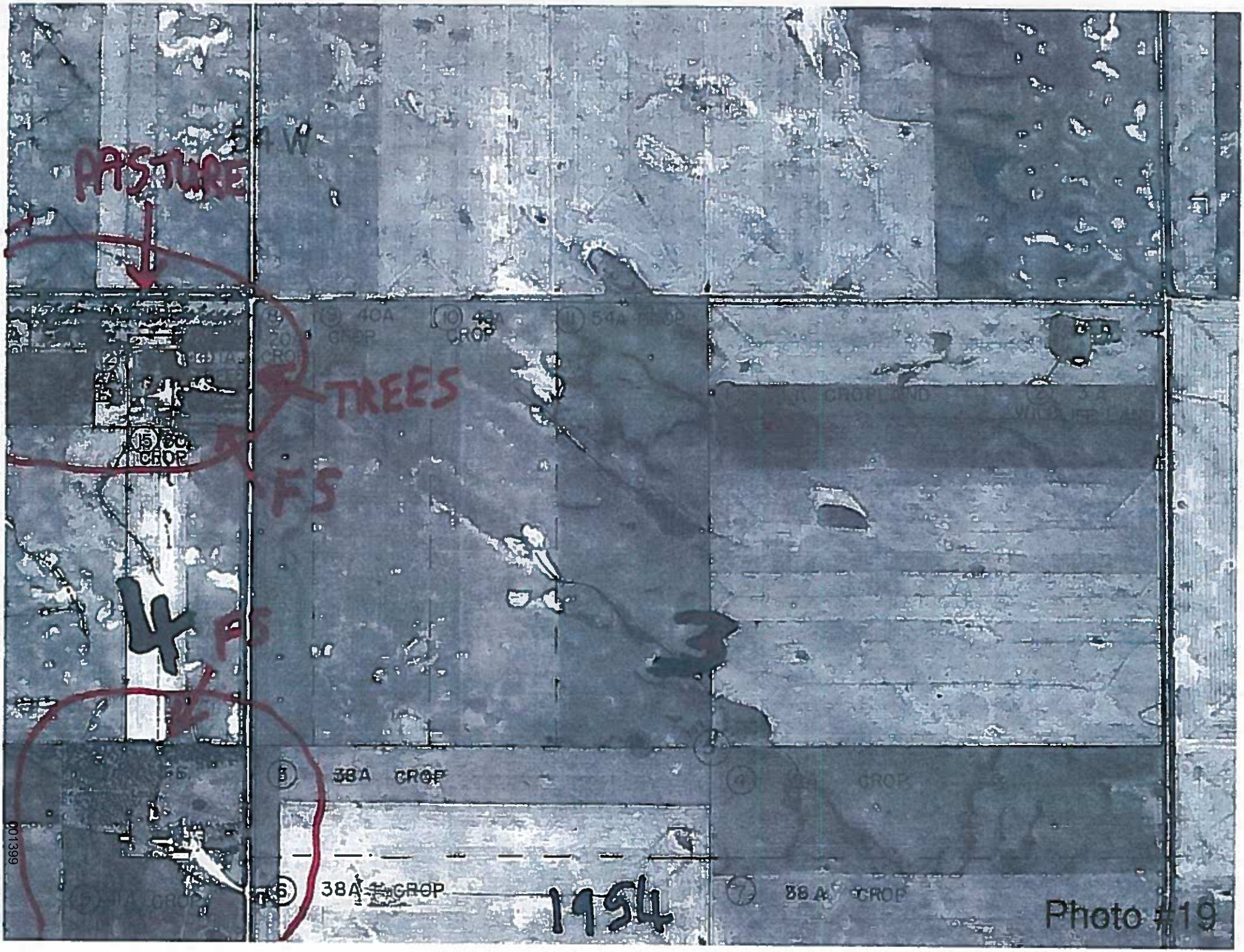
1962
Photo #18


PASTURE
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38A CROP
38A CROP
38A CROP
1954
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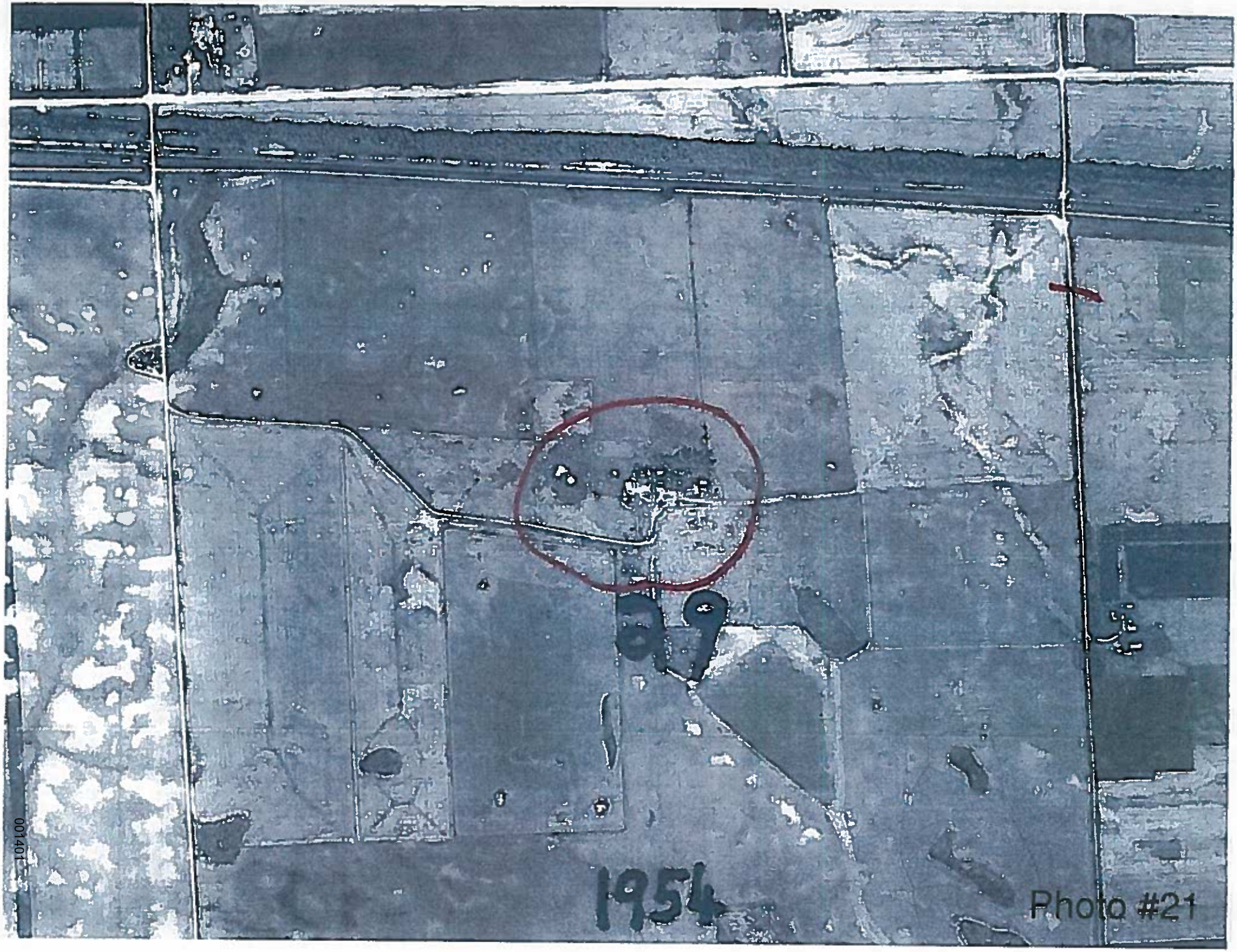
Photo #19

1962

001400

Photo #20


89
1954
Photo #21
001401

001402

1962

HALLANAS FARM

Photo #22

Harris, K. L. 1987. Surface geology of the Sheyenne River map area. Atlas Series Map 15. N.D. Geological Survey. Bismarck.

From the Legend: Red thick lines are eskers; paired black lines are buried meltwater channel, collapsed tunnel valley or esker complex

Map indicates there are significant coarser/sandier lens of soil beneath this area. Whatever water/nutrients that enter the soil from above in these areas could enter these soil lens below and move more rapidly downhill (eastward) likely. Bottom line is that there are significant soil features below the soil in the portion of Cass County near the old Lake Agassiz beach line. Hard to determine exactly what goes on below the ground here, but certainly reason for concern when applying and holding large quantities of nutrients/manure above these areas.

Photo #23

TO: North Dakota Department of Health

My name is Kent Beilke, a resident of Howes Township. My wife and I are the 3rd generation living on our family farm, with a fourth generation coming. Our farmstead is 2-1/2 miles southeast of the proposed site, and there is farmland designated within a mile of our home where they're planning to spread pig manure.

I am submitting a document titled "Howes Township Feedlot Ordinance" which was filed with the ND Dept of Health on Friday February 26, 2016.

Keep in mind that Howes Township has had the requirement that construction/improvements must request a Conditional Use Permit from the Township since 1992, without which no construction is allowed. I am also submitting that document.

Here we are showing the setbacks as required by this ordinance. The inside red ring shows the 1-1/2 mile setback for residents and the outside ring is the 3-1/2 mile setback for a town.

Now we are showing the wind directions and the percentage of time the wind blows from each direction.

I oppose the issuance of this illegal permit.

Chapter 2

Howes Township Feedlot Ordinance

AN ORDINANCE REGULATING THE PERMITTING, LOCATION, DEVELOPMENT AND EXPANSION OF FEEDLOTS. PROTECTING THE NATURAL ENVIRONMENT, AND, SAFEGUARDING THE PUBLIC HEALTH, SAFETY AND GENERAL WELFARE OF THE CITIZENS OF HOWES TOWNSHIP.

SECTION 1. INTENT AND PURPOSE

This ordinance is adopted for the purpose of:

Establishing a procedure for the permitting of feedlots.

Regulating the location, development, and expansion of feedlots.

Protecting the natural environment.

Protecting human and animal health.

Protecting human welfare.

SECTION 2. GENERAL PROVISIONS

1. Jurisdiction. The jurisdiction of this Ordinance shall apply to all the areas of Howes Township.

2. Scope. From and after the effective of this Ordinance and subsequent amendments, all existing or proposed feedlots shall be in conformity with the provisions of this ordinance.

3. Application.
   A. In their interpretation and application, the provisions of this ordinance shall be held to be the minimum requirements to satisfy the Intent and Purpose of this Ordinance.
   B. Where the conditions imposed by any provision of this Ordinance are either more restrictive or less restrictive than comparable conditions imposed by any other law, ordinance, statute, resolution, or regulation of any kind, the regulations which are more restrictive or which impose higher standards or requirements shall prevail.

SECTION 3. DEFINITIONS

1. For the purpose of this Ordinance, certain terms or words used herein shall be interpreted as follows.

A. The word "shall" is mandatory, and not discretionary; the word "may" is permissive.

B. Words used in the present tense shall include the future; and words used in the singular shall include the plural, and the plural the singular.

C. Words shall be given their common usage if not defined.

D. The word "Board" includes the "Howes Township Board" or any other word or words meaning the "Howes Township Board".

E. The word "Commission" includes the "Howes Township Zoning and Planning Commission" or any other words or word meaning the "Howes Township Zoning and Planning Commission."

F. The word "person" includes a firm, association, organization, partnership, trust, company, cooperative, corporation, or individual.

2. Animal Manure. Poultry, livestock or other animal excreta or mixture with feed, bedding, water or other materials.

3. Animal Unit (AU). A unit of measure used to compare differences in the production of animal manures that employs as a standard the average weight of the animal divided by 1,000 pounds. The total number of animal units subject to permit or registration shall be determined by including operations under common ownership or management and which utilize a common area or system for manure disposal. For purposes of this ordinance, the following equivalents shall apply (taken from ND century code 58-03-11.1. section 2) For purposes of this section, animal units are determined as follows.

a. One mature dairy cow, whether milking or dry, equals 1.33 animal units;
b. One dairy cow, heifer, or bull, other than an animal described in subdivision a equals 1.0 animal unit;
c. One weaned beef animal, whether a calf, heifer, steer, or bull, equals 0.75 animal unit;
d. One cow-calf pair equals 1.0 animal unit;
e. One swine weighing fifty-five pounds [24.948 kilograms] or more equals 0.4 animal unit;
f. One swine weighing less than fifty-five pounds [24.948 kilograms] equals 0.1 animal unit;
g. One horse equals 2.0 animal units;
h. One sheep or lamb equals 0.1 animal unit;
i. One turkey equals 0.0182 animal unit;
j. One chicken, other than a laying hen, equals 0.008 animal unit;

4. Board. The Howes Township Board of Supervisors.

5. Building, Agricultural. All buildings, other than dwellings, which are incidental to a farming operation.

6. Confined Animal Feeding Operation (CAFO). A Concentrated Animal Feeding Operation is defined as a lot, yard, corral, building or other area where animals have been, are, or will be stabled or confined for a total of 45 days or more during any 12-month period, and where crops, vegetation, forage growth, or post-harvest residues are not sustained over any portion of the lot of facility. Two or more animal feeding operations under common ownership are considered a single operation if they adjoin each other, or if they use a common area, or if they use a common area or system for disposal of manure.

For the purpose of these regulations, Concentrated Animal Feeding Operations are divided into the following classes:

(A) If there are fewer than three hundred animal units.
(B) If there are at least three hundred animal units but no more than one thousand animal units.
(C) If there are at least one thousand one animal units but no more than two thousand animal units.
(D) If there are at least two thousand one animal units but no more than five thousand animal units.
(E) If there are five thousand one or more animal units.

7. Family. For the purpose of this Ordinance a family shall include the feedlot, the feedlot owner's grandparents, parents or stepparents, aunts or uncles, siblings, spouses, children or stepchildren, or grandchildren.

8. Farm. A tract of land which is principally used for agricultural activities such as the production or cash crops, livestock or poultry farming.

9. Feedlot. A lot or building or combination of lots and buildings intended for the confined feeding, breeding, raising or holding of animals and specifically designated as a confinement area in which manure may accumulate, or where the concentration of animals is such that a vegetative cover cannot be maintained within the enclosure. Pastures shall not be considered feedlots under these rules. Fish farms shall be considered feedlots for the purpose of this Ordinance. Confined Animal Feeding Operations (CAFO) as defined by North Dakota, Federal, or Cass County definitions shall be considered feedlots for the purposes of this ordinance.

10. Feedlot (New). An unpermitted or unregistered feedlot, a feedlot constructed and operated at a site where no feedlot existed previously or where a pre-existing feedlot has been abandoned or unused for a period of two years.

11. Feedlot Operator. An individual, a corporation, a cooperative, a group of individuals, a partnership, joint venture, owner or any other business entity having charge or control of one or more livestock feedlots, poultry lots or other animal lots.

12. Feedlot Runoff. The movement of water from a feedlot, either in the form of rainfall, snow or as water from a waterway, ditch, etc. passing through a feedlot, carrying particles of manure as well as soil into a body of water and thereby constituting a potential pollution hazard.

13. Floodplain. The channel or beds proper and the areas adjoining a wetland, lake or watercourse which have been or hereafter may be covered by the regional flood. Floodplain areas within Howes Township shall encompass all areas designated as Zone A on the Flood Insurance Rate Maps prepared by the Federal Emergency Management Agency.

14. Floodway. The channel of the water course and those portions of the adjoining floodplains which are reasonably required to carry or store the regional flood discharge.

15. Liquid Manure. Manure that contains less than 15% solids content.

16. Manure Storage Structure. A structure where lot runoff, manure effluent or other diluted animal waste is stored or treated, including earthen manure storage basins, earthen lagoons, concrete or glass-lined storage.

17. Modification. Any change in the feedlot operation that does not result in an increase in animal numbers.

18. NDDH. North Dakota Department of Health.

19. NRCS. Natural Resources Conservation Service.

20. Owner. Any person having possession, control or title to a feedlot.

21. Parcel. A contiguous quantity of land legally described and recorded with the County Register of Deeds as the property of a person.

22. Pastures. Areas where grass or other growing plants are used for grazing, and where the concentration of animals is such that a vegetative ground cover is maintained during the growing season except in the immediate vicinity of temporary supplemental feeding or watering devises.

23. Permit, State. A document issued by the NDDH which contains requirements, conditions, and compliance schedules relating to the discharge of animal manure pollutants, and, issued to the contractor, owner or operator, cooperative, stating that the feedlot meets the minimum standards as required by this Ordinance and the NDDH.

24. Permit, Township. A document issued by Howes Township which contains conditions and compliance schedules relating to the discharge of animal pollutants, and, issued to the contractor, owner or operator, cooperative, stating the feedlot meets the minimum standards as required by this Ordinance and the NDDH.

25. Potential Pollution Hazard. A condition which indicated a potential for pollution of land and waters including,

A. Allowing a discharge of biological oxygen demand (BOD) pollutants in excess of 25 parts per million;

B. A feedlot or manure storage area located within a shore-land or floodplain.

C. A feedlot or manure storage area located above a groundwater supply considered Waters of the State

26. Public Well. A well that accesses the Waters of the State for distribution to the public. This includes the Wellhead Protection Area.

27. Setback. The distance from a property boundary enclosing a concentrated animal feeding operation, including its animal waste collection system, and the nearest occupied residence, the nearest buildings used for nonfarm or non-ranch purposes, or the nearest land zoned for residential, recreational, or commercial purposes.

28. Solid Manure. Manure which has at least 15% solids content and contains added fibrous material excluding mineral solids.

29. Surface Waters. Waters of the State which include, but are not limited to rivers, streams, creeks, coulees, ponds, intermittent streams, and wetlands.

30. USDA. United States Department of Agriculture.

31. Waters of the State. All waters defined under North Dakota Century Code as Waters of the State.

32. Wetlands. Wetlands as defined by the USDA.

SECTION FOUR. CONFINED ANIMAL FEEDING OPERATION PERMIT REQUIREMENTS

1. **Owners of Class A, Class B, Class C, Class D and Class E Concentrated Feeding Operations are required to complete a permit application whenever any of the following occur.**
   A. A new Concentrated Animal Feeding Operation is proposed where one does not exist.
   B. An expansion is proposed beyond what a current permit allows.
   C. A cumulative expansion by 300 or more animal units after 2/25/16 of existing feedlot that does not have a permit.
   D. A change in ownership.
   E. An existing feedlot is to be restocked after being idle for two (2) or more years.
   F. A signed complaint has been received by the Howes Township Zoning and Planning Committee or the Cass County Zoning Officer and after inspection reveals that the Concentrated Animal Feeding Operation is in violation of Township, County, or State regulations.

SECTION FIVE CONFINED ANIMAL FEEDING OPERATION CONTROL REQUIREMENTS

1. **No Significant Contribution or Pollution.** In general, no Concentrated Animal Feeding Operation shall be constructed, located, or operated so as to create a significant contribution of pollution.

2. **State General Permit.** Classes A, B, C, D and E Concentrated Animal Feeding Operations shall obtain a North Dakota Department of Health Permit pertaining to the animal species of the Concentrated Animal Feeding Operation.

3. **County Special Use Permit.** A Cass County Special Use Permit must be obtained.

4. **Nutrient Management Plan.** The applicant shall develop, maintain, and follow a nutrient management plan to ensure safe disposal of manure and protection of surface and ground water. The Howes Township Zoning and Planning Commission must approve the plan prior to land application of any wastes. Due to crop rotation, site changes, and other operational changes, the producer shall update the plan annually to reflect the current operation and crops grown on the application sites. The applicant shall collect, store, and dispose of liquid and solid manure according to recognized practices of good agricultural management.

   A. A generic nutrient management plan that the applicant may use in developing a nutrient management plan is available from the North Dakota Department of Health. The generic nutrient management plan is based on application of nitrogen. The applicant may use other plans, provided the alternate plan contains all the information necessary to determine compliance with conditions of this permit. Nitrogen, in addition to that allowed in the nutrient management plan, may be applied up to the amounts as indicated by soil or crop nitrogen test results that are necessary to adhere with recognized agronomic rates. Land for application of manure shall have soil tests yearly, with a minimum of four

soil samples per forty acre parcels, in a transect across the parcel, that detail nitrogen levels or chemical derivatives. Results and copies of such tests shall be submitted annually to the Board. The applicant shall maintain records to show compliance with the plan.

B. The Howes Township Zoning and Planning Commission also requires applicants to develop nutrient management plans for phosphorous and potassium. Phosphorus and potassium, in addition to that allowed in the nutrient management plan, may be applied up to the amounts as indicated by soil or crop phosphorus and potassium test results that are necessary to adhere to recognized agronomic rates. Land for application of manure shall have soil tests yearly, with a minimum of four soil samples per forty acre parcels, in a transect across the parcel, that detail phosphorus and potassium levels or their chemical derivatives. Results and copies of such tests shall be submitted annually to the Board. The applicant shall maintain records to show compliance with the plan. The plan shall comply with Township and County Manure Application Setbacks.

C. Manure shall be applied only to land which is suitable for the production of crops and where crops shall routinely grow to utilize the nutrient value of the applied manure on a yearly basis. Manure shall not be applied to land which will lie fallow in the upcoming crop year.

D. Applicants shall provide proof of sufficient cropland acreage for application of total manure volume. If applicant does not own sufficient cropland acreage, binding written manure application agreements for the expected life of the facility shall be provided.

E. Animal manure shall be applied within two (2) miles of the Concentrated Animal Feeding Operation. If sufficient suitable cropland cannot be obtained within two (2) miles of the Confined Animal Feeding Operation, a variance of no more than four (4) miles may be granted by the Board.

H. Binding easements for transportation of manure waste via pipeline, hose or vehicular transport shall be provided, including township right of ways and ditches; legal drains or other properties or easements.

I. A minimum of eight test wells shall be located no greater than one quarter mile from and surrounding the waste manure holding facility, two or more on four sides of the facility. These wells shall be located to a depth no greater than but sufficient to sample ground water in a downslope hydraulic grade from the waste manure storage facility, in the same ground water profile as the waste manure storage facility. Tests indicating levels of Nitrogen, Phosphorus, and Potassium or chemical derivatives shall be maintained by the applicant and copies shall be submitted annually to the Board. Violations of state water quality standards attributable to the waste management facility or ground application may be cause or grounds for revocation of the conditional use permit.

SECTION 6. REQUIRED SETBACKS AND SEPARATION DISTANCES FOR MANURE APPLICATION AND NEW CONFINED ANIMAL FEEDING OPERATIONS AND THOSE EXPANDING BY 300 OR MORE ANIMAL UNITS AND FOR AFTER 2/25/16.

Required Setbacks and Separation Distances for New Confined Animal Feeding Operations.

A. New animal feeding operations shall be set back from any existing residence, church, school, business, public building, park, or campground;

(1) If there are fewer than three hundred animal units (Class A), there is no minimum setback requirement.

(2) If there are at least three hundred animal units but no more than one thousand animal units(Class B), the setback for any animal operation is one mile.

(3) If there are at least one thousand one animal units but no more than two thousand animal units(Class C), the setback for a hog operation is one and one-half mile and the setback for any other animal operation is one and one quarter mile.

(4) If there are at least two thousand one animal units but no more than five thousand animal units (Class D), the setback for a hog operation is one and one –half mile and the setback for any other animal operation is one and one-half mile.

(5) If there are five thousand one or more animal units (Class E), the setback for a hog operation is two and one-quarter mile and the setback for any other animal operation is one and one-half mile.

B. New animal feeding operations shall be set back from any existing municipality, town, city, village, military facility or incorporated area.;

(1) If there are fewer than three hundred animal units (Class A), there is no minimum setback requirement.

(2) If there are at least three hundred animal units but no more than one thousand animal units(Class B), the setback for any animal operation is one mile.

(3) If there are at least one thousand one animal units but no more than two thousand animal units(Class C), the setback for a hog operation is two and one-half miles. and the setback for any other animal operation is one and one-quarter mile.

(4) If there are at least two thousand one animal units but no more than five thousand animal units(Class D), the setback for a hog operation is three and one-half miles. and the setback for any other animal operation is two and one-quarter miles.

(5) If there are five thousand one or more animal units(Class E), the setback for a hog operation is four miles and the setback for any other animal operation is two and three-quarter miles.

C. Concentrated Animal Feeding Operation expansion of 300 or more animal units or more can apply to the Howes Township Zoning and Planning Commission for a variance to the required setback and separation distance regulations. Expansion of permitted animal units up to twenty-five percent shall require notification of the Howes Township Board of Supervisors within ten days of expansion. Expansion of permitted animal units exceeding permit are allowed only on one occasion.

D. If a Concentrated Animal Feeding Operation is closer than the separation distances provided in these regulations, the applicant can request a written waiver from the separation distance. A public hearing shall be required for any variance from the setback distances. Written notice of such hearing shall be provided to each person in the Township, and to every person within 4 miles of the facility in any adjoining townships or municipalities, or any persons attending schools, places of businesses, and members of church congregations within 4 miles of the proposed facility.

E. Required Manure Application Setback Distances for New Confined Animal Feeding Operations.

The following manure application setbacks apply to all classes of Concentrated Animal Feeding Operations.

	Irrigation Applied	Surface Applied with Immediate Incorporation or Injection
Established Residences	Not allowed	½ mile
Churches, Businesses, Parks, and Commercially Zoned Areas	Not allowed	½ mile
Municipalities	Not allowed	½ mile
Lakes, Streams, and Water Impoundment Areas	Not allowed	1 mile
Shallow Aquifers	Not allowed	1 to ½ mile
Wildlife Easement Areas	Not allowed	1 mile
Wells, Private and Public	Not allowed	1 mile
Cemeteries	Not allowed	½ mile
Road ROW	Not allowed	300 feet

No solid manure shall be applied on frozen ground or on snow cover. Spread solid manure must be incorporated before ground freezes to avoid pollution hazards.

SECTION 7. MANURE STORAGE AND TRANSPORTATION

1. **Compliance with State, County, and Local Standards.** All animal manure shall be stored and transported in conformance with the Howes Township Feedlot Ordinance.

2. **Potential Pollution Hazard Prohibited.** No manure storage area shall be constructed, located, or operated so as to create or maintain a potential pollution hazard.

3. **Vehicles, Spreaders.** All vehicles used to transport animal manure on County, State, and Township highways and roads shall be leak proof. Manure spreaders with end gates shall be in compliance with this provision provided the end gate works effectively to restrict leakage and the manure spreader is leak proof.

4. **Utilization as Domestic Fertilizer.** Animal manure, when utilized as domestic fertilizer, shall not be stored longer than one year.

5. **Stacking of Manure Onsite.** For Class A, Class B, Class C, Class D and Class E Confined Animal Feeding Operations, solid manure that is stacked for more than six (6) months shall be stored on a concrete containment pad designed with a water containment and diversion plan approved by the NDDH.

6. **Runoff Control Structures.** All outside manure storage areas shall have runoff control structures to contain the liquid.

7. **Manure Storage and Utilization.** The manure Management Plan shall provide for twelve (12) months of storage and utilization capacity for new or expanding feedlots. A nutrient management plan shall also be required. The Plan must be approved by the Township Zoning and Planning Commission.

8. **Storage Design Approval.**
   A. All plans for manure storage structures shall be reviewed and approved by the Township.
   B. Plans for all earthen manure storage structures and all manure storage structures of 500,000 gallons or larger shall be approved by the NDDH.

9. **Minimum Location, Design, Construction and Maintenance Standards for Earthen Manure Storage Structures.**
   A. **Location Standards.**
      i. All location criteria for earthen manure storage structures, as established by the NDDH, shall be included in this standard.

ii. No earthen manure storage structure shall be located in an area where the seasonal high groundwater table will be within two (2) feet of the bottom of the structure sealing liner. The installation of a groundwater drainage system to lower the seasonal high groundwater table shall be prohibited.

iii. No earthen storage structure shall be located in an area identified as having a high susceptibility to groundwater contamination.

iv. No earthen manure storage structure shall be located in an area identified as primarily sand and/or gravel.

v. No earthen storage structure shall be located in an abandoned gravel pit, or other surface mined area.

vi. Before approval, a minimum of one (1) year of groundwater monitoring shall be implemented to determine hydraulic gradients at the site. This information shall be essential to lagoon design and proper placement of long-term monitoring wells.

B. Design Standards.

i. Site Investigation.

1. A minimum of five soil borings for the first ½ acre of site area plus two soil borings per acre thereof shall be made at the proposed location of the structure by an ARCPACS certified soil scientist. The borings shall be advanced to a depth of ten (10) feet below the proposed bottom of the structure.
2. A record of the findings of the soil borings shall be made and will include the following.
    a. A listing of the soils types by USDA classification and the thickness of the soil layers encountered in the boring;
    b. The depth to the highest evidence of seasonal high groundwater table;
    c. The depth to saturated soil conditions or groundwater table; and
    d. The date and location relative to the proposed basin to be shown on the plan set of the borings, the elevation of the ground at the borings and the name of the ARCPACS certified soil scientist conducting the boring operation and soils interpretation.

ii. Basic Design.

1. The earthen storage structure shall be designed with sufficient volume to hold the waste from the proposed number of animals for the design period while providing at least two (2) feet of freeboard between the surface of the waste and the lowest point in the surrounding embankment.
2. The design period shall not exceed 365 days.
3. The design of the structure shall be prepared and signed by a registered Professional Engineer qualified in the design of earthen structures.

iii. Liner Design.

1. Liner thickness shall be based on liquid depth and storage capacity.

a. The earthen structure shall have a clay liner that is at least 24 inches in thickness after compaction. The overall thickness shall be increased by 1.5 inches for each additional foot in design depth over 10 feet (not including freeboard depth). Liner thickness shall be increased as required to achieve a demonstrated permeability rate of 10^{-7} cm/second (500 gallons/acre/day) or less; all earthen structures shall also require a synthetic membrane liner of adequate thickness in relation to the depth and volume of the lagoon, and installed according to manufacturer specifications.

b. Minimum liner thickness shall be increased to thirty (30) inches for earthen structures of 1-1.5 million gallons of capacity.

c. Earthen structures having more than a two million-gallon capacity shall meet the technical standards for solid waste management facilities under NDDH standards.

d. The liner design standards required above shall apply to a feedlot where any combination or earthen structures have a total capacity that meet the above thresholds.

2. The interior side slopes of the liner shall not be greater than 2:1 (horizontal : vertical) or 50%, or 3:1 (horizontal : vertical) if compaction efforts on sidewalls are parallel to the slope.

3. The specified soil used to make up the liner shall be composed of at least 50% material finer than the #200 sieve and at least 25% small than 0.002 millimeters as tested by hydrometer. The soil shall contain no rock larger than 3 inches in diameter and no organic matter such as roots or grass.

4. The soil used in the liner specifications shall have a minimum liquid limit of 25% and a minimum plasticity index of 15% and be capable of attaining a demonstrated permeability rate of 10^{-7} cm/second (500 gallons/acre/day) or less.

iv. Liner Borrow Area.

1. Soil borings shall be conducted at the proposed source for the soil liner material. A minimum of five soil borings shall be made at the proposed location by an ARCPACS certified soil scientist. The borings shall be advanced to a depth below the proposed bottom of the excavation.

2. A record of the findings of the soil borings shall be made and will include the following.

a. A listing of soils types by USDA classification and the thickness of the soil layers encountered in the boring;

b. The depth to the highest evidence of seasonal high groundwater table;

c. The depth to saturated soil conditions or groundwater table; and

d. Size and location in boring hole of any rocks greater than 3 inches in diameter.

e. The date and location to be shown on plan set of the borings and the name of the ARCPACS certified soil scientist conducting the boring operation and soils interpretation.

f. An estimate of the volume of borrow material required and available.

C. Construction Standards

i. Liner Placement and Compaction.

1. The soil liner shall be placed in horizontal lifts of no more than six (6) inches in thickness after compaction. The liner on the side walls shall also be placed in horizontal lifts to facilitate compaction, unless the builder can demonstrate the ability to achieve the required compaction on the slopes using other methodologies. The surface of the lifts shall be scarified prior to placement of the succeeding lift to facilitate bonding of the lifts.
2. The moisture content of the liner soil shall be at or above the optimum moisture content identified in the preconstruction testing. In no case shall the moisture content exceed 4% above or fall below the identified optimum moisture content.
3. The soil shall be compacted to a minimum of 95% of the identified Proctor maximum density. The compaction shall be done with a "sheepsfoot" roller or other kneading compactors. The compaction shall be verified by field testing of the compacted material using nuclear density (ASTM D2922), and cone (ASTM D1556) or rubber balloon methods (ASTM D2167). One density test shall be conducted for each 1,000 square feet of surface area of the soil liner (including side walls) for each lift. These tests shall be conducted by qualified personnel.
4. No frozen soil materials shall be used in the construction of the liner nor shall placement or compaction of soil material take place during freezing weather conditions.

ii. Construction Certification.

1. All clay liner placement and compaction shall be observed by a registered Professional Engineer. Records of the construction activities and conditions shall be kept onsite.
2. Upon completion of construction of the liner, a construction report shall be filed with the Howes Township Zoning Commission, the County, and the NDDH. This report shall contain the testing results, a summary of the construction activities, an as-built plan set and a certification that the work was conducted according to the plans and specifications approved by the State, County, and Township for construction.

10. Underground Tanks. Underground tanks for manure storage shall be prohibited.

11. Earthen Pits. Unlined earthen pits for manure storage shall be prohibited.

12. Fly and Odor Control Plan. An Odor Control Plan shall be prepared by the feedlot operator for all new Class A, Class B, Class C, Class D and Class E Confined Animal Feeding Operations. A management plan is required for

submission of a permit. The Township Planning and Zoning Commission shall review the plan, taking into consideration the prevailing wind direction and topography.

13. Groundwater Monitoring. After hydraulic gradient is determined, groundwater monitoring wells shall be placed in such locations as to best monitor any potential flow of leaching wastewater from the liquid manure handling system.
    A. For lagoons and storage facilities a minimum of eight (8) wells, two on each side, and any additional wells being appropriate as determined by NDDH and a groundwater expert designated by the Township.
    B. A minimum of two (2) lateral wells shall also be installed beneath the lagoon or storage facility to monitor for vertical leaching of wastewater.

14. Odor Monitoring. Odors shall be monitored according to the following conditions.
    A. Upon an oral or written complaint of a citizen to the Township Board of Supervisors, the County Health Officer, or the County Sheriff of an unacceptable odor emanating from the facility, the NDDH or a citizens group trained in odor detection under provisions of North Dakota law shall determine if the level of odor is unacceptable. If findings are unacceptable, remedial measures for odor abatement shall be undertaken by the operator until satisfactory odor levels are met on a sustained basis.
    B. Odor levels will be checked within two working days after the receipt of a written or oral complaint.
    C. Odor levels will be checked downwind from the facility an equal distance from the facilities as the residence, place of business, or public facility of the complainant.

SECTION 8. FEEDLOT CLOSURE

1. Responsible Parties. The landowner, owner and operator of any feedlot shall be responsible for the ongoing management of manure and the final closure of the feedlot including the cleaning of buildings and the emptying and proper disposal of manure from all manure storage structures.

2. Environmental Financial Assistance. Financial assurance guaranteeing proper closure shall be required with all applications for new or expanding feedlots with a liquid manure storage structure as part of their basic design. Such assurance shall be a $25,000 bond, letter of credit, or escrow account for each 1.0 million gallons of storage capacity.

3. Closure Plan. If a feedlot ceases operation, the owner shall submit to the Township a Closure Plan.
    A. The Closure Plan shall be submitted at least 60 days prior to the final day of operation. This plan shall be prepared by a registered Professional Engineer.
    B. Closure may be postponed for a period of 12 months if the property is posted for sale. However, pollution hazards must be remediated immediately.

C. Manure storage structure closure shall include the removal of the sludge in the facilities and its disposal by proper land application at agronomic rates or by other legally permissible method. Manure storage structure and the seeding of the area.

D. All wastes from the feedlot operation and its waste control system must be removed and disposed of on land or in some other manner which is legally permissible as soon as practical and in accordance with the approved Plan in order to promote and protect public health.

E. Each time ownership of the feedlot changes, the new owner must notify the Howes Township Zoning and Planning Commission in writing within 60 days of the transfer of ownership that the approved Plan has been read and is understood and that all provisions of the Plan will be implemented.

F. If the new ownership will continue to operate the feedlot, closure shall not be required.

SECTION 9. ABANDONMENT

1. Owners and operators of feedlots shall have joint and several liability for clean-up, closure or remediation of abandoned feedlot sites, including cases of neglect.
2. Abandoned live animals shall be assessed for health by the State Veterinarian and costs of disposal shall be assessed against the bond.

Approved and adopted this 25 day of FEBRUARY, 2016.

Bud Beattie chairman

Howes Township Officer

Attest:

Clerk

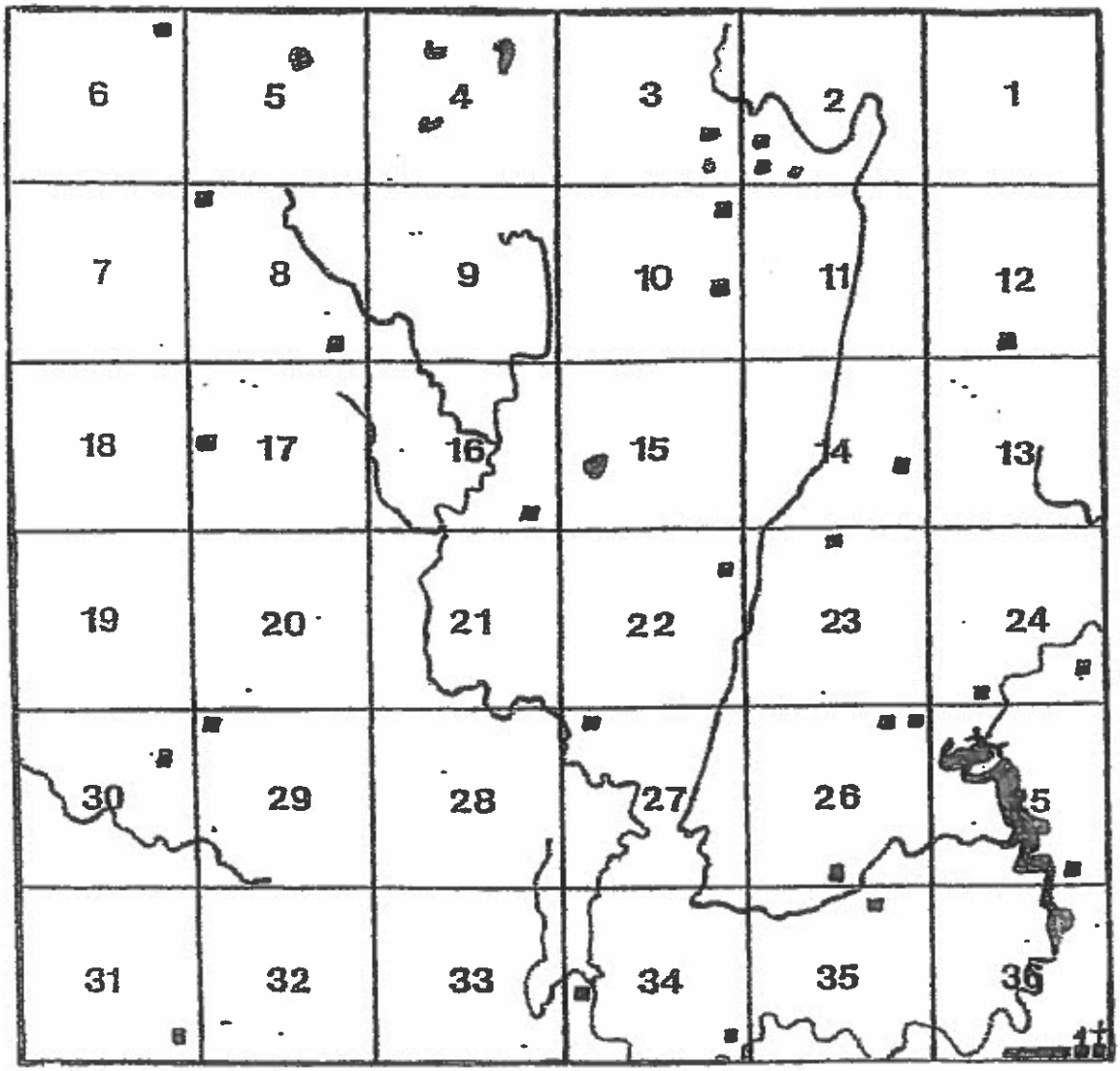
Official

Land Use Map

HOWES TOWNSHIP

Township 139 N

Range 54 W



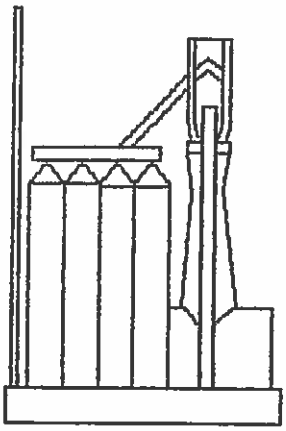
KEY:

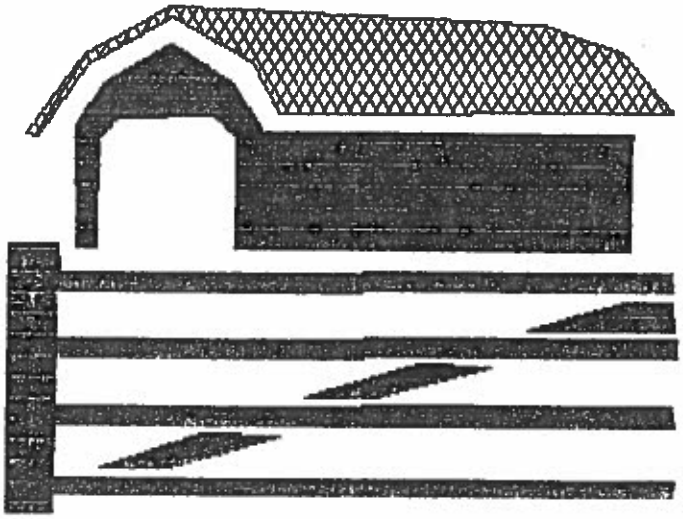
Township Hall	Watercourse	Date Adopted:
Church	Surface Water	2-25-2016
Residence	Flowing Well	By:
Dam		

001422

HOWES TOWNSHIP
ZONING ORDINANCE

C





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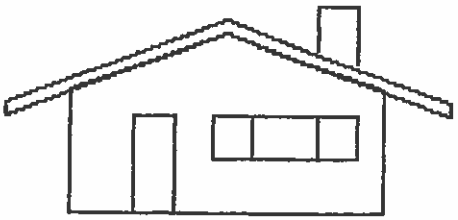

A

RESOLUTION

WHEREAS, the Howes Township Board of Supervisors in conjunction with the Howes Township Zoning Commission, composed of members from the affected areas, have investigated and determined the necessity of amending the "Howes Township Zoning Ordinance"; and

WHEREAS, after investigation and consultation with the Cass County Planning Department, the Howes Township Zoning Commission has prepared an amended "Howes Township Zoning Ordinance" to be submitted herewith to the Howes Township Board of Supervisors and filed in the office of the Howes Township Clerk and the Cass County Planning Department; and

WHEREAS, after filing of the proposed amended "Howes Township Zoning Ordinance", the Howes Township Zoning Commission held a public hearing thereon at which the proposed amendments were submitted for discussion, and parties in interest and citizens had an opportunity to be heard. Notice of the time, place, and purpose of the hearing was published fifteen days prior to the hearing in the official newspaper of the County. Said notice described the nature, scope, and purpose of the proposed rules and regulations, and stated the times at which it would be available to the public for inspection and copying at the office of the Cass County Planning Department; and

WHEREAS, the Howes Township Zoning Commission has approved this draft of the amended "Howes Township Zoning Ordinance" and recommends it be adopted by the Howes Township Board of Supervisors.

NOW, THEREFORE, BE IT RESOLVED that the Howes Township Board of Supervisors hereby adopts the amended "Howes Township Zoning Ordiance".

Approved and adopted this 7 day of April, 1992.

Lee K. Frame
Chairman

ATTEST:

Kenneth Hamilton
Clerk

Article I

Introduction

I. Authority: This ordinance is adopted under the authority granted in Chapter 58-03 of the North Dakota Century Code.

II. Purpose: The purpose of this ordinance is to:
1. Implement the Howes Township Comprehensive Plan
2. Promote public health, safety, & general welfare
3. Preserve prime agricultural land and property values
4. Facilitate provision of adequate public facilities
5. Control population density & distribution
6. Secure safety from fire, flood, panic, & other dangers
7. Prevent overcrowding of land.
8. Lessen governmental expenditures
9. Conserve & develop natural resources
10. Regulate and restrict the erection, construction, reconstruction, alteration, repair, or use of buildings and structures; and land for trade, industry, residence, or other purposes.

III. Severability: If any provision or section of this ordinance is adjudged invalid by a court of competent jurisdiction, the remainder of the ordinance shall not be affected.

IV. Repeal: All other ordinances or parts of ordinance of Howes Township in conflict with this ordinance are hereby repealed.

V. Title: This ordinance shall be known as "Zoning Ordinance of Howes Township".

VI. Effective Date: This ordinance shall become effective after a public hearing adoption by the Howes Township Board of Supervisors.

Article II

General Provisions

I. Jurisdiction: The jurisdiction of this ordinance shall include all unincorporated areas of Howes Township.

II. Compliance: Except as hereinafter provided, no building, structure, or land shall be erected, repaired, or used except in conformance with this ordinance.

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III. Agriculture Exempted: Nothing in this ordinance shall be applied for the purpose of preventing or prohibiting the use of land or buildings for agriculture or any of the normal incidents of agriculture.

IV. Interpretation: In the interpretation and application of this ordinance the provisions of this ordinance shall be held to be the minimum requirements. Where this ordinance imposes a greater restriction than existing law, the provisions of this ordinance shall govern.

V. Non-Conforming Uses:

1. Lawful, non-conforming uses of land or buildings existing at the date of adoption of this ordinance may continue provided no structural alterations except for normal maintenance are made and such non-conforming uses shall not be extended to occupy a greater area of land that occupied at the time of adoption.

2. No building or structure destroyed where a non-conforming use has been discontinued for a period of 1 year or has changed to a permitted use shall again be devoted to a non-conforming use.

3. A non-conforming structure destroyed or damaged less than 50 percent of its fair market value may be reconstructed within 1 year of such casualty. If damaged more than 50 percent of its fair market value, such building shall be reconstructed in conformance to this ordinance.

4. The provisions of this section shall not be applicable to conditional uses or any use made non-conforming by a change in district regulations.

VI. Amendments: In accordance with Section 58-03-13 of the North Dakota Century Code, the Board of Township Supervisors may from time to time amend the provisions of this ordinance. Such amendment shall not become effective until after a public hearing at which parties of interest and citizens shall have the opportunity to be heard. At least 15 days notice of the time and place shall be published in the official newspaper of the county. The description of any land within any zoning district, together with any restriction therein, or any amendment to the zoning ordinance, shall be filed with the Board of Township Supervisors.

VII. Definitions: For the purpose of this ordinance, the following definitions have been adopted:

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A. Rules:
   1. Words used in the present shall include the future, the singular number shall include the plural.
   2. The word "person" includes a firm, partnership, association, corporation, or individual.
   3. The word "shall" is mandatory.

B. List of Definitions:
   1. Agriculture: The use of land for agricultural purposes, including the necessary building or structures for farm or farm labor use. Agriculture shall include farming, dairying, pasturage, horticulture, animal and poultry husbandry, and accessory uses and buildings for packing, treating, or storing produce, providing accessory uses are secondary to normal agriculture activities.

   2. Accessory Use or Accessory Structure: A use or structure incidental and subordinate to the main use of the property and located on the same lot as the main use, such as a garage or tool shed.

   3. Building: Any structure used for shelter or enclosure of persons, animals, or chattels.

   4. Conditional Use: A use conditionally permitted in order to reduce any adverse effects on surrounding property.

   5. Dwelling: A building or portion thereof occupied exclusively for residential purposes, but not including mobile recreational vehicles.

   6. Dwelling, Farm: A single family dwelling or mobile home located on a farm which is occupied by the farm's owner or person employed thereon.

   7. Dwelling, Non-Farm: One and two-family dwellings located on a farm or otherwise of which the occupant does not derive at least 50 percent of his income from agricultural activities.

   8. Family: A group of one or more persons occupying a single premise and living as a single housekeeping unit.

   9. Farm: Any aggregate area operated by one person, family, partnership, corporation, or joint venture for agriculture or farming purposes.

   10. Feedlot: The use of land or buildings for the exclusive purpose of concentrated feeding or fattening of

livestock for marketing. The application of feedlot regulations shall be limited to non-farm related enterprises.

11. Home Occupations: Any occupation carried on solely by the occupants of a residence provided: that no more than one room of a dwelling be used for such purposes; no use shall require internal or external alteration or construction; that anything not produced on the premises is sold; and no display of goods or services is visible from the road.

12. Junk Yard: Any land or building used for the storage, sale, or dismantling of obsolete vehicles, junk, and other machinery.

13. Lot: a parcel of land sufficient to provide the yard requirements of the ordinance.

14. Mobile Home: A mobile home is a dwelling unit designed for transportation after construction. A recreational travel trailer is not to be considered a mobile home.

15. Non-Conforming Use: Any structure, land, or building existing at time of adoption or amendment of this ordinance which does not conform to the provisions of the ordinance.

16. Setback: The open space extending the full width of a lot between a building and the centerline of a public road.

17. Structural Alteration: Any change in the supporting members or any substantial change in the roof or exterior walls of a building.

18. Variance: The grant of relief from the requirements of the ordinance where it can be shown that due to unusual conditions of the property, strict application of the ordinance would result in undue hardship.

Article III

District Regulations

I. Establishment of District Regulations: For the purpose of this ordinance, the entire area of Howes Township is zoned agricultural.

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A. Zoning Map - The location and boundaries of the zoning districts are hereby established as shown on the map entitled "Zoning District Map" which accompanies and is hereby made a part of the ordinance.

1. Location of District Boundaries

a) Where the district boundary lines on the Zoning District Map are indicated to follow highway, road, or railroad rights of way, such boundary lines shall be construed to be the centerline of said rights of way unless clearly shown to the contrary.

b) Where any uncertainty exists as to the exact location on the Zoning District boundary line, the Township Board of Supervisors, with a recommendation from the Zoning Commission, shall determine the location of such boundary lines.

II. Agricultural District:

A. Purpose: To establish and preserve areas of agriculture and low intensity development which does not significantly change the existing character of the area.

B. Permitted Uses: Agriculture and agricultural buildings, including farm dwellings, non-farm dwellings, cemeteries, churches, existing railroad rights of way, home occupations, accessory uses to the permitted uses.

C. Conditional Uses: All other lawful use of land may be permitted on conditions as set by the Township Board of Supervisors.

D. Dimensional Standards:

1. Setbacks: Structures - 150 feet
Windbreaks - As specified by the Township Board of Supervisors

2. Minimum Lot Size: Two Acres (87,120 sq. ft.)

3. Lot Width - 100 feet

4. Side Yard - 25 feet

5. Height - 35 feet

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Article IV

Certificate Required

I. Certificate of Zoning Compliance: No building or other structure shall be erected, moved, added to or structurally altered without a certificate issued by the Zoning Administrator. No certificate shall be issued except in conformity with the provisions of this Ordinance except after written order from the Township Board of Supervisors.

1. Permitted Use:

A. Applications: All applications for certificates shall be accompanied by site plans. The site plans shall be drawn to scale, showing the actual dimensions and shape of the lot to be built upon; the exact sizes and locations on the lot of buildings already existing, if any; and the location and dimensions of the proposed building or alteration. The application shall include such other information as lawfully may be required by the Zoning Administrator, including existing or proposed building or alteration; existing or proposed uses of the building and land; existing or proposed parking; the number of families, housekeeping units, or rental units the building is designed to accommodate; conditions existing on the lot; and such other matters as may be necessary to determine conformance with and provide for the enforcement of this Ordinance.

B. Expiration: If the work described in any certificate has not begun within twelve (12) calendar months from the date of issuance thereof, or such work described ceases for a period of twelve (12) calendar months, or if work described in the certificate is not completed within twenty-four (24) months said certificate shall expire. Time limitations cited above shall also apply to accessory buildings. The Zoning Administrator may grant a reasonable extension subject to the demonstration of a hardship condition. If canceled by the Zoning Administrator, a written notice thereof shall be given to the persons affected, together with notice that further work as described in the canceled certificate shall not proceed unless and until a new certificate has been obtained.

C. Construction and Use to be as Provided in Applications, Plans, and Certificate: Certificates issued on the basis of plans and applications approved by the Zoning Administrator authorize only the use, arrangement, and construction set forth in such approved plans and

applications, and no other use, arrangement, or construction. Use, arrangement, or construction at variance with that authorized shall be a violation of this Ordinance.

D. Septic Permit Condition to Certificate: When, for any use, a private sewer system will be used, a septic permit from the Environmental Health Office of the Community Health Dept. of the City of Fargo will be required before any certificate is issued.

2. Conditional Use:

A. Applications: All applications for conditional use certificates shall be accompanied by site plans. The site plans shall be drawn to scale, showing the actual dimensions and shape of the lot to be built upon; the exact sizes and locations on the lot of buildings already existing, if any; and the location and dimensions of the proposed building or alteration. The application shall include such other information as lawfully may be required by the Zoning Administrator, including existing or proposed building or alteration; existing or proposed uses of the building and land; existing or proposed parking; the number of families, housekeeping units, or rental units the building is designed to accommodate; conditions existing on the lot; and such other matters as may be necessary to determine conformance with and provide for the enforcement of this Ordinance.

B. Conditions May Be Imposed: If the Township Board grants the conditional use, the Board may impose such conditions, including time limits, as may be deemed necessary for or appropriate to serve the purposes of the Comprehensive Plan, the Zoning Ordinance and to protect the public health, safety and welfare.

C. Criteria for Approval: No conditional use shall be granted unless the Township Board finds the following:

1. The use will not create an excessive burden on parks, schools, streets, and other public facilities and utilities which serve or are proposed to service the area.

2. The use will be sufficiently compatible or separated by distance or screening from adjacent residentially zoned or used land.

3. The structure and site shall have an appearance that will not have any adverse effect upon adjacent residential properties.

4. The use in the opinion of the Township Board is reasonably related to the existing and projected land use of the Township.

5. The use is consistent with the purposes of the Zoning Ordinance and the purposes of the zoning district in which the applicant intends to locate the proposed use.

6. The use is not in conflict with the Comprehensive Plan of the Township.

D. Public Hearing: When considering an application for a conditional use, the Zoning Commission shall hold a public hearing. At least fifteen (15) days prior to the date of hearing, notice of the purpose, time and place of such hearing shall be published in the official newspaper of Cass County.

E. Order a Certificate be Issued: If the Township Board of Supervisors approve the conditional use application, the Board shall order the Zoning Administrator to issue a certificate of zoning compliance.

F. Expiration: Where applicable, unless otherwise specified by the Board at the time it is authorized, a conditional use shall expire if the applicant fails to utilize such conditional use within one (1) year from the date of its authorization.

No application for a conditional use of a particular piece of property shall be accepted more than once in any twelve (12) month period except.

G. Construction and Use to be as Provided in Applications, Plans, and Certificate: Certificates issued on the basis of plans and applications approved by the Township Board of Supervisors authorize only the use, arrangement, and construction set forth in such approved plans and applications, and no other use, arrangement, or construction. Use, arrangement, or construction at variance with that authorized shall be a violation of this Ordinance.

H. Septic Permit Condition to Certificate: When, for any use, a private sewer system will be used, a septic permit from the Environmental Health Office of the Community Health Dept. of the City of Fargo will be required before any certificate is issued.

3. Variance: As used in this ordinance, a variance is authorized only for height, area, or size of structures or yards.

A. Application: All applications for Variances shall be accompanied by site plans. The site plans shall be drawn to scale, showing the actual dimensions and shape of the lot to be built upon; the exact sizes and locations on the lot of buildings already existing, if any; and the location and dimensions of the proposed building or alteration. The application shall include such other information as lawfully may be required by the Zoning Administrator, including existing or proposed building or alteration; existing or proposed uses of the building and land; existing or proposed parking; the number of families, housekeeping units, or rental units the building is designed to accommodate; conditions existing on the lot; and such other matters as may be necessary to determine conformance with and provide for the enforcement of this Ordinance.

B. Conditions May Be Imposed: If the Township Board grants the variance, the Board may impose such conditions, including time limits, as may be deemed necessary for or appropriate to serve the purposes of the Comprehensive Plan, the Zoning Ordinance and to protect the public health, safety and welfare.

C. Criteria for Approval: No variance shall be granted unless the Township Board finds the following:

1. That there are exceptional or extraordinary circumstances applying to the property in question or to the intended use of the property that do not apply generally to other properties or class or use in the same zoning district.

2. That such variance is necessary for the preservation and enjoyment of a substantial property right possessed by other properties in the same zoning district and in the vicinity.

3. That the authorization of such variance will not be of substantial detriment to adjacent property and will not materially impair the purpose of the ordinance or the public interest.

4. The owner cannot otherwise obtain a reasonable return on this property.

5. The hardship is not self-created.

6. The variance request is the minimum necessary to permit a reasonable use of the land.

D. Public Hearing: When considering an application for a variance, the Zoning Commission shall hold a public hearing. At least fifteen (15) days prior to the date of hearing, notice of the purpose, time and place of such hearing shall be published in the official newspaper of Cass County.

E. Order a Certificate be Issued: If the Township Board of Supervisors approve the variance application, the Board shall order the Zoning Administrator to issue a certificate of zoning compliance.

F. Expiration: Where applicable, unless otherwise specified by the Board at the time it is authorized, a variance shall expire if the applicant fails to utilize such variance within one (1) year from the date of its authorization.

No application for a variance of a particular piece of property shall be accepted more than once in any twelve (12) month period.

G. Construction and Use to be as Provided in Applications, Plans, and Certificate: Certificates issued on the basis of plans and applications approved by the Township Board of Supervisors authorize only the use, arrangement, and construction set forth in such approved plans and applications, and no other use, arrangement, or construction. Use, arrangement, or construction at variance with that authorized shall be a violation of this Ordinance.

H. Septic Permit Condition to Certificate: When, for any use, a private sewer system will be used, a septic permit from the Environmental Health Office of the Community Health Dept. of the City of Fargo will be required before any certificate is issued.

Article V

Administration and Enforcement

I. Zoning Administrator: A person shall be appointed by the Township Board of Supervisors to administrate and enforce this ordinance. The person appointed shall be known as the "Zoning Administrator". He may be provided with the assistance of such other persons as the Township Board of Supervisors may direct.

Duties of the Zoning Administrator shall include:

1. Issuance of all certificates,

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2. Conduct inspections,
3. Maintain records of the ordinance and applications,
4. Transmit to the Zoning Commission all applications for appeals, variances, conditional use certificates, and all applications for amendments.

II. Zoning Commission: A Zoning Commission shall be appointed with the membership composed of the three Township Supervisors.

The duties of the Zoning Commission shall be:

1. Recommend the establishment of plans, rules, regulations, and procedures for the purpose of administrating this ordinance.

2. Assist the Zoning Administrator in conducting inspection of land uses and administrating this ordinance.

3. Hear and forward recommendations on appeals where it is adjudged by the applicant that an error in judgement has been made by the Zoning Administrator.
   A. Procedure:
      i. Any person aggrieved by any order of determination of the Zoning Administrator may within 60 days of such action petition the Zoning Commission for a hearing. Such appeal shall be in writing and shall specify in detail the grounds for the appeal. The appeal shall be filed with the Zoning Administrator.
      ii. Within 30 days of filing, the Zoning Commission shall fix a date for a hearing.
      iii. Notice in writing shall be given to the petitioner at least 5 days prior to the hearing.
      iv. Within 15 days after the hearing, the Zoning Commission shall take action and shall mail by registered mail a copy of its order to the petitioner.
      v. If the petitioner is aggrieved by the determination of the Zoning Commission, the petitioner may petition the Township Board of Supervisors for a hearing.
      vi. The procedure followed by the Zoning Commission shall be followed by the Township Board of Supervisors in hearing the appeal petition.
      vii. If the petitioner is aggrieved by the determination of the Township Board of Supervisors, the petitioner may make an appeal to the Cass County District Court. This appeal must be taken in accordance with the procedure provided in Section 28-34-01 of the North Dakota Century Code.

4. Conduct public hearings and forward recommendations to the Township Board of Supervisors on applications for

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conditional uses, variances, and amendments of this ordinance

5. Review and study from time to time the provisions of this ordinance.

III. Township Board of Supervisors: The Township Board of Supervisors shall have final authority in all matters of this ordinance.

IV. Violations: If any building or structure is erected, constructed, reconstructed, altered, repaired, converted, or maintained, or if any building, structure, or land is used, in violation of this ordinance, the Zoning Administrator, Zoning Commissioners, or Township Supervisors, or any affected citizen or property owner, in addition to other remedies, may institute any appropriate action or proceeding as outlined in Section 58-03-14 of the North Dakota Century Code.

V. Fees: For the purpose of administrating this ordinance, fees may be instituted by the Board of Township Supervisors.

Official
Zoning District Map

HOWES

TOWNSHIP 139 N RANGE 54 W

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

NORTH

KEY

☐ Agricultural District

Date Adopted: 4-7-92

BY: Lee K. Frazee
Chair, Township Board

Amended: _____ _____ _____

_____

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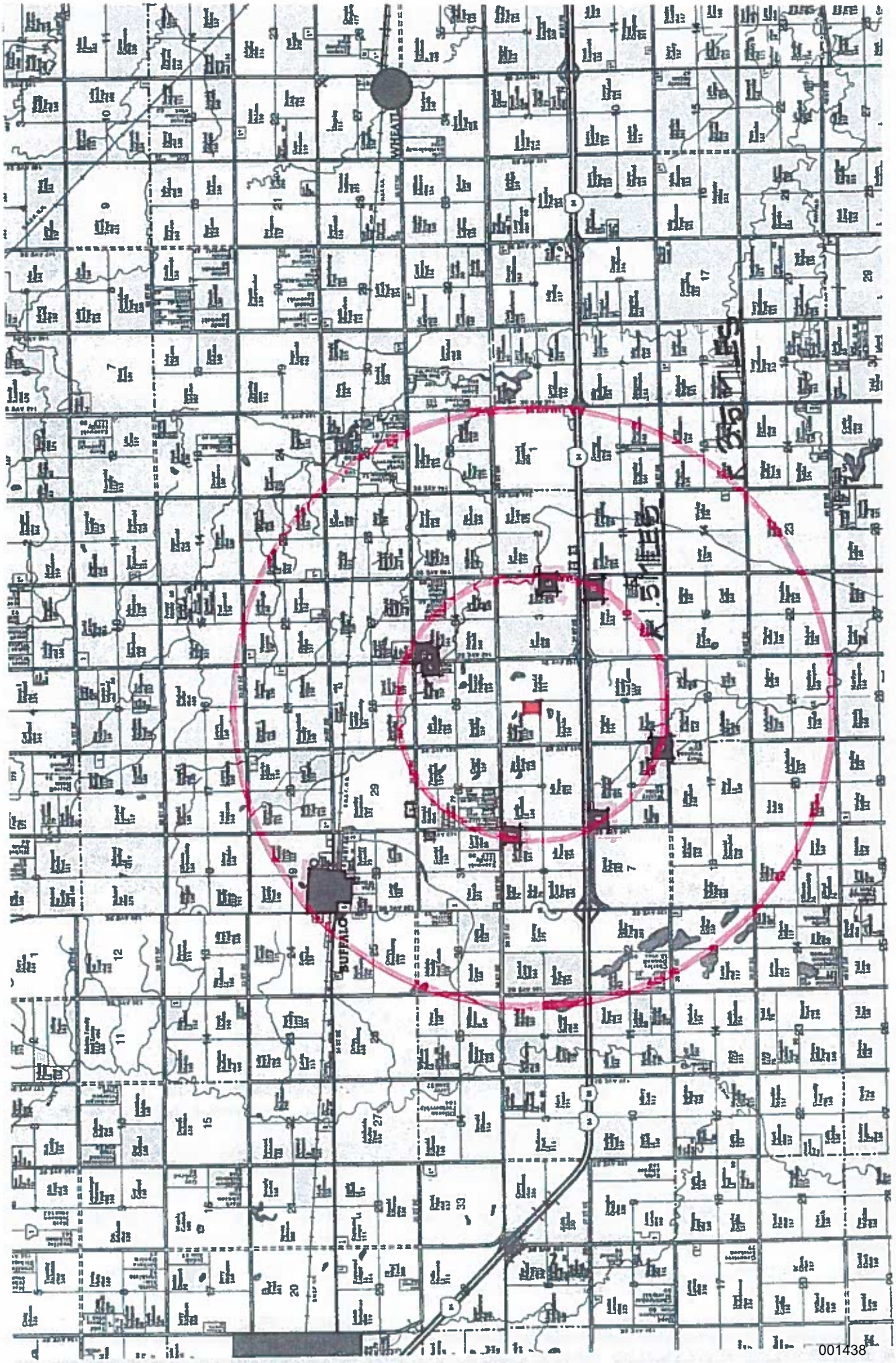
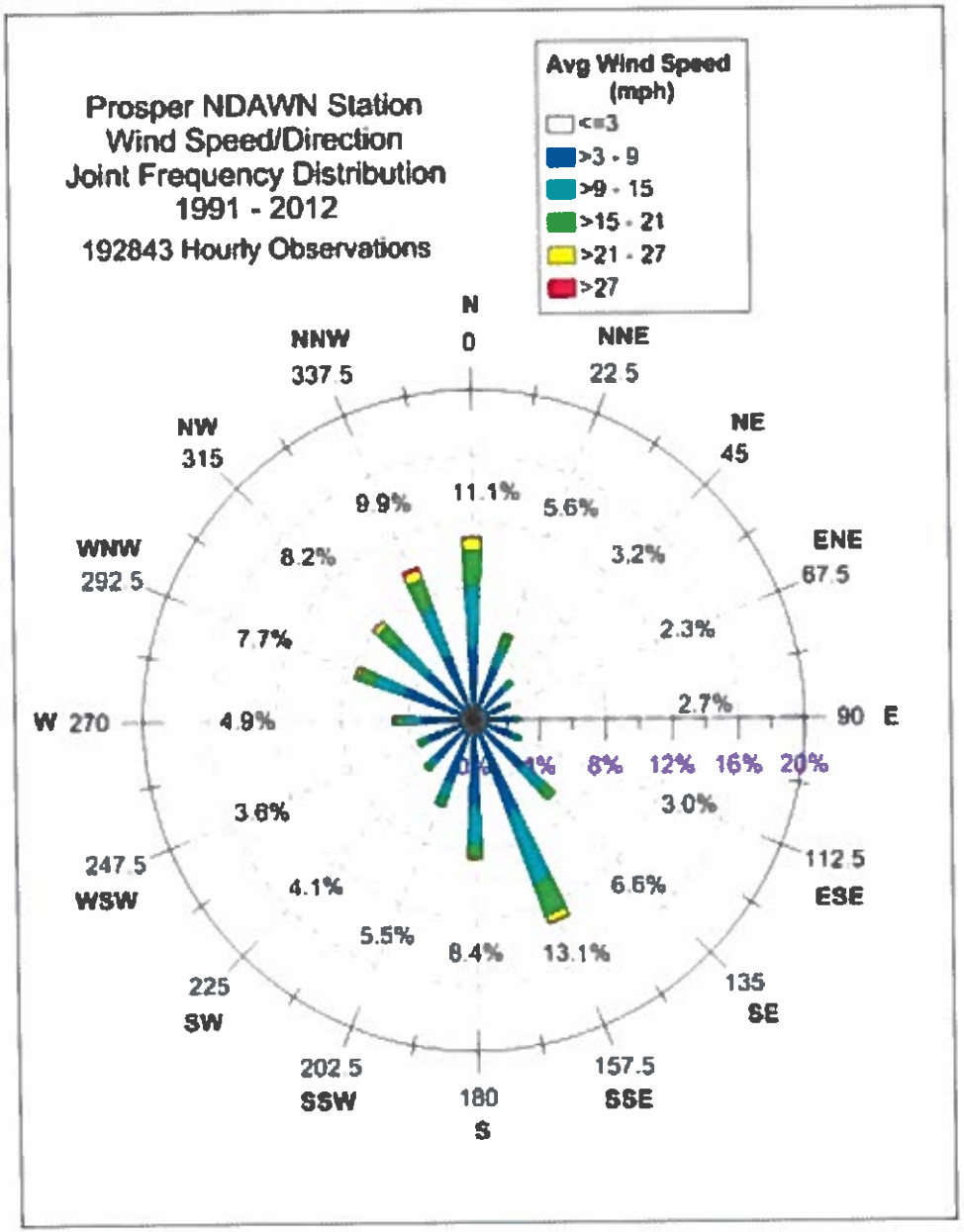

WHEAT
BUFFALO


Prosper NDAWN Station
Wind Speed/Direction
Joint Frequency Distribution
1991 - 2012
192843 Hourly Observations
Avg Wind Speed (mph)
<=3
>3 - 9
>9 - 15
>15 - 21
>21 - 27
>27
N
0
NNE
22.5
NE
45
ENE
67.5
E
90
ESE
112.5
SE
135
SSE
157.5
S
180
SSW
202.5
SW
225
WSW
247.5
W
270
WNW
292.5
NW
315
NNW
337.5
11.1%
5.6%
3.2%
2.3%
2.7%
3.0%
6.6%
13.1%
8.4%
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4.9%
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0%
4%
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12%
16%
20%

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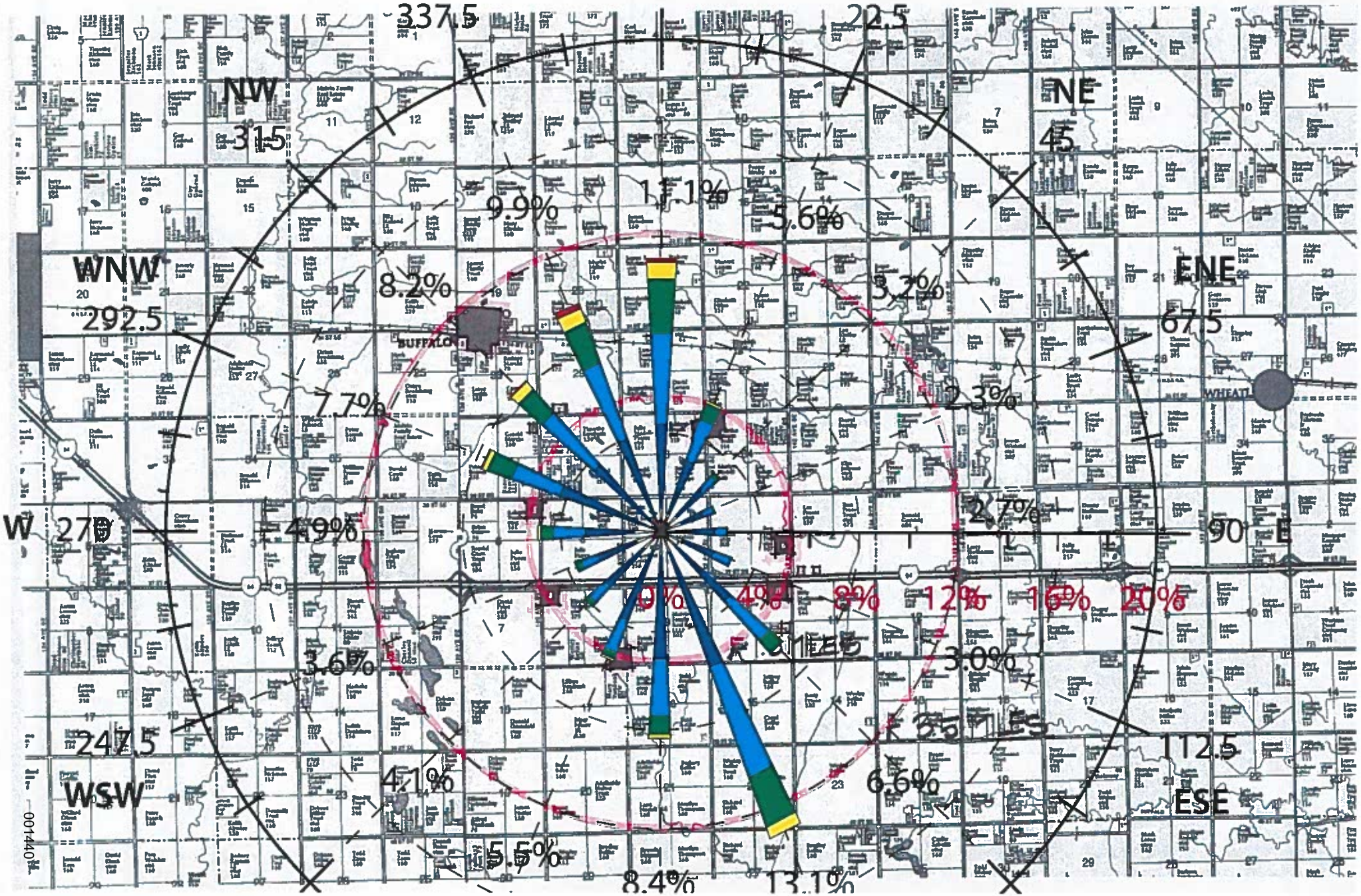
337.5
22.5
NW
NE
315
45
11.1%
9.9%
5.6%
WNW
ENE
8.2%
3.2%
292.5
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7.7%
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270
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WSW
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ESE
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8.4%
13.1%

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5. Application Review

Design/Plan Analysis

Design/Plan Analysis

The 40 acre site has basically 6 structures (GDU Facility, Farrowing Facility, Gestation Facility, Office, Shop and a Compost Structure). The GDU, Gestation Farrowing Facility and the Office are all linked together. The Farrowing Facility and the Gestation Facility are linked with a structure that is more than just an access corridor. They are linked with a structure that includes the link itself, loadout area, holding pens, cistern and other support functions.

For future reference within this report, the "deep pit" structures include the GDU/Isolation Facility as well as the Gestation Facility.

GDU/Isolation Facility

Dimensions:

114.7' x 174.5' = 20,015 S.F.

Subgrade 1138.8

Tile Outlet 1137.0

Water Table 1141.1

4.1 Feet Below the Water Table

Gestation Facility

Dimensions:

181.5' x 770' = 139,755 S.F.

Subgrade 1138.8

Tile Outlet 1137.0

Water Table 1143.9

6.9 Feet Below the Water Table

Calculated Expansion of the Concrete Foundation of the Gestation Facility:

770 x 12 (size in inches) x .0000055 (expansion coefficient of building concrete) x 100 (temperature range -10 to 90 degrees) = 5.5"

Calculated Expansion of a pre-engineered metal building system of the Gestation Facility:

770 x 12 (size in inches) x .000006.7 (expansion coefficient of metal skin building materials) x 100 (temperature range -10 to 90 degrees) = 6.7"

Introduction Narrative

Introduction Narrative:

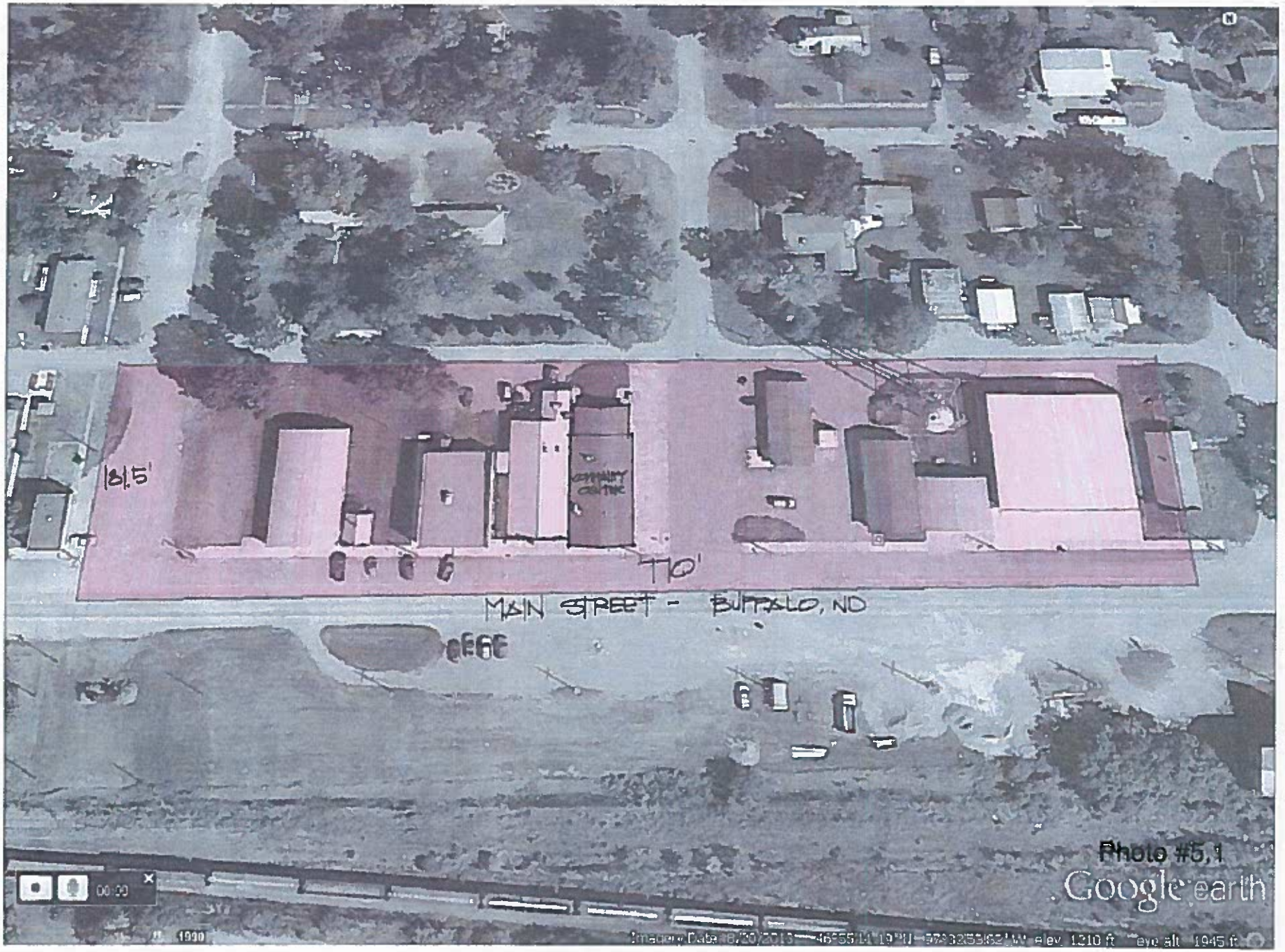
If you buy into this being an Agrarian Occupancy, the facility is exempt from the Model Codes of the State of North Dakota except Mechanical/Plumbing Codes and Electrical Codes.

However, consider the intensity of use and size of these buildings (the Gestation Facility alone is more than 2x and approaching 3x the size of a football field – see Photo #5.1), the potential of negative environmental effects, and the Life Safety of the workers in this facility. In an effort to protect the lives of the workers, mitigate the potential costs in loss of property and insurance claims, and to protect the environment, we ask that the following concerns in the application, concerns over the quality of the design documentation, and ultimately concerns of the configuration and details of the design itself, be carefully considered prior to the issuing of the permit itself, and that notwithstanding if a permit is issued, when considering and stipulating the official Approval Conditions of the permit.

If this commercial facility is permitted, and these concerns are not addressed, and where appropriate, integrated into the Approval Conditions of the Permit, who will safeguard this Community?

A building of this size and intensity, in any other setting, would have serious code requirements to protect the Health, Safety and Welfare of the Public. If approved, we demand that the State Health Department use whatever tools (Approval Conditions) are available to truly live up to The NSHD purpose and mission statement:

> ***"The mission of the North Dakota Department of Health is to protect and enhance the health and safety of all North Dakotans and the environment in which we live."***


181.5'
COMMUNITY CENTRE
770'
MAIN STREET - BUFFALO, ND
Photo #5,1
Google earth

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Concerns on the Permit Application

Concerns on the Permit Application – Technical Specifications

When reviewing the technical portions of the illegal permit application, there are some real concerns regarding the care and quality of the work. One would expect a nearly flawless submittal (in terms of technical aspects), due to the intensity, size, and exposures of this facility.

General Quality of the Submittal:

17 locations where material requirements are not included/referenced

2 conflicts in the material requirements

Specific Issues: Section 5: Technical Specifications of the (illegal) Permit Application

Page 4: No references for "Methods 1, 2, or 3".

Page 5: Testing – no frequency of tests specified.

Page 6: "strip 4"- 6" of topsoil" is noted on the drawings – soil borings note 6+" - Placing fill on organics is a potential for consolidation and differential settlement.

Conflict with geotextile splice overlap on page 7, 18" or 24"?

Page 7: "If Proctor Density tests are to be performed on-site..." Why wouldn't they be required?

Page 9: Nine different notations to material requirements that are not included in the documents or referenced to a Standard

Page 10: Compressive Strength is not specified.

Page 12: Incorrect reference to "Section 24".

Page 14: Expansion Joints/Control Joints referenced to locations on the drawings and are not indicated on the drawings.

Waterstop specified by reference that is not included - the waterstop is a critical assembly for this facility. It should be definitively specified and should be subject to inspection.

Page 15: Reference to Section 24 which does not apply (two locations).

Page 16: Rates of application for curing compound are meaningless without a Product/material specified.

Page 17: Non-shrink grout not specified.

Page 18: Reference to "Nebraska Department of Roads" as a standard is not likely known by North Dakota Contractors.

Page 19: Rebar material requirements are referenced to non-existent Specifications.

ACI Standard 318 only is referenced. ACI 350R-89 is referenced in the North Dakota Livestock Program Design Manual, and is appropriate for the quality of care that the concrete in this facility should meet and should be included.

Page 20: Inspection of rebar is not included, however is critical to insure quality.

Page 22: Insure that ACI 350R-89 is met in regards to placing and coverage/protection.

Page 23: Incomplete directive under 3.10.1.6.

Page 24: Pipe bedding is not specified.

Page 25: Reference to Bedding "if required" - Bedding is a requirement to prevent settlement at fill areas.

Page 29: Redundant specification back to 2.6.

The above referenced items, as any one item do not pose a significant issue as long as they are remedied though a revised submittal. Collectively, however, they indicate a pervasive tendency that this technical specification was submitted as a nonresponsive boiler plate effort, or a submittal lacking professional quality control. Whatever the reason for the volume of errors, it raises concerns about the balance of the work product.

Concerned Citizens of Buffalo requires a stringent review as to whether this submittal meets minimum standards for its approval, however, as a minimum, all corrections must be made prior to the issuance of a permit.

Site Review Concerns

Site Review Concerns

40 Acres/1,263,690 S.F. Approx. 400,000 S.F. Impervious Surface Area/32%

The drainage of this 40 acres currently sheet drains into established field cuts/tillable drainage swales. Not all of the 40 acres drain into the same singular point that the proposed site modifications now cause (photo #5.2).

Please review the comments from Roger Kluck, P.E., civil engineer (Exhibit 5A, attached) regarding deficiencies in the storm water/runoff design/calculations/requirements.

The (illegal) Permit Application site plan indicates a 5 row shelter belt/tree planting surrounding the 40 acre site, and Part 9C: Order Control Plan, Article G. Best Management Practices , Paragraph 4 of the (illegal) Permit Application states "Vegetative barriers is proposed as a part of the plan to reduce odor" is also part of the (illegal) Permit Application. The concern is that there are no planting schedule/planting details/specifications in the permit application to establish this "vegetative barrier" and it will not get installed unless mandated. In the event it would be installed, it would be several years before it would have in any impact of beneficial service unless substantial specimen plants are utilized and maintained.

Please find the recommendations (Exhibit 5B, attached) that must be implemented in the Approval Conditions (from a qualified landscape company) as to the type, size, and spacing of plant materials, to make this a meaningful effort. Ongoing maintenance would also be expected under the Approval Conditions.

The (illegal) Permit Application indicates that water will be gained from onsite wells, these are not located on the plans (to insure safe setbacks from compost structures and runoff areas). It has been confirmed that the Applicant has approached Cass Rural Water for service to the site. It is assumed that the water usage will be in the magnitude of 500,000 gallons per day. Concerned Citizens demand, in the event that rural water is used, that a statement from Cass Rural be obtained to indicate this does not endanger the reliable supply of water to the City of Buffalo and the

surrounding water users and that any utilization/installation cost of this service be borne by the Applicant, and not passed on to the current users.

Photo # 5.2

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Ground Water
Subsurface Construction
Foundation Concerns
Site Elevation

Ground Water/Subsurface Construction/Foundation Concerns/Site Elevation

Ground Water

The deep manure holding pits of the GDU/Isolation Facility and the Gestation Facility have a subgrade elevation of 1138.8 (with drain tile outlet elevation of 1137.0) and the water table, according to the soil boring logs (within only 2 hrs wait time – normally, especially in clay soils, the drilling company comes back 12 to 24 hrs later to establish the "static level"), indicate elevations of 1141.1 and 1142.9. This means that the "deep holding pits" have exposures of 4.1' and 5.9' (respectfully) into the water table. Again these water table depths were documented with only a 2 hr wait time and were executed during what can be characterized as a "dry late summer and fall".

The presence of this ground water presents additional very concerning issues. One of these concerns is that the shallow ground water has not been tested for its content. The following article elaborates on that issue and on the other concerns.

Subsurface Construction

From the permit application, 2" granular subgrade fill is documented under the deep pit slabs. The drain tile is 4" diameter connecting into 6" diameter end tile. The 4" tile runs longitudinal under the facilities on 40' centers.

From the (illegal) Permit Application it is stated;

> *"<u>Leak Detection:</u>*
> *Drain tile will be placed under the deep pits of the gestating barn and the isolation barn that will serve a dual purpose: (1), it will collect any clean water from outside the deep pits, thereby acting as a leak detection system, and (2), it will collect and clean water from outside water sources from applying pressure to the walls as well as premature deterioration of the concrete. Water collected in the drain tile will be collected in a shallow containment pond."*

That statement acknowledges the potential for leaks in the pits. Thus the real threat of the sump water being "effluent" and not "clean water". There is a concern that if a leak develops, there is no way of addressing it without a very interruptive structural repair effort, say nothing of the timeliness of actions before the leak is detected and acted upon.

Concerned Citizens demand the following concerns be addressed by adding the subsequent resolutions/mitigation efforts be added to the Approval Conditions. Due to the extremely high potential of hydrostatic pressure under the deep pit floor slabs, increase the granular subgrade to at least the depth of the tile (4" or 6" respectively) it is feeding, reduce the spacing of the tile to 20' centers, and require that the granular fill be a free draining "pea rock" or similar material. These changes will be necessary to reduce the hydrostatic pressure from beneath the pit slabs, and to carry away any "leaks" from the pit that may contaminate the ground water.

Further, to reduce the potential for ground water and surface water runoff, the sump water must be treated like "effluent" and be "completely contained" not just retained. It cannot be allowed to run across the property to the south. This containment pond must meet the requirements outlined in the ND Department of Health, North Dakota Livestock Program Design Manual, Section 5 and any other applicable requirements of that publication.

As mentioned previously, this sump water has not been tested for salts, alkalinity, etc. The permit application design will have this water running across the neighboring agriculture crop land (to the south). This must not be allowed for two reasons; first, it has the potential to "poison" the topsoil and reduce crop yields by adversely affecting the PH balance in the soil. Secondly, it will result in an almost continuous flow of water into field drainage cuts that already collect the bulk of the upstream water and make the SW ¼ of Section 4 one of the last fields that can be accessed in the spring due to wetness. Allowing the increased flow of surface water and adding shallow subsurface water will exasperate this existing condition making it impossible to till and plant in a timely manner each spring, thus negatively impacting the neighbor's crop operations (see photo #1 for confirmation of the

water flow). The Owner of that agricultural land is committed to take separate legal action to protect this from happening.

Foundation Concerns

The pit construction (slabs and walls) will be subject to considerable forces both hydraulic (from the manure within and from ground water) and from surloading of the adjacent site. Further the concrete with be subject to severe sulfate exposure due to the contained manure and potential contaminated ground water. These concrete assemblies are required by the North Dakota Livestock Program Design Manual to meet the requirements of ACI (American Concrete Institute Standards) 318-89, ACI 350-89 and ACI 351R-93/AWWA (1994).

Mix design, rebar coverage and placement are all in question. With the amount of initial curing shrinkage, due to lack of control joints, and temperature movement (5+" as calculated under the Design/Plan Analysis portion of this report), due to the size and lack of expansion joints, the concrete structure will see a deterioration after only a couple years of seasonal temperature stress and movement. As per publication ACI 350 – Requirements for Concrete Exposed to Sulfate-Containing Solutions, Table 4.3.1, the mix design (required to be 5000 PSI compressive strength and sulfate resistant additives – pozzolan, utilized), pit liner, rebar coverage and placement all must be integrated into the Approval Conditions to reduce potentials for deterioration of the concrete structure and subsequent environmental contamination. It is an engineering fact/standard of care, that when loading can be expected from either side of a foundation wall, a double matt (inner and outer) should be utilized to contain the tensile forces on each of the opposite face of the wall and to minimize elongation of rebar to minimize how much a crack can open – thus minimizing leaks. The (illegal) Permit Application does not include a double matt. Further, it is common practice (and also contained in the North Dakota Livestock Program Design Manual, page 36) to protect "steel and other corrodible material".

To meet this requirement, the Permit Application would require epoxy coated rebar and misc. embedded items (anchor bolts, embedded angles etc.) be fabricated of

stainless steel items in the Approval Conditions to protect this facility (if approved) into the future. None of these requirements have been meet.

One of item, which may seem insignificant, is the specification, location and details for water stops both at construction joints (joints between concrete pours) and assembly joints (joints between walls and stabs etc.). These assemblies are critical to contain contamination from "leaking" into the ground water. These assemblies need to be of high quality, carefully specified and detailed, and finally, inspected.

Site Elevation

The biggest singular requirement that must be placed into the Approval Conditions, is to require that the site elevation (individual deep pit structures) be raised above the established ground water table. Failure to do so will immerse the manure pits well into the established water table and expose the water table to an inferior design destined to leak and cause contamination. The invert of the drain tile should be at least 1' above the reported water table due to seasonal variation and some "freeboard" to protect the ground water from potential contamination. This translates into setting the subgrade of the GDU/Isolation Facility and the Gestation Facility to approximately 1145.0, effectively getting the pits and the associated drainage assemblies approximately 1' above the established ground water elevation.

Additional Construction Concerns

Additional Construction Concerns

Differential Settlement

The Farrowing Facility footings and foundations (shallow pit) bear on fill material, the Gestation Facility footings and foundations (deep pit) bear on excavated ground (undisturbed). Further, the soils directly below the fill (under the Farrowing Facility) have a very low bearing capacity rated at 5 blows per foot – as noted from the "N" Values (Blows/Ft) from the Soil Boring Logs.

Given the size of these facilities, and the vastly differing bearing characteristics of the soils, there is a very high potential of differential settlement within the footprint of each facility and between the facilities. There is a 10" connecting PVC sewer pipe that connects these two facilities (100' apart), and it is set at .5% slope and is gravity fed. The potential for problems include constant plugging to outright pipe shear/failure and subsequent ground water contamination.

Water Table Level/Borings

As previously mentioned, the static water level was documented in a time frame of 2 hrs after the initial drill. In clay type soils is can take a minimum of 24 hrs, to as long as a week, for the water level to stabilize to its static or uninterrupted levels.

Within the North Dakota Livestock Program Design Manual, under Section 4. SITE SELECTION AND ASSESSEMENT STANDARDS, Article 4.3.2 Site Assessment Requirements, it states:

> *"There shall be a minimum of three soil evaluations in the manure storage structure area..."*

This requirement has not been met at the deep pit of the GDU/Isolation Facility nor the Fallowing Facility – both of which not only receive the manure, but also contribute to the storage capacity of the facility.

Facility Plans

Given that this structure is an "agrarian" occupancy, and that it is not subject to a local jurisdiction of authority, in terms of general building code enforcement, however, due to the size, use, and intensity of its function, and potential of risk to animals, people and environment, NDDH must require that basic building plans of the superstructure be submitted for some level of review. Only site design and foundation details have been submitted under this permitting exercise. This when one of the buildings will be subject to over 5" of temperature movement in its foundation, and over 7" of temperature movement in the metal structure above (see expansion calculations at the beginning of this section).

Critical construction activities and assemblies such as excavation (inspection of trenches), rebar placement, concrete forms, waterstops, etc. all should be subject to special inspections and/or independent inspections from a qualified construction inspection agency.

Mechanical/Ventilation

No information is included in the Permit Application that deals with specific movement of the air through the facility, especially from the manure pits.

Bio-filtration is not included in the submittal under Section 9A: OPERATION & MAINTENACE GUILDLINES, Article IV. (Oder Control). It has been mentioned several times by supporters of this facility, that claim to have knowledge of this fact, that, the facility will be use "odor filtration" and that "...odor will not be a problem - These are lean and green and there are "after burners" that eliminate the smell...".

Given that assurance, the Concerned Citizens demand that Bio-filtration of the exhaust air leaving these facilities be installed and maintained as an Approval Condition.

Electrical

No information is included in the Permit Application that deals with specific conditions of the electrical service and systems.

The following excerpt comes from the University of Minnesota Extension Fact sheet of September 5, 2012:

> *Foaming on the manure surface in deep-pit barns is not a new phenomenon, but until recently spontaneous foaming was rare. Foaming incidence has increased significantly since 2008 and concerns over the potential hazards posed by foam have risen accordingly.*

It is a very well-known condition that in the Midwest there have been problems with manure foam forming over the top of the manure when in deep storage pits. These recent studies have looked at the effectiveness of using rumensin to treat these pits. Spreading of the manure containing this chemical has not been approved.

The following is also an excerpt from the above referenced publication:

> *Note that **neither** Rumensin 90 **nor** Coban (both trade names for rumensin) is environmentally approved to be added to manure in a pit if the nutrients will be added to the land.*

The following excerpt is from a white paper titled "Op Ed: Fundamental Problems", dated September 2010, by Bob Watson and included in the publication "Unintended Health and Environmental Consequences of CAFO Agriculture" by Bob Watson and Larry Stone:

> *Based on the conversations with producers at the World Pork Expo, this op-ed concerned the problem of foaming in pits beneath hog confinements, exacerbating the already serious problem of dead pigs and flash fire caused by hydrogen-sulfide and methane*

The concern for flammable build-up remains in these pits and with documented fires which results in almost total loss of livestock. One such fire which occurred May 11, 2015 near Jasper Minnesota, resulted in the death of two workers that were cleaning the facility, and a total loss of structure.

A report from the Kansas Chapter of the Sierra Club titled "Pig Confinement Technology Risks Deadly Fires" dated August 12, 2013 states;

> *In 2011 and 2012 there were at least 22 hog barn fires in the U.S. and Canada that killed over 28,000 pigs.*

Given the real exposure/existence of explosive/flammable gases being released and subsequent potential of flash over fires, it is imperative to consider classifying all electrical devices – that is making lights, switches, motors, etc. explosion proof. Given these conditions, the Concerned Citizens demand that all electrical devices be "Class 1 Division 1" (explosion proof) as an Approval Condition.

Summary

Summary

Like the review of the technical specifications there are a multitude of concerns, however unlike the technical specifications, any one of the above referenced design/configuration concerns, can pose a significant issue to create serious risks to animals, environment, and people. Collectively, they create a facility that cannot be permitted to move ahead and again give cause to deny the approval of this illegal permit application due to the pervasive tendency of these multiple concerns.

Again, the Concerned Citizens of Buffalo request a close review as to whether this submittal meets minimum standards for its approval. In the case of the afore mention design/configuration concerns, **ALL** corrections/modifications must be included as an Approval Condition, prior to the issuance of a permit to protect animals, environment, and people from serious risks.

Exhibits

Exhibit 5A: Storm Water Assessment Review

EXHIBIT 5A.

March 16, 2016

Concerned citizens of Buffalo, ND

At the request of the concerned citizens of Buffalo, ND, I have prepared the following report and summary concerning the proposed Rolling Green Family Farms RE, LLP Hog Operation in the NW ¼ Section 4, TWP 139N, R54 west in Cass County, ND. My review and analysis followed two primary areas:

1. Cass County planning and zoning requirements.
2. North Dakota requirements for storm water runoff.

The following are the findings from my preliminary review.

We were provided with plan sheets index thru 11 of a 30 page plus 4 addendum set of plans. We were also provided with stormwater report pages 7 and 8 and two each -25 year discharge charts and two each ditch analysis charts. We also received a portion of a "Section 8" report titled Geologic/Hydraulic or soil information.

I. The Cass County Planning and Zoning Ordinance covers several key areas that serve the basis for local requirements for the subject facility and my review of the documents submitted.

1. Section 607 – Proposed drainage shall demonstrate no adverse impact on surrounding land and drainage systems.

   Section 608.04 System Demand.

   b. Stormwater management facilities shall be provided so that the peak discharge of the calculated post development runoff to an adjacent property does not exceed the peak discharge of the calculated pre-development runoff. Runoff calculations for the pre and post development comparison shall consider three (3) different storm frequencies: the two (2), ten (10), and one hundred (100) years storm events.

   Response: The reports provided to me only looked at the post construction flows for a 25 year rain event and the plans do not indicate any attempts to mitigate post construction storm flows from the subject site.

2. Section 605.05 Stormwater drainage easements required…, "easements shall be required for all conveyance systems crossing private property…".

   Response: No evidence of signed drainage easements from downstream properties were provided.

3. Section 403.04 – Plan information.

   P. Erosion control and sedimentation: The following storm water management data shall be provided for all proposed major subdivisions plans designed in accordance with Section 608 of this Ordinance. This information may be provided on a sheet with other data or on separate sheets and need not necessarily be recorded with the Final Plat. In the case of any dispute in the methodology used in the design of any storm water management plan

and/or in the presentation of such information, the Planning Commission shall make the final determination on design criteria, methodology and form of presentation.

1) All calculations, assumptions, criteria and references used in the design of the storm water management facilities, the establishment of existing facilities capacities and the pre and post development peak discharges.
2) All plans and profiles of the proposed storm water management facilities, including the horizontal and vertical location, size and type of material. This information shall be to a detail required for the construction of the facilities.
3) For all basins, a plotting or tabulation of the storage volumes and discharge curves with corresponding water surface elevations, inflow hydrography and outflow hydrography.
4) For all basins which hold two (2) acre feet or more of water and have an embankment that is six (6) feet or more in height, soil structure and characteristics shall be provided. Plans and data shall be prepared by a registered professional engineer. These submissions shall provide design solutions for frost-heave potential, spring-swell potential, soil bearing strength, water infiltration, soil settling characteristics, fill and back-filling procedures and soil treatment techniques as required to protect the improvements for adjacent structures.
5) All erosion and sedimentation control measures, temporary as well as permanent, including the staging of the earth moving activities, in sufficient detail to clearly indicate their function.
6) The guidelines for lot grading within subdivisions. This information shall identify the direction of storm water runoff flow within each lot and the areas where storm water runoff flows will be concentrated. This information shall be provided by flow arrows or topographic data (see
7) Appendix 15 for examples). In areas where the Planning Commission feels additional lot grading information is needed to assure proper function of the storm water management facilities, specific grading information will be required as part of the Final Plat submittal.

Response: **The plans provided did not include a storm water pollution prevention plan or related details. The inclusion of these plan sheets in a site development plan is also required by the North Dakota Health Department along with details to establish that plan design follows North Dakota Health Department requirements for site runoff. The reports and plans provided also did not follow the stormwater analysis methodology required in this section.**

4. The planning and zoning ordinance Appendix 7 outlines onsite parking requirements.

   Response: The plans provided did not include an area or design for necessary parking facilities for this size of site development.

5. The zoning ordinance requires a traffic impact analysis that studies the effect on surrounding roads by the subject development Appendix 1 outlines the study parameters.

   Response: There was not a traffic study included in the documents provided.

6. Plan Review: In studying the plans provided. I could not find design details for clean water diversion 1A, clean water diversion 2B, and Diversion 2C.

Response: These details are important to determine slopes and ultimately flow rates and flow routes.

7. Pervious and Impervious Calculation and stormwater detention computation.

   A. Pre-construction 29.01 acres. Land is used for farming.
   B. Post construction pervious 8 acres or 28%.
   C. Post construction impervious 21.01 acres or 72%.
   D. The City of Fargo uses a provided formula for computing stormwater detention requirements using the total developed acreage and the percent impervious. This calculation is attached and finds for 10 year storm event that detention shall be as a minimum 84,034.43 cubic feet of storage and for a 100 year storm event detention shall be a minimum 152,727.51 cubic feet of storage. The formula also determines the allowable release rate from a control structure and shall not exceed a 10 year post construction flow rate of 15.00 CFS and a 100 year rate of 26.0 CFS. (See attachment 1)

Response: The stormwater analysis provided shows that;
Area 1 has a 25 year peak flow of 23.25 CFS.
Area 2A has a 25 year peak flow of 10.3 CFS
Area 2C clean water diversion has a 25 year peak flow of 10.3 CFS.
The total post construction flows from these 3 areas in a 25 year event is 43.85 CFS and do not cover the whole site. This number exceeds the computation guidelines.

8. Appendix 12 of the Cass County ordinance requires that the engineer certify that the storm drainage plan and facilities are designed in conformance with the ordinance.

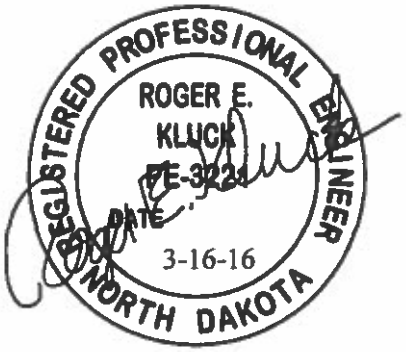
Response: There was no certification provided. The total flow from the three subject areas during a 25 year event with no detention is 43.85 CFS. The Fargo formula that is accepted for use in Cass County identifies maximum site release flows of 15.00 CFS as the controlling flow rate from the site utilizing stormwater detention and a controlled outlet structure. The plans provided do not include any on site detention or control of water leaving the site to mitigate downstream effects.

II. Summary:
I performed a preliminary analysis of the potential flows for a 2 year, 10 year, and a 100 year storm event for the pre-construction condition for the subject property. This preliminary report is found in attachment 3 and finds the following:

Pre-construction 2 year: 12.05 CFS
Pre-construction 10 year: 23.60 CFS
Pre-construction 100 year: 48.52 CFS

My review of the submitted plans and included documents are found in this report. There were several areas identified that did not follow Cass County and North Dakota Health Department design methodology requirements. The site design engineer needs to follow the ordinance requirements and provide the necessary analysis, reporting, and stormwater detention before construction is authorized. The site design as provided does not identify sufficient area for onsite stormwater detention to control off site drainage to mitigate adverse effects to downstream properties.

Roger E. Kluck, P.E. (ND, MN, SD, Montana pending)



Retention Requirements for Sites Under 25 acres

Q=120*A.55*1.2

Total Acres	Percent Impervious	V - 10 yr Cubic ft Retention	V - 100 yr Cubic ft Retention	Allowable Realease Rate(10)	Allowable Release Rate (100)
29.01	72	84,034.43	144,352.19	14.505	29.01

Retention Requirements for Sites 25 - 100 acres

Total Acres	Percent Impervious	V - 10 yr Cubic ft Retention	V - 100 yr Cubic ft Retention	Allowable Realease Rate(10)	Allowable Release Rate (100)
		0.00	0.00	9	16

Retention Requirements for Sites Greater than 100 acres

Total Acres	Percent Impervious	V - 10 yr Cubic ft Retention	V - 100 yr Cubic ft Retention	Allowable Realease Rate(10)	Allowable Release Rate (100)
		0.00	0.00	16	26

Notes:

At 25 acres the methods are roughly equivalent, both in retention requirements and the allowable discharges

At 160 acres (with a C-factor of 0.6), this method provides for approximately 20 Acre-feet of storage

If sites exceed a C-factor of 0.6, they would be required to provide on-site retention on all sites whether regional retention facilities are provided or not

Minnesota Drainage outflow with modified 100 year retention requirements of + 0.2% per acre of drainage basin

Enter your information into the yellow boxes

Calculate Reset Form

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United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Cass County, North Dakota

March 14, 2016

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (http://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the

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individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

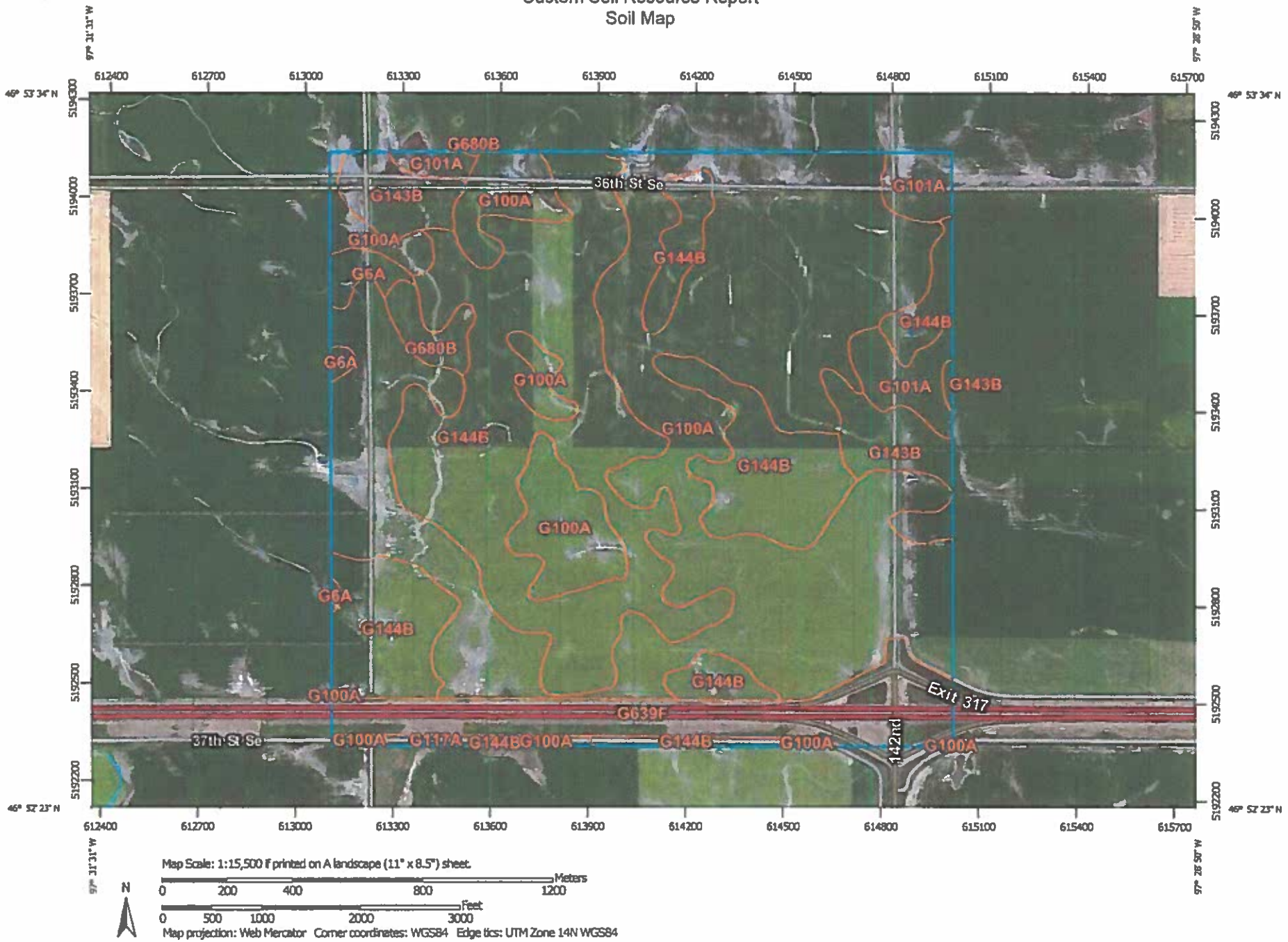
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map



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MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cass County, North Dakota
Survey Area Data: Version 15, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Aug 27, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

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Map Unit Legend

Cass County, North Dakota (ND017)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
G6A	Vallers loam, 0 to 1 percent slopes	8.9	1.0%
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	421.3	48.5%
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	30.6	3.5%
G117A	Hamerly loam, saline, 0 to 3 percent slopes	2.7	0.3%
G143B	Barnes-Svea loams, 3 to 6 percent slopes	40.8	4.7%
G144B	Barnes-Buse loams, 3 to 6 percent slopes	288.0	33.1%
G639F	Orthents-Aquents-Urban Land, highway complex, 0 to 35 percent slopes	67.1	7.7%
G680B	Barnes-Sioux complex, 1 to 6 percent slopes	10.0	1.1%
Totals for Area of Interest		869.3	100.0%

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used.

Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Cass County, North Dakota

G6A—Vallers loam, 0 to 1 percent slopes

Map Unit Setting

National map unit symbol: 2q3ts
Elevation: 980 to 2,130 feet
Mean annual precipitation: 17 to 24 inches
Mean annual air temperature: 37 to 46 degrees F
Frost-free period: 120 to 150 days
Farmland classification: Prime farmland if drained

Map Unit Composition

Vallers and similar soils: 67 percent
Minor components: 33 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Vallers

Setting

Landform: Depressions, ground moraines
Landform position (three-dimensional): Dip
Down-slope shape: Concave
Across-slope shape: Concave, linear
Parent material: Fine-loamy till

Typical profile

Ap - 0 to 8 inches: loam
Bkg1 - 8 to 30 inches: loam
Bkg2 - 30 to 41 inches: loam
BCyg - 41 to 79 inches: loam

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.14 to 1.42 in/hr)
Depth to water table: About 0 to 18 inches
Frequency of flooding: None
Frequency of ponding: Rare
Calcium carbonate, maximum in profile: 35 percent
Gypsum, maximum in profile: 5 percent
Salinity, maximum in profile: Slightly saline to moderately saline (4.0 to 8.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 7.0
Available water storage in profile: High (about 9.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4w
Hydrologic Soil Group: B/D
Ecological site: Wet Meadow (R055BY071ND)
Other vegetative classification: Wet (G055BY900ND)

Minor Components

Hamerly

Percent of map unit: 13 percent
Landform: Ground moraines
Landform position (three-dimensional): Dip
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Limy Subirrigated (R055BY058ND)
Other vegetative classification: Subirrigated (G055BY700ND)

Vallers, moderately saline

Percent of map unit: 8 percent
Landform: Depressions, ground moraines
Landform position (three-dimensional): Dip
Down-slope shape: Concave
Across-slope shape: Concave, linear
Ecological site: Saline Lowland (R055BY060ND)
Other vegetative classification: Saline (G055BY895ND)

Tonka

Percent of map unit: 5 percent
Landform: Depressions
Landform position (three-dimensional): Dip
Down-slope shape: Concave
Across-slope shape: Concave
Ecological site: Wet Meadow (R055BY071ND)
Other vegetative classification: Wet (G055BY900ND)

Parnell

Percent of map unit: 3 percent
Landform: Depressions
Landform position (three-dimensional): Dip
Down-slope shape: Concave
Across-slope shape: Concave
Ecological site: Shallow Marsh (R055BY070ND)
Other vegetative classification: Not suited (G055BY000ND)

Cresbard

Percent of map unit: 2 percent
Landform: Ground moraines
Landform position (three-dimensional): Rise
Down-slope shape: Concave
Across-slope shape: Linear
Ecological site: Clayey (R055BY056ND)
Other vegetative classification: Clayey Subsoil (G055BY210ND)

Barnes

Percent of map unit: 2 percent
Landform: Ground moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Loamy (R055BY064ND)
Other vegetative classification: Loam (G055BY100ND)

G100A—Hamerly-Tonka complex, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: 2q3vh
Elevation: 980 to 2,130 feet
Mean annual precipitation: 17 to 24 inches
Mean annual air temperature: 37 to 46 degrees F
Frost-free period: 120 to 150 days
Farmland classification: Prime farmland if drained

Map Unit Composition

Hamerly and similar soils: 42 percent
Tonka and similar soils: 28 percent
Minor components: 30 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hamerly

Setting

Landform: Ground moraines
Landform position (three-dimensional): Dip
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Fine-loamy till

Typical profile

Ap - 0 to 8 inches: loam
Bk - 8 to 35 inches: loam
BCk - 35 to 43 inches: loam
C - 43 to 79 inches: loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.14 to 1.42 in/hr)
Depth to water table: About 18 to 42 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 45 percent
Gypsum, maximum in profile: 3 percent
Salinity, maximum in profile: Slightly saline to moderately saline (4.0 to 8.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 7.0
Available water storage in profile: High (about 9.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C
Ecological site: Limy Subirrigated (R055BY058ND)
Other vegetative classification: Subirrigated (G055BY700ND)

Description of Tonka

Setting

Landform: Depressions
Landform position (three-dimensional): Dip
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Local alluvium over till

Typical profile

Ap - 0 to 7 inches: silt loam
A - 7 to 13 inches: silt loam
E - 13 to 19 inches: loam
Bt - 19 to 34 inches: silty clay loam
2BC - 34 to 50 inches: clay loam
2Cg - 50 to 79 inches: loam

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately low (0.01 to 0.14 in/hr)
Depth to water table: About 0 to 18 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Calcium carbonate, maximum in profile: 10 percent
Gypsum, maximum in profile: 2 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 3.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 2.0
Available water storage in profile: High (about 10.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4w
Hydrologic Soil Group: C/D
Ecological site: Wet Meadow (R055BY071ND)
Other vegetative classification: Wet (G055BY900ND)

Minor Components

Vallers, moderately saline

Percent of map unit: 7 percent
Landform: Depressions, ground moraines
Landform position (three-dimensional): Dip
Down-slope shape: Concave
Across-slope shape: Concave, linear
Ecological site: Saline Lowland (R055BY060ND)
Other vegetative classification: Saline (G055BY895ND)

Wyard

Percent of map unit: 7 percent
Landform: Depressions on ground moraines, swales on ground moraines
Landform position (three-dimensional): Dip
Down-slope shape: Concave
Across-slope shape: Concave
Ecological site: Subirrigated (R055BY065ND)
Other vegetative classification: Subirrigated (G055BY700ND)

Balaton

Percent of map unit: 5 percent
Landform: Ground moraines
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: Thin Loamy (R055BY068ND)
Other vegetative classification: Limy Upland (G055BY400ND)

Parnell

Percent of map unit: 5 percent
Landform: Depressions
Landform position (three-dimensional): Dip
Down-slope shape: Concave
Across-slope shape: Concave
Ecological site: Shallow Marsh (R055BY070ND)
Other vegetative classification: Not suited (G055BY000ND)

Barnes

Percent of map unit: 3 percent
Landform: Ground moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Loamy (R055BY064ND)
Other vegetative classification: Loam (G055BY100ND)

Cavour

Percent of map unit: 3 percent
Landform: Ground moraines
Landform position (three-dimensional): Talf
Down-slope shape: Concave
Across-slope shape: Linear
Ecological site: Claypan (R055BY057ND)
Other vegetative classification: Claypan (G055BY800ND)

G101A—Hamerly-Wyard loams, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: 2q3vj

Elevation: 980 to 2,130 feet
Mean annual precipitation: 17 to 24 inches
Mean annual air temperature: 37 to 46 degrees F
Frost-free period: 120 to 150 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Hamerly and similar soils: 46 percent
Wyard and similar soils: 24 percent
Minor components: 30 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hamerly

Setting

Landform: Ground moraines
Landform position (three-dimensional): Dip
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Fine-loamy till

Typical profile

Ap - 0 to 8 inches: loam
Bk - 8 to 35 inches: loam
BCk - 35 to 43 inches: loam
C - 43 to 79 inches: loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.14 to 1.42 in/hr)
Depth to water table: About 18 to 42 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 45 percent
Gypsum, maximum in profile: 3 percent
Salinity, maximum in profile: Slightly saline to moderately saline (4.0 to 8.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 7.0
Available water storage in profile: High (about 9.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C
Ecological site: Limy Subirrigated (R055BY058ND)
Other vegetative classification: Subirrigated (G055BY700ND)

Description of Wyard

Setting

Landform: Depressions on ground moraines, swales on ground moraines
Landform position (three-dimensional): Dip
Down-slope shape: Concave

Across-slope shape: Concave
Parent material: Local alluvium over till

Typical profile

Ap - 0 to 8 inches: loam
A - 8 to 15 inches: loam
Bw1 - 15 to 21 inches: loam
Bw2 - 21 to 30 inches: loam
Bk - 30 to 40 inches: loam
BC - 40 to 79 inches: loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.14 to 1.42 in/hr)
Depth to water table: About 18 to 42 inches
Frequency of flooding: None
Frequency of ponding: Occasional
Calcium carbonate, maximum in profile: 25 percent
Gypsum, maximum in profile: 2 percent
Salinity, maximum in profile: Nonsaline to slightly saline (1.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 4.0
Available water storage in profile: High (about 10.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2c
Hydrologic Soil Group: C
Ecological site: Subirrigated (R055BY065ND)
Other vegetative classification: Subirrigated (G055BY700ND)

Minor Components

Tonka

Percent of map unit: 8 percent
Landform: Depressions
Landform position (three-dimensional): Dip
Down-slope shape: Concave
Across-slope shape: Concave
Ecological site: Wet Meadow (R055BY071ND)
Other vegetative classification: Wet (G055BY900ND)

Balaton

Percent of map unit: 7 percent
Landform: Ground moraines
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: Thin Loamy (R055BY068ND)
Other vegetative classification: Limy Upland (G055BY400ND)

Hamerly, moderately saline

Percent of map unit: 5 percent
Landform: Ground moraines

Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Saline Lowland (R055BY060ND)
Other vegetative classification: Saline (G055BY895ND)

Vallers
Percent of map unit: 4 percent
Landform: Depressions, ground moraines
Landform position (three-dimensional): Dip
Down-slope shape: Concave
Across-slope shape: Concave, linear
Ecological site: Wet Meadow (R055BY071ND)
Other vegetative classification: Wet (G055BY900ND)

Barnes
Percent of map unit: 3 percent
Landform: Ground moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Loamy (R055BY064ND)
Other vegetative classification: Loam (G055BY100ND)

Cresbard
Percent of map unit: 3 percent
Landform: Ground moraines
Landform position (three-dimensional): Talf
Down-slope shape: Concave
Across-slope shape: Linear
Ecological site: Clayey (R055BY056ND)
Other vegetative classification: Clayey Subsoil (G055BY210ND)

G117A—Hamerly loam, saline, 0 to 3 percent slopes

Map Unit Setting
National map unit symbol: 2q3vm
Elevation: 980 to 2,130 feet
Mean annual precipitation: 17 to 24 inches
Mean annual air temperature: 37 to 46 degrees F
Frost-free period: 120 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition
Hamerly, moderately saline, and similar soils: 55 percent
Minor components: 45 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hamerly, Moderately Saline

Setting

Landform: Ground moraines
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Fine-loamy till

Typical profile

Ap - 0 to 8 inches: loam
Bkz - 8 to 35 inches: loam
BCkz - 35 to 43 inches: loam
C - 43 to 79 inches: loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.14 to 1.42 in/hr)
Depth to water table: About 18 to 42 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 45 percent
Gypsum, maximum in profile: 4 percent
Salinity, maximum in profile: Moderately saline to strongly saline (8.0 to 16.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 10.0
Available water storage in profile: Moderate (about 7.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3s
Hydrologic Soil Group: C
Ecological site: Saline Lowland (R055BY060ND)
Other vegetative classification: Saline (G055BY895ND)

Minor Components

Wyard

Percent of map unit: 12 percent
Landform: Depressions on ground moraines, swales on ground moraines
Landform position (three-dimensional): Dip
Down-slope shape: Concave
Across-slope shape: Concave
Ecological site: Subirrigated (R055BY065ND)
Other vegetative classification: Subirrigated (G055BY700ND)

Hamerly

Percent of map unit: 8 percent
Landform: Ground moraines
Landform position (three-dimensional): Dip
Down-slope shape: Linear
Across-slope shape: Linear

Ecological site: Limy Subirrigated (R055BY058ND)
Other vegetative classification: Subirrigated (G055BY700ND)

Vallers, moderately saline
Percent of map unit: 8 percent
Landform: Depressions on ground moraines
Landform position (three-dimensional): Dip
Down-slope shape: Concave
Across-slope shape: Concave, linear
Ecological site: Saline Lowland (R055BY060ND)
Other vegetative classification: Saline (G055BY895ND)

Balaton
Percent of map unit: 7 percent
Landform: Ground moraines
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: Thin Loamy (R055BY068ND)
Other vegetative classification: Limy Upland (G055BY400ND)

Barnes
Percent of map unit: 5 percent
Landform: Ground moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Loamy (R055BY064ND)
Other vegetative classification: Loam (G055BY100ND)

Tonka
Percent of map unit: 3 percent
Landform: Depressions on ground moraines
Landform position (three-dimensional): Dip
Down-slope shape: Concave
Across-slope shape: Concave
Ecological site: Wet Meadow (R055BY071ND)
Other vegetative classification: Wet (G055BY900ND)

Cresbard
Percent of map unit: 2 percent
Landform: Ground moraines
Landform position (three-dimensional): Rise
Down-slope shape: Concave
Across-slope shape: Linear
Ecological site: Clayey (R055BY056ND)
Other vegetative classification: Clayey Subsoil (G055BY210ND)

G143B—Barnes-Svea loams, 3 to 6 percent slopes

Map Unit Setting

National map unit symbol: 2pwz6
Elevation: 980 to 2,130 feet
Mean annual precipitation: 17 to 24 inches
Mean annual air temperature: 37 to 46 degrees F
Frost-free period: 120 to 150 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Barnes and similar soils: 42 percent
Svea and similar soils: 21 percent
Minor components: 37 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Barnes

Setting

Landform: Ground moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Fine-loamy till

Typical profile

Ap - 0 to 7 inches: loam
Bw - 7 to 16 inches: loam
Bk - 16 to 37 inches: loam
C - 37 to 79 inches: loam

Properties and qualities

Slope: 3 to 6 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.14 to 1.42 in/hr)
Depth to water table: About 48 to 79 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 30 percent
Gypsum, maximum in profile: 1 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (1.0 to 3.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 2.0
Available water storage in profile: High (about 10.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e

Hydrologic Soil Group: B
Ecological site: Loamy (R055BY064ND)
Other vegetative classification: Loam (G055BY100ND)

Description of Svea

Setting

Landform: Ground moraines
Landform position (three-dimensional): Rise
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Fine-loamy till

Typical profile

Ap - 0 to 8 inches: loam
A - 8 to 11 inches: loam
Bw - 11 to 22 inches: loam
Bk - 22 to 37 inches: loam
C - 37 to 79 inches: loam

Properties and qualities

Slope: 3 to 6 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Moderately well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.14 to 1.42 in/hr)
Depth to water table: About 36 to 60 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 25 percent
Gypsum, maximum in profile: 2 percent
Salinity, maximum in profile: Nonsaline to slightly saline (1.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 4.0
Available water storage in profile: High (about 10.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B
Ecological site: Loamy Overflow (R055BY059ND)
Other vegetative classification: Loam (G055BY100ND)

Minor Components

Balaton

Percent of map unit: 12 percent
Landform: Ground moraines
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: Thin Loamy (R055BY068ND)
Other vegetative classification: Limy Upland (G055BY400ND)

Buse

Percent of map unit: 9 percent
Landform: Ground moraines

Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: Thin Loamy (R055BY068ND)
Other vegetative classification: Limy Upland (G055BY400ND)

Renshaw

Percent of map unit: 4 percent
Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Convex
Across-slope shape: Linear
Ecological site: Shallow Gravel (R055BY063ND)
Other vegetative classification: Very Droughty Loam (G055BY130ND)

Cresbard

Percent of map unit: 3 percent
Landform: Ground moraines
Landform position (three-dimensional): Talf
Down-slope shape: Concave
Across-slope shape: Linear
Ecological site: Clayey (R055BY056ND)
Other vegetative classification: Clayey Subsoil (G055BY210ND)

Tonka

Percent of map unit: 3 percent
Landform: Depressions
Landform position (three-dimensional): Dip
Down-slope shape: Concave
Across-slope shape: Concave
Ecological site: Wet Meadow (R055BY071ND)
Other vegetative classification: Wet (G055BY900ND)

Parnell

Percent of map unit: 3 percent
Landform: Depressions
Landform position (three-dimensional): Dip
Down-slope shape: Concave
Across-slope shape: Concave
Ecological site: Shallow Marsh (R055BY070ND)
Other vegetative classification: Not suited (G055BY000ND)

Swenoda

Percent of map unit: 3 percent
Landform: Ground moraines
Landform position (three-dimensional): Talf
Down-slope shape: Concave
Across-slope shape: Linear
Ecological site: Loamy Overflow (R055BY059ND)
Other vegetative classification: Overflow (G055BY500ND)

G144B—Barnes-Buse loams, 3 to 6 percent slopes

Map Unit Setting

National map unit symbol: 2pwz2
Elevation: 1,000 to 2,050 feet
Mean annual precipitation: 16 to 20 inches
Mean annual air temperature: 39 to 45 degrees F
Frost-free period: 120 to 140 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Barnes and similar soils: 25 percent
Buse and similar soils: 24 percent
Minor components: 51 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Barnes

Setting

Landform: Rises
Landform position (two-dimensional): Backslope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Fine-loamy till

Typical profile

Ap - 0 to 7 inches: loam
Bw - 7 to 19 inches: loam
Bk - 19 to 37 inches: loam
C - 37 to 60 inches: loam

Properties and qualities

Slope: 3 to 6 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.14 to 1.42 in/hr)
Depth to water table: About 48 to 72 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 30 percent
Gypsum, maximum in profile: 1 percent
Salinity, maximum in profile: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Available water storage in profile: High (about 10.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e

Hydrologic Soil Group: B
Ecological site: Loamy (R055BY064ND)
Other vegetative classification: Loam (G055BY100ND)

Description of Buse

Setting

Landform: Rises
Landform position (two-dimensional): Summit, shoulder
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Fine-loamy till

Typical profile

Ap - 0 to 8 inches: loam
Bk - 8 to 40 inches: loam
C - 40 to 60 inches: loam

Properties and qualities

Slope: 3 to 6 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.14 to 1.42 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 30 percent
Gypsum, maximum in profile: 1 percent
Salinity, maximum in profile: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Available water storage in profile: High (about 10.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B
Ecological site: Thin Loamy (R055BY068ND)
Other vegetative classification: Limy Upland (G055BY400ND)

Minor Components

Svea

Percent of map unit: 14 percent
Landform: Rises
Landform position (two-dimensional): Footslope
Down-slope shape: Concave
Across-slope shape: Linear
Ecological site: Loamy Overflow (R055BY059ND)
Other vegetative classification: Loam (G055BY100ND)

Balaton

Percent of map unit: 10 percent
Landform: Rises
Landform position (two-dimensional): Summit, shoulder
Down-slope shape: Convex
Across-slope shape: Convex

Ecological site: Thin Loamy (R055BY068ND)
Other vegetative classification: Limy Upland (G055BY400ND)

Hamerly
Percent of map unit: 7 percent
Landform: Flats
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Limy Subirrigated (R055BY058ND)
Other vegetative classification: Subirrigated (G055BY700ND)

Tonka
Percent of map unit: 5 percent
Landform: Depressions
Down-slope shape: Concave
Across-slope shape: Concave
Ecological site: Wet Meadow (R055BY071ND)
Other vegetative classification: Wet (G055BY900ND)

Langhei
Percent of map unit: 4 percent
Landform: Rises
Landform position (two-dimensional): Summit, shoulder
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: Thin Loamy (R055BY068ND)
Other vegetative classification: Limy Upland (G055BY400ND)

Swenoda
Percent of map unit: 3 percent
Landform: Rises
Down-slope shape: Concave
Across-slope shape: Linear
Ecological site: Loamy Overflow (R055BY059ND)
Other vegetative classification: Overflow (G055BY500ND)

Cresbard
Percent of map unit: 3 percent
Landform: Rises
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Clayey (R055BY056ND)
Other vegetative classification: Clayey Subsoil (G055BY210ND)

Parnell
Percent of map unit: 3 percent
Landform: Depressions
Down-slope shape: Concave
Across-slope shape: Concave
Ecological site: Shallow Marsh (R055BY070ND)
Other vegetative classification: Not suited (G055BY000ND)

Sioux
Percent of map unit: 2 percent
Landform: Rises
Landform position (two-dimensional): Summit, shoulder
Down-slope shape: Convex
Across-slope shape: Convex

Ecological site: Very Shallow (R055BY069ND)
Other vegetative classification: Not suited (G055BY000ND)

G639F—Orthents-Aquents-Urban Land, highway complex, 0 to 35 percent slopes

Map Unit Setting

National map unit symbol: 2q5ss
Elevation: 1,000 to 2,050 feet
Mean annual precipitation: 16 to 20 inches
Mean annual air temperature: 39 to 45 degrees F
Frost-free period: 120 to 140 days
Farmland classification: Not prime farmland

Map Unit Composition

Orthents and similar soils: 41 percent
Aquents, clayey, and similar soils: 16 percent
Urban land, highway: 15 percent
Minor components: 28 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Orthents

Setting

Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Till

Typical profile

A - 0 to 3 inches: loam
C - 3 to 60 inches: loam

Properties and qualities

Slope: 0 to 35 percent
Percent of area covered with surface fragments: 0.5 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.14 to 1.42 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Gypsum, maximum in profile: 1 percent
Salinity, maximum in profile: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Available water storage in profile: High (about 10.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: C
Ecological site: Non-site (R055BY999ND)
Other vegetative classification: Not suited (G055BY000ND)

Description of Aquents, Clayey

Setting

Landform: Depressions
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Glaciolacustrine deposits

Typical profile

A - 0 to 5 inches: clay loam
Cg1 - 5 to 15 inches: silty clay
Cg2 - 15 to 60 inches: silty clay

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately low (0.01 to 0.14 in/hr)
Depth to water table: About 0 to 18 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Calcium carbonate, maximum in profile: 30 percent
Gypsum, maximum in profile: 3 percent
Salinity, maximum in profile: Nonsaline to moderately saline (0.0 to 8.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 2.0
Available water storage in profile: Moderate (about 8.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: C/D
Ecological site: Non-site (R055BY999ND)
Other vegetative classification: Not suited (G055BY000ND)

Description of Urban Land, Highway

Interpretive groups

Land capability classification (irrigated): None specified
Ecological site: Non-site (R055BY999ND)
Other vegetative classification: Not suited (G055BY000ND)

Minor Components

Sisseton

Percent of map unit: 10 percent
Landform: Ridges on hills
Landform position (two-dimensional): Summit, shoulder
Down-slope shape: Convex

Across-slope shape: Convex
Ecological site: Thin Loamy (R055BY068ND)
Other vegetative classification: Limy Upland (G055BY400ND)

Renshaw
Percent of map unit: 6 percent
Landform: Rises
Landform position (two-dimensional): Backslope
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Shallow Gravel (R055BY063ND)
Other vegetative classification: Very Droughty Loam (G055BY130ND)

Parnell
Percent of map unit: 3 percent
Landform: Depressions
Down-slope shape: Concave
Across-slope shape: Concave
Ecological site: Shallow Marsh (R055BY070ND)
Other vegetative classification: Not suited (G055BY000ND)

Svea
Percent of map unit: 3 percent
Landform: Rises
Landform position (two-dimensional): Footslope
Down-slope shape: Concave
Across-slope shape: Linear
Ecological site: Loamy Overflow (R055BY059ND)
Other vegetative classification: Loam (G055BY100ND)

Barnes
Percent of map unit: 3 percent
Landform: Knolls
Landform position (two-dimensional): Backslope
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Loamy (R055BY064ND)
Other vegetative classification: Loam (G055BY100ND)

Water, intermittent
Percent of map unit: 3 percent
Landform: Depressions
Ecological site: Non-site (R055BY999ND)
Other vegetative classification: Not suited (G055BY000ND)

G680B—Barnes-Sioux complex, 1 to 6 percent slopes

Map Unit Setting
National map unit symbol: 2q5w2

Elevation: 1,000 to 2,050 feet
Mean annual precipitation: 16 to 20 inches
Mean annual air temperature: 39 to 45 degrees F
Frost-free period: 120 to 140 days
Farmland classification: Farmland of statewide importance

Map Unit Composition
Barnes and similar soils: 39 percent
Sioux and similar soils: 26 percent
Minor components: 35 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Barnes

Setting
Landform: Rises
Landform position (two-dimensional): Backslope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Fine-loamy till

Typical profile
Ap - 0 to 7 inches: loam
Bw - 7 to 19 inches: loam
Bk - 19 to 37 inches: loam
C - 37 to 60 inches: loam

Properties and qualities
Slope: 1 to 6 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.14 to 1.42 in/hr)
Depth to water table: About 48 to 72 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 30 percent
Gypsum, maximum in profile: 1 percent
Salinity, maximum in profile: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Available water storage in profile: High (about 10.5 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B
Ecological site: Loamy (R055BY064ND)
Other vegetative classification: Loam (G055BY100ND)

Description of Sioux

Setting
Landform: Rises
Landform position (two-dimensional): Summit, shoulder
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Granitic glaciofluvial deposits

Typical profile

A - 0 to 6 inches: gravelly sandy loam
ABk - 6 to 10 inches: gravelly sandy loam
BCk - 10 to 19 inches: very gravelly loamy sand
C - 19 to 80 inches: very gravelly sand

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Excessively drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to very high (1.42 to 14.17 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Available water storage in profile: Low (about 4.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: A
Ecological site: Very Shallow (R055BY069ND)
Other vegetative classification: Not suited (G055BY000ND)

Minor Components

Svea

Percent of map unit: 7 percent
Landform: Rises
Down-slope shape: Concave
Across-slope shape: Linear
Ecological site: Loamy Overflow (R055BY059ND)
Other vegetative classification: Overflow (G055BY500ND)

Buse

Percent of map unit: 7 percent
Landform: Rises
Landform position (two-dimensional): Summit, shoulder
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: Thin Loamy (R055BY068ND)
Other vegetative classification: Limy Upland (G055BY400ND)

Balaton

Percent of map unit: 6 percent
Landform: Rises
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: Thin Loamy (R055BY068ND)
Other vegetative classification: Limy Upland (G055BY400ND)

Renshaw

Percent of map unit: 6 percent
Landform: Rises
Down-slope shape: Convex

Across-slope shape: Linear
Ecological site: Shallow Gravel (R055BY063ND)
Other vegetative classification: Very Droughty Loam (G055BY130ND)

Swenoda

Percent of map unit: 6 percent
Landform: Rises
Down-slope shape: Concave
Across-slope shape: Linear
Ecological site: Loamy Overflow (R055BY059ND)
Other vegetative classification: Overflow (G055BY500ND)

Langhei

Percent of map unit: 3 percent
Landform: Rises
Landform position (two-dimensional): Summit, shoulder
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: Thin Loamy (R055BY068ND)
Other vegetative classification: Limy Upland (G055BY400ND)

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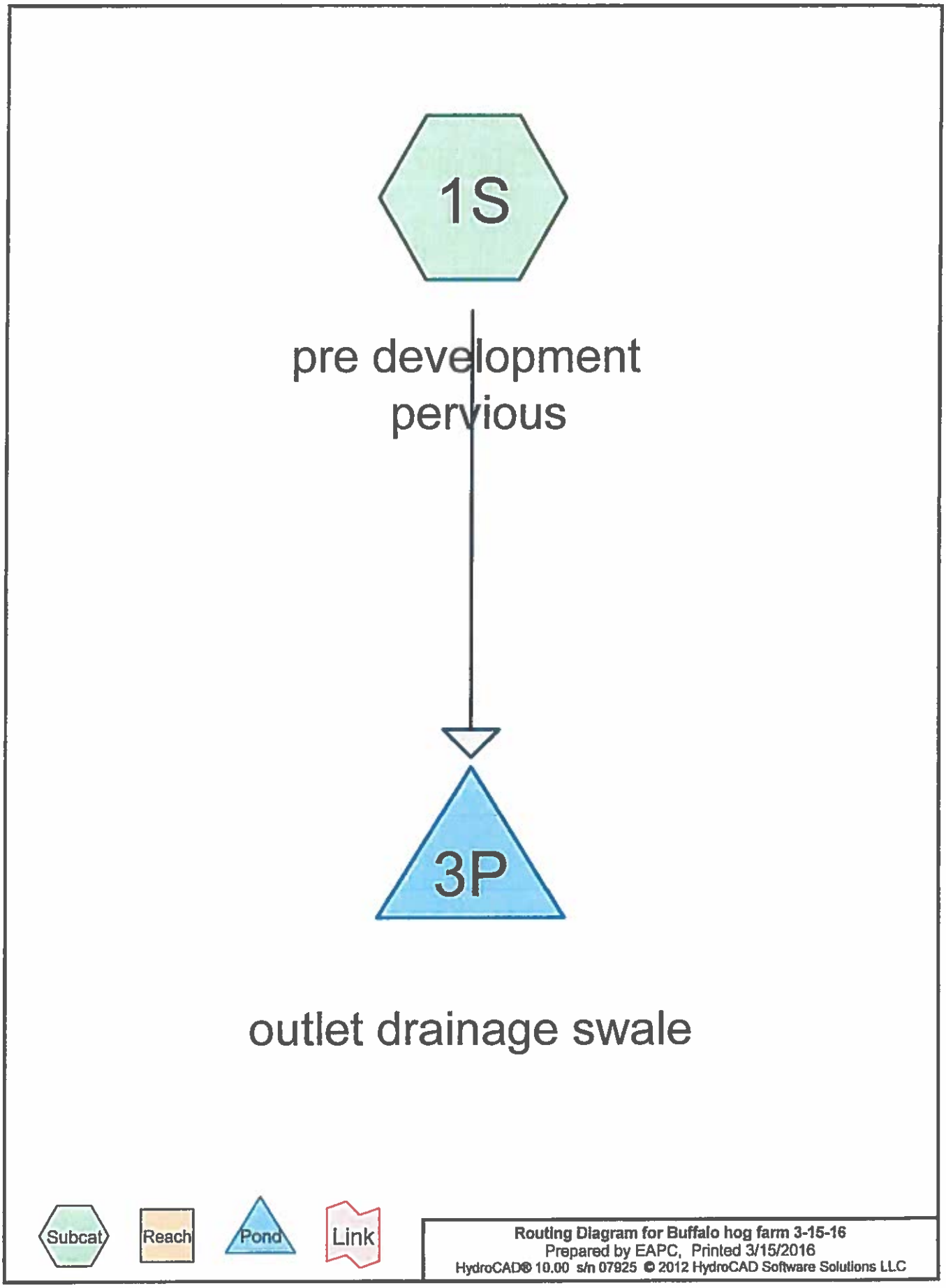
Attachment 3

My preliminary analysis of onsite drainage pre-development utilized the NRCS soil types (attached) and utilized "Hydro Cad" drainage design software.

From Appendix 16 of the Zoning Ordinance, I used the runoff coefficient for cultivated land using "Summer Conditions". The NRCS report included in attachment 2 finds the majority of the property to be Hamerly-Tonka Complex 0 to 3 percent slopes and Barnes-Buse Loams, 3 to 6 percent slopes. I used Group B from the ordinance for the design category for "C" of 85. Flow distance is 1,475 feet total and there is currently a low area mid property 5 feet lower than NW the northwest corner of the property and 3 feet higher than SW corner of the property that provides intermittent storage. The resulting average drop for determining pre-construction design slope is 4 feet or .0027 slope average.

Analysis: 2 year 12.05 CFS
Preconstruction: 10 year 23.60 CFS
Flow Results: 100 year 48.52 CFS

The allowable release rate post construction for a 10 year event is 15.00 CFS and current design flows provided by the engineer are 43.80 CFS or more for a 25 year event. A logical conclusion is that storm water detention with a control structure is hydraulically necessary to mitigate downstream flows as required by the ordinance.


1S
pre development
pervious
3P
outlet drainage swale
Subcat
Reach
Pond
Link
Routing Diagram for Buffalo hog farm 3-15-16
Prepared by EAPC, Printed 3/15/2016
HydroCAD® 10.00 s/n 07925 © 2012 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
29.010	85	Row crops, straight row, Good, HSG C (1S)
29.010	**85**	**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
0.000	HSG B	
29.010	HSG C	1S
0.000	HSG D	
0.000	Other	
29.010		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchmen Numbers
0.000	0.000	29.010	0.000	0.000	29.010	Row crops, straight row, Good	1S
0.000	**0.000**	**29.010**	**0.000**	**0.000**	**29.010**	**TOTAL AREA**	

Time span=0.00-36.00 hrs, dt=1.00 hrs, 37 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: pre development Runoff Area=29.010 ac 0.00% Impervious Runoff Depth=1.15"
Flow Length=1,475' Slope=0.0027 '/' Tc=52.6 min CN=85 Runoff=12.05 cfs 2.772 af

Pond 3P: outlet drainage swale Inflow=12.05 cfs 2.772 af
Primary=12.05 cfs 2.772 af

Total Runoff Area = 29.010 ac Runoff Volume = 2.772 af Average Runoff Depth = 1.15"
100.00% Pervious = 29.010 ac 0.00% Impervious = 0.000 ac

Summary for Subcatchment 1S: pre development pervious

[49] Hint: Tc<2dt may require smaller dt

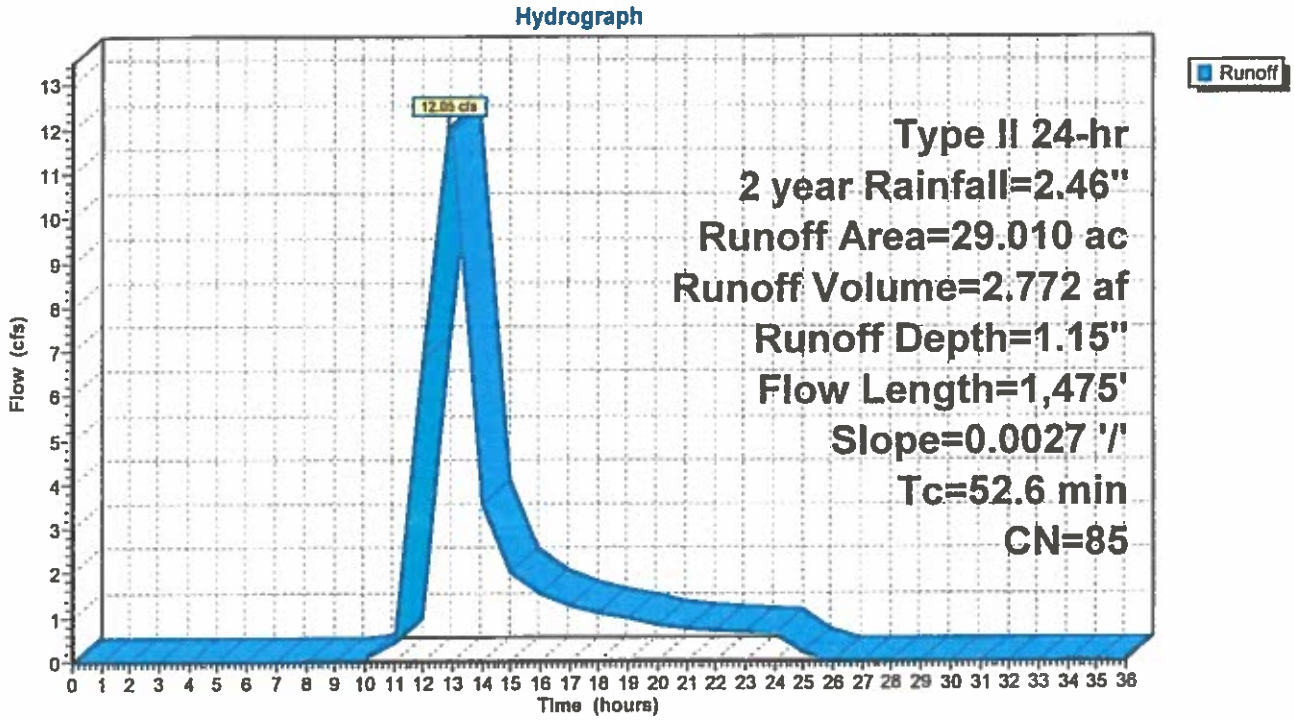
Runoff = 12.05 cfs @ 12.88 hrs, Volume= 2.772 af, Depth= 1.15"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 1.00 hrs
Type II 24-hr 2 year Rainfall=2.46"

Area (ac)	CN	Description
29.010	85	Row crops, straight row, Good, HSG C
29.010		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
52.6	1,475	0.0027	0.47		**Shallow Concentrated Flow, pre develop** Cultivated Straight Rows Kv= 9.0 fps

Subcatchment 1S: pre development pervious



Hydrograph for Subcatchment 1S: pre development pervious

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
1.00	0.03	0.00	0.00
2.00	0.05	0.00	0.00
3.00	0.08	0.00	0.00
4.00	0.12	0.00	0.00
5.00	0.15	0.00	0.00
6.00	0.20	0.00	0.00
7.00	0.24	0.00	0.00
8.00	0.30	0.00	0.00
9.00	0.36	0.00	0.00
10.00	0.45	0.00	0.08
11.00	0.58	0.03	0.44
12.00	1.63	0.54	6.82
13.00	1.90	0.72	**11.95**
14.00	2.02	0.81	3.56
15.00	2.10	0.87	2.01
16.00	2.16	0.92	1.55
17.00	2.22	0.96	1.26
18.00	2.27	0.99	1.10
19.00	2.31	1.03	0.97
20.00	2.34	1.05	0.84
21.00	2.37	1.08	0.74
22.00	2.40	1.10	0.70
23.00	2.43	1.12	0.67
24.00	**2.46**	**1.15**	0.63
25.00	2.46	1.15	0.20
26.00	2.46	1.15	0.01
27.00	2.46	1.15	0.00
28.00	2.46	1.15	0.00
29.00	2.46	1.15	0.00
30.00	2.46	1.15	0.00
31.00	2.46	1.15	0.00
32.00	2.46	1.15	0.00
33.00	2.46	1.15	0.00
34.00	2.46	1.15	0.00
35.00	2.46	1.15	0.00
36.00	2.46	1.15	0.00

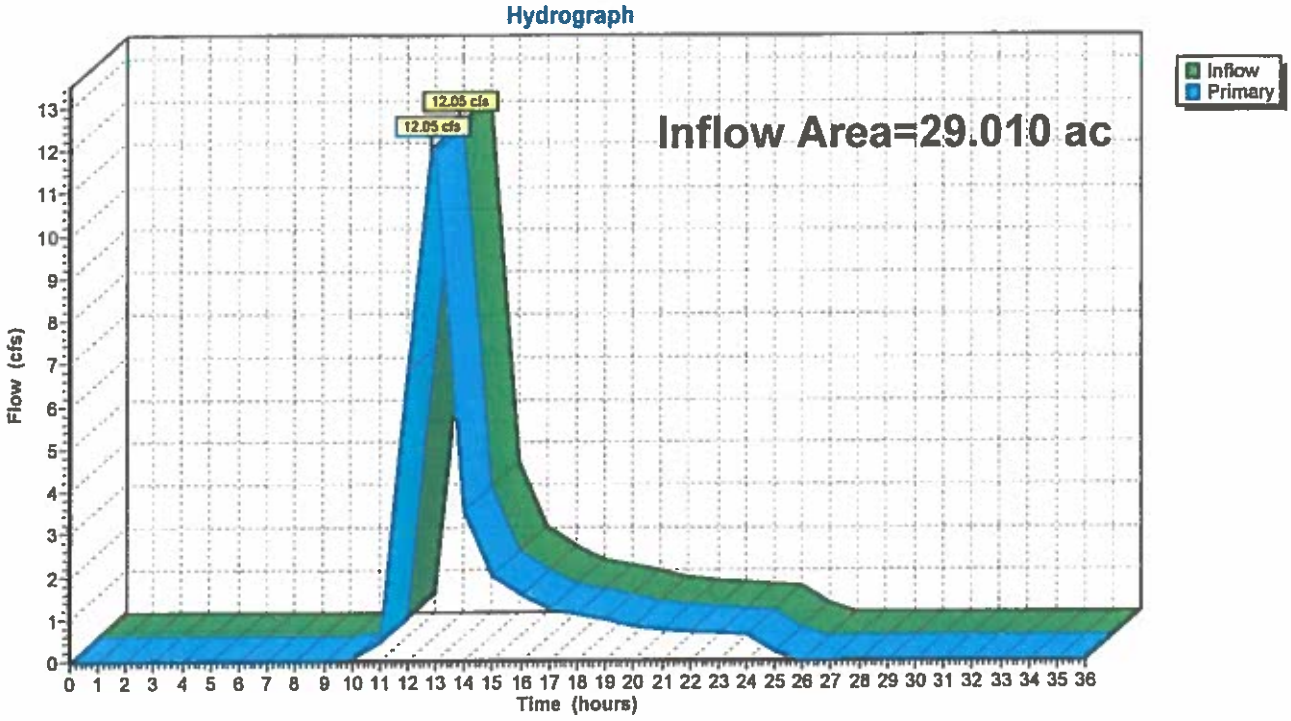
Summary for Pond 3P: outlet drainage swale

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 29.010 ac, 0.00% Impervious, Inflow Depth = 1.15" for 2 year event
Inflow = 12.05 cfs @ 12.88 hrs, Volume= 2.772 af
Primary = 12.05 cfs @ 12.88 hrs, Volume= 2.772 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 1.00 hrs / 3

Pond 3P: outlet drainage swale



Hydrograph for Pond 3P: outlet drainage swale

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
0.00	0.00		0.00
1.00	0.00		0.00
2.00	0.00		0.00
3.00	0.00		0.00
4.00	0.00		0.00
5.00	0.00		0.00
6.00	0.00		0.00
7.00	0.00		0.00
8.00	0.00		0.00
9.00	0.00		0.00
10.00	0.08		0.08
11.00	0.44		0.44
12.00	6.82		6.82
13.00	**11.95**		**11.95**
14.00	3.56		3.56
15.00	2.01		2.01
16.00	1.55		1.55
17.00	1.26		1.26
18.00	1.10		1.10
19.00	0.97		0.97
20.00	0.84		0.84
21.00	0.74		0.74
22.00	0.70		0.70
23.00	0.67		0.67
24.00	0.63		0.63
25.00	0.20		0.20
26.00	0.01		0.01
27.00	0.00		0.00
28.00	0.00		0.00
29.00	0.00		0.00
30.00	0.00		0.00
31.00	0.00		0.00
32.00	0.00		0.00
33.00	0.00		0.00
34.00	0.00		0.00
35.00	0.00		0.00
36.00	0.00		0.00

Time span=0.00-36.00 hrs, dt=1.00 hrs, 37 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: pre development Runoff Area=29.010 ac 0.00% Impervious Runoff Depth=2.26"
Flow Length=1,475' Slope=0.0027 '/' Tc=52.6 min CN=85 Runoff=23.60 cfs 5.469 af

Pond 3P: outlet drainage swale Inflow=23.60 cfs 5.469 af
Primary=23.60 cfs 5.469 af

Total Runoff Area = 29.010 ac Runoff Volume = 5.469 af Average Runoff Depth = 2.26"
100.00% Pervious = 29.010 ac 0.00% Impervious = 0.000 ac

Summary for Subcatchment 1S: pre development pervious

[49] Hint: Tc<2dt may require smaller dt

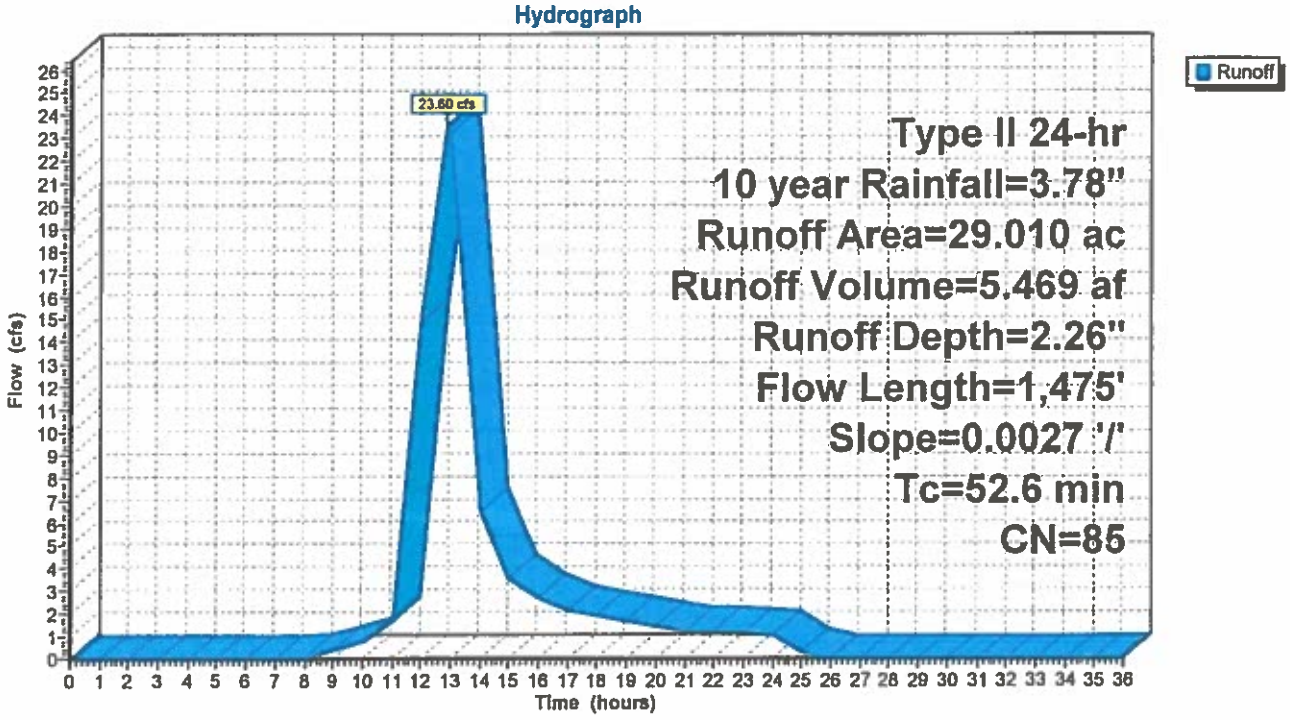
Runoff = 23.60 cfs @ 12.83 hrs, Volume= 5.469 af, Depth= 2.26"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 1.00 hrs
Type II 24-hr 10 year Rainfall=3.78"

Area (ac)	CN	Description
29.010	85	Row crops, straight row, Good, HSG C
29.010		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
52.6	1,475	0.0027	0.47		**Shallow Concentrated Flow, pre develop** Cultivated Straight Rows Kv= 9.0 fps

Subcatchment 1S: pre development pervious



Hydrograph for Subcatchment 1S: pre development pervious

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
1.00	0.04	0.00	0.00
2.00	0.08	0.00	0.00
3.00	0.13	0.00	0.00
4.00	0.18	0.00	0.00
5.00	0.24	0.00	0.00
6.00	0.30	0.00	0.00
7.00	0.37	0.00	0.00
8.00	0.45	0.01	0.10
9.00	0.56	0.02	0.35
10.00	0.68	0.05	0.77
11.00	0.89	0.12	1.70
12.00	2.51	1.18	14.88
13.00	2.92	1.52	**23.25**
14.00	3.10	1.67	6.49
15.00	3.23	1.78	3.56
16.00	3.33	1.87	2.72
17.00	3.41	1.94	2.20
18.00	3.48	2.00	1.92
19.00	3.54	2.06	1.69
20.00	3.60	2.10	1.45
21.00	3.65	2.14	1.27
22.00	3.69	2.19	1.21
23.00	3.74	2.22	1.16
24.00	**3.78**	**2.26**	1.09
25.00	3.78	2.26	0.35
26.00	3.78	2.26	0.02
27.00	3.78	2.26	0.00
28.00	3.78	2.26	0.00
29.00	3.78	2.26	0.00
30.00	3.78	2.26	0.00
31.00	3.78	2.26	0.00
32.00	3.78	2.26	0.00
33.00	3.78	2.26	0.00
34.00	3.78	2.26	0.00
35.00	3.78	2.26	0.00
36.00	3.78	2.26	0.00

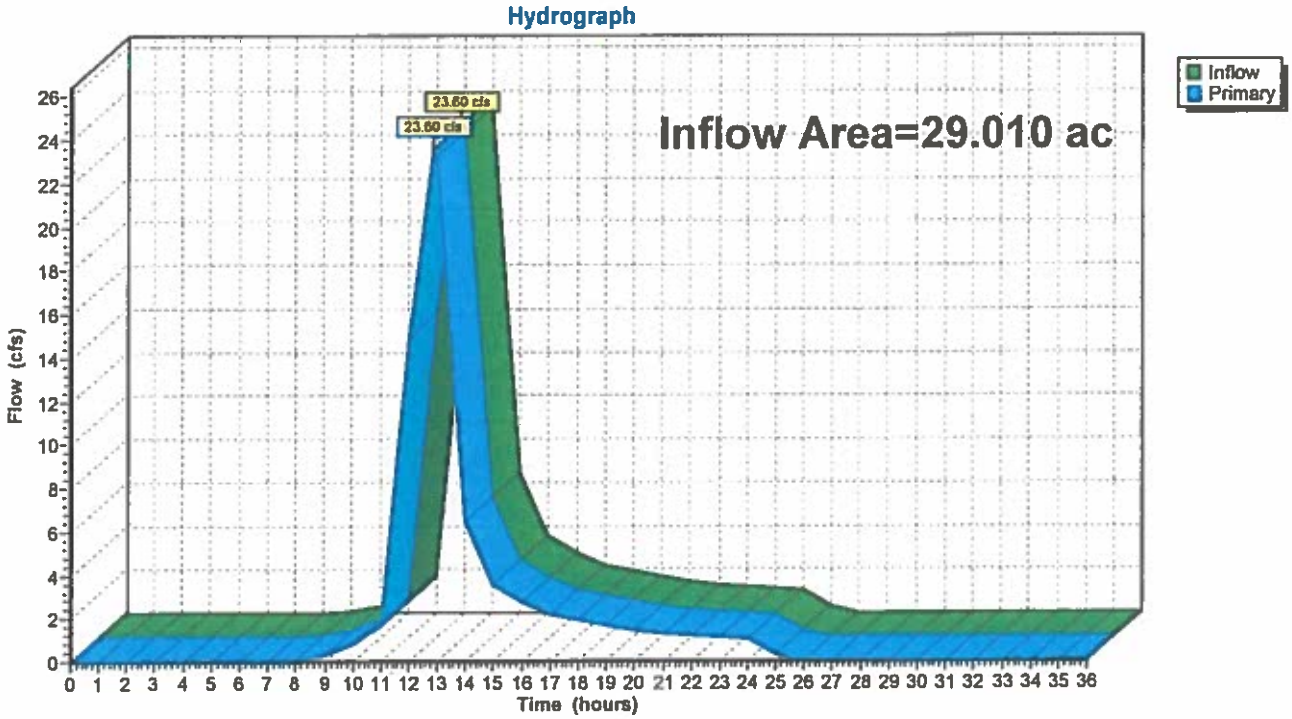
Summary for Pond 3P: outlet drainage swale

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 29.010 ac, 0.00% Impervious, Inflow Depth = 2.26" for 10 year event
Inflow = 23.60 cfs @ 12.83 hrs, Volume= 5.469 af
Primary = 23.60 cfs @ 12.83 hrs, Volume= 5.469 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 1.00 hrs / 3

Pond 3P: outlet drainage swale



Hydrograph for Pond 3P: outlet drainage swale

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
0.00	0.00		0.00
1.00	0.00		0.00
2.00	0.00		0.00
3.00	0.00		0.00
4.00	0.00		0.00
5.00	0.00		0.00
6.00	0.00		0.00
7.00	0.00		0.00
8.00	0.10		0.10
9.00	0.35		0.35
10.00	0.77		0.77
11.00	1.70		1.70
12.00	14.88		14.88
13.00	**23.25**		**23.25**
14.00	6.49		6.49
15.00	3.56		3.56
16.00	2.72		2.72
17.00	2.20		2.20
18.00	1.92		1.92
19.00	1.69		1.69
20.00	1.45		1.45
21.00	1.27		1.27
22.00	1.21		1.21
23.00	1.16		1.16
24.00	1.09		1.09
25.00	0.35		0.35
26.00	0.02		0.02
27.00	0.00		0.00
28.00	0.00		0.00
29.00	0.00		0.00
30.00	0.00		0.00
31.00	0.00		0.00
32.00	0.00		0.00
33.00	0.00		0.00
34.00	0.00		0.00
35.00	0.00		0.00
36.00	0.00		0.00

Time span=0.00-36.00 hrs, dt=1.00 hrs, 37 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: pre development Runoff Area=29.010 ac 0.00% Impervious Runoff Depth=4.78"
Flow Length=1,475' Slope=0.0027 '/' Tc=52.6 min CN=85 Runoff=48.52 cfs 11.546 af

Pond 3P: outlet drainage swale Inflow=48.52 cfs 11.546 af
Primary=48.52 cfs 11.546 af

Total Runoff Area = 29.010 ac Runoff Volume = 11.546 af Average Runoff Depth = 4.78"
100.00% Pervious = 29.010 ac 0.00% Impervious = 0.000 ac

Summary for Subcatchment 1S: pre development pervious

[49] Hint: Tc<2dt may require smaller dt

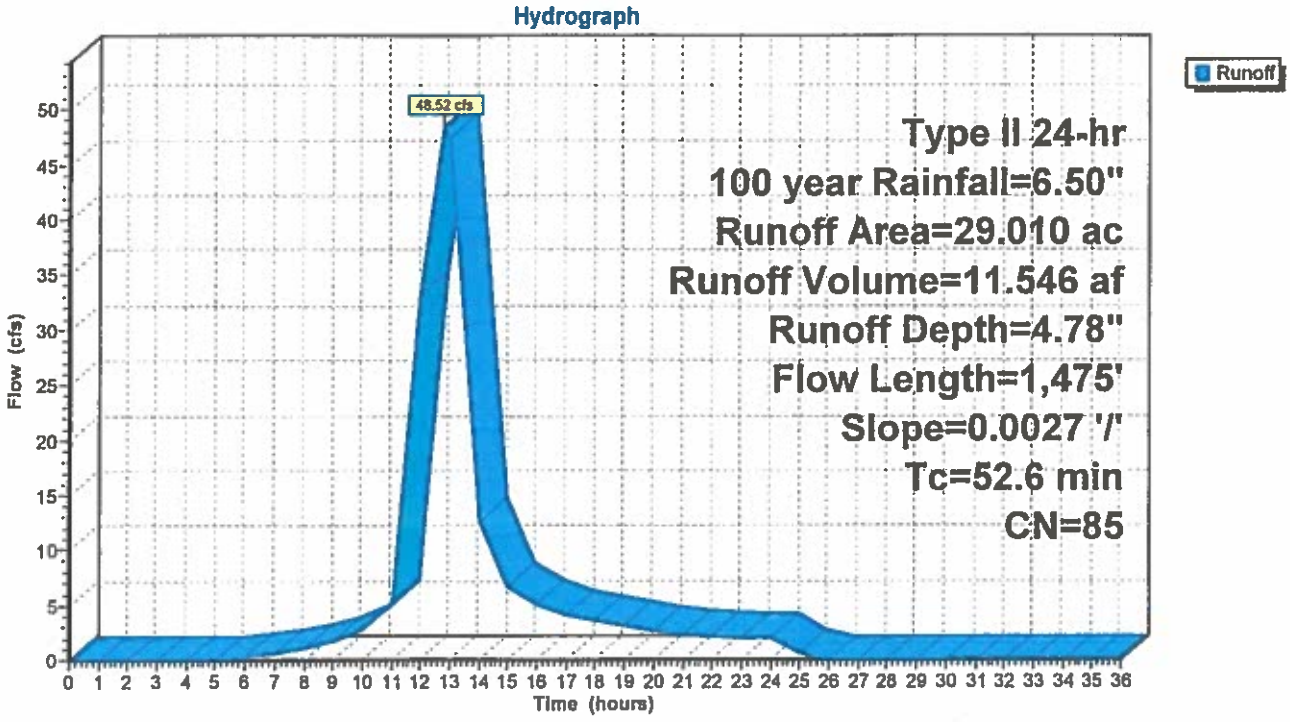
Runoff = 48.52 cfs @ 12.79 hrs, Volume= 11.546 af, Depth= 4.78"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 1.00 hrs
Type II 24-hr 100 year Rainfall=6.50"

Area (ac)	CN	Description
29.010	85	Row crops, straight row, Good, HSG C
29.010		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
52.6	1,475	0.0027	0.47		**Shallow Concentrated Flow, pre develop** Cultivated Straight Rows Kv= 9.0 fps

Subcatchment 1S: pre development pervious



Hydrograph for Subcatchment 1S: pre development pervious

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
1.00	0.07	0.00	0.00
2.00	0.14	0.00	0.00
3.00	0.22	0.00	0.00
4.00	0.31	0.00	0.00
5.00	0.41	0.00	0.03
6.00	0.52	0.01	0.27
7.00	0.64	0.04	0.65
8.00	0.78	0.08	1.09
9.00	0.96	0.15	1.76
10.00	1.18	0.26	2.83
11.00	1.53	0.47	5.05
12.00	4.31	2.74	33.17
13.00	5.02	3.38	**47.44**
14.00	5.33	3.67	12.56
15.00	5.55	3.88	6.73
16.00	5.72	4.04	5.12
17.00	5.86	4.17	4.12
18.00	5.99	4.29	3.59
19.00	6.10	4.39	3.14
20.00	6.19	4.48	2.70
21.00	6.27	4.56	2.36
22.00	6.35	4.63	2.24
23.00	6.43	4.71	2.15
24.00	**6.50**	**4.78**	2.01
25.00	6.50	4.78	0.64
26.00	6.50	4.78	0.04
27.00	6.50	4.78	0.00
28.00	6.50	4.78	0.00
29.00	6.50	4.78	0.00
30.00	6.50	4.78	0.00
31.00	6.50	4.78	0.00
32.00	6.50	4.78	0.00
33.00	6.50	4.78	0.00
34.00	6.50	4.78	0.00
35.00	6.50	4.78	0.00
36.00	6.50	4.78	0.00

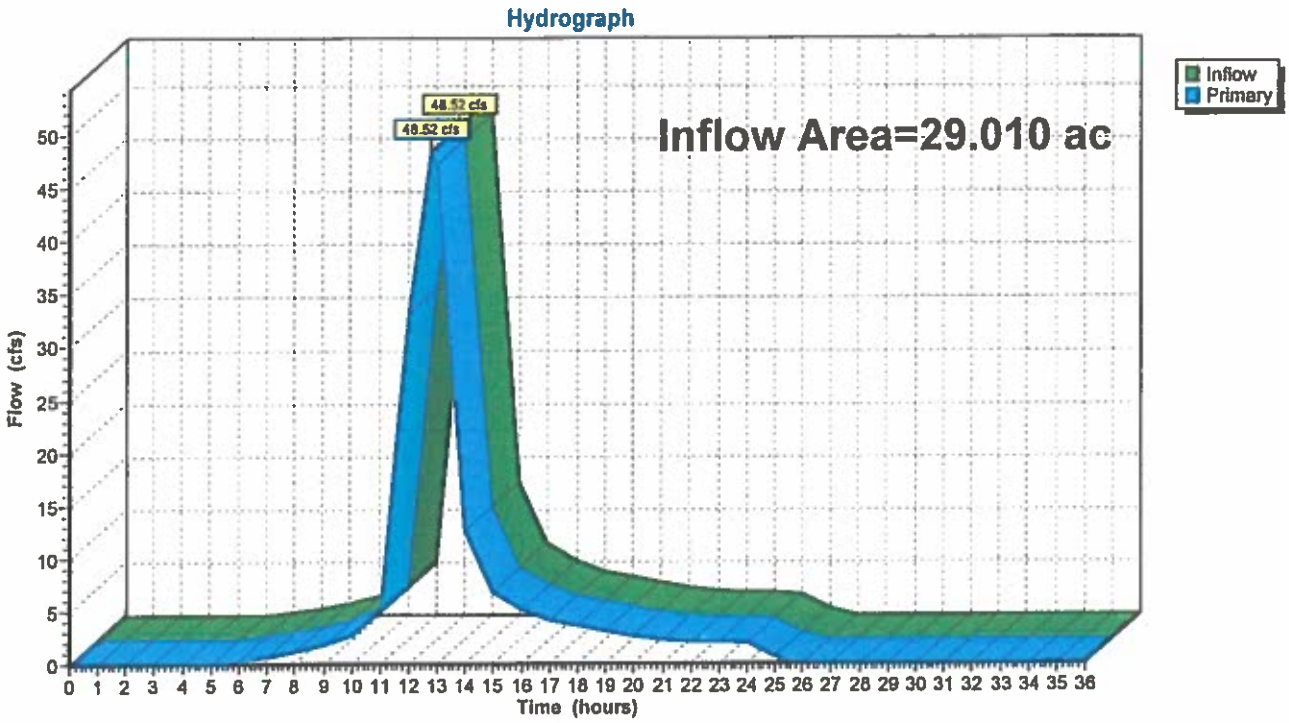
Summary for Pond 3P: outlet drainage swale

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 29.010 ac, 0.00% Impervious, Inflow Depth = 4.78" for 100 year event
Inflow = 48.52 cfs @ 12.79 hrs, Volume= 11.546 af
Primary = 48.52 cfs @ 12.79 hrs, Volume= 11.546 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 1.00 hrs / 3

Pond 3P: outlet drainage swale



Hydrograph for Pond 3P: outlet drainage swale

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
0.00	0.00		0.00
1.00	0.00		0.00
2.00	0.00		0.00
3.00	0.00		0.00
4.00	0.00		0.00
5.00	0.03		0.03
6.00	0.27		0.27
7.00	0.65		0.65
8.00	1.09		1.09
9.00	1.76		1.76
10.00	2.83		2.83
11.00	5.05		5.05
12.00	33.17		33.17
13.00	**47.44**		**47.44**
14.00	12.56		12.56
15.00	6.73		6.73
16.00	5.12		5.12
17.00	4.12		4.12
18.00	3.59		3.59
19.00	3.14		3.14
20.00	2.70		2.70
21.00	2.36		2.36
22.00	2.24		2.24
23.00	2.15		2.15
24.00	2.01		2.01
25.00	0.64		0.64
26.00	0.04		0.04
27.00	0.00		0.00
28.00	0.00		0.00
29.00	0.00		0.00
30.00	0.00		0.00
31.00	0.00		0.00
32.00	0.00		0.00
33.00	0.00		0.00
34.00	0.00		0.00
35.00	0.00		0.00
36.00	0.00		0.00

Exhibit 5B: Tree and Shrub Planting Guidelines

EXHIBIT 5B

The Concerned Citizens of Buffalo ND

Tree & Shrub Planting and Grass Seeding Requirements for Rolling Green Family Farms RE, LLP

SECTION

PLANTS & SEEDING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions, apply to work of this section.

1.02 SUMMARY

A. Extent of landscape development work is shown on drawings and in schedules. Development work is to include furnishing and installing all components shown on plans, details and as described in the specifications for plantings, lawns, soil conditioning, accessories, etc.

1.03 PERFORMANCE REQUIREMENTS

A. Subcontract planting work to a single firm specializing in planting work with a minimum of 5 years planting experience.

B. General: Ship plant materials with certificates of inspection required by governing authorities. Comply with regulations applicable to plant materials.

C. Do not make substitutions. If specified plant material is not obtainable, submit proof of non-availability to Concerned Citizens of Buffalo ND, together, with proposal for use of equivalent material.

D. Analysis and Standards: Package standard products with manufacturer's certified analysis. For other materials, provide analysis by recognized laboratory made in accordance with methods established by the Association of Official Agriculture Chemists, where applicable.

E. Trees, Shrubs and Plants: Provide trees and shrubs of quantity, size, genus, species and variety shown and scheduled for landscape work and complying with recommendations and requirements of ANSI Z60.1 "American Standards for Nursery Stock". Provide healthy, vigorous stock, grown in recognized nursery in accordance with good horticultural practice and free of disease, insects, eggs, larvae and defects such as knots, sun-scald, injuries, abrasions, or disfigurement.

F. Label at least one tree and one shrub of each variety with a securely attached waterproof tag bearing legible designation of botanical and common name.

G. Inspection: The Concerned Citizens of Buffalo ND may inspect trees and shrubs either at place of growth or at site before planting, for compliance with requirements for genus, species, variety, size and quality. The Concerned Citizens of Buffalo ND retains right to further inspect trees and shrubs for size and condition of balls and root systems, insects, injuries and latent defects, and to reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from project site.

1.04 SUBMITTALS

A. Certification: Submit certificates of inspection as required by governmental authorities. Submit manufacturers or vendors certified analysis for soil amendments and fertilizer materials. Submit other data substantiating that materials comply with specified requirements.

B. Certification of Grass Seed: From seed vendor for each grass-seed mono-stand or mixture stating the botanical and common name and percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging. Certification of each seed mixture for turfgrass seeded areas, identifying source, including name and telephone number of supplier.

C. Maintenance Instructions: Recommend procedures to Owner for maintenance of lawns during a calendar year. Submit before expiration of required maintenance periods.

1.05 DELIVERY, STORAGE AND HANDLING

A. Packaged Materials: Deliver packaged materials in containers showing weight, analysis and name of manufacturer. Protect materials from deterioration during delivery, and while stored at site.

B. Do not remove container-grown stock from containers until planting time.

1.06 JOB CONDITIONS

A. Proceed with and complete landscape work as rapidly as portions of site become available, working within seasonal limitations for each kind of landscape work required.

B. Utilities: Determine location of underground utilities and perform work in a manner, which will avoid possible damage. Hand excavate, as required. Maintain grade stakes set by others until removal is mutually agreed upon by parties concerned.

C. Excavation: When conditions detrimental to plant growth are encountered, such as rubble fill, adverse drainage conditions, or obstructions, notify The Concerned Citizens of Buffalo ND before planting.

D. Coordination with Lawns: Plant trees and shrubs after final grades are established and prior to planting of lawns, unless otherwise acceptable to The Concerned Citizens of Buffalo ND. If planting of trees and shrubs occurs after lawn work, protect lawn areas and promptly repair damage to lawns resulting from planting operations.

1.07 SPECIAL PROJECT WARRANTY

A. Warranty trees, shrubs, and lawns, for a period of two years after date of substantial completion, against defects including death and unsatisfactory growth.

B. Remove and replace trees, shrubs, or other plants found to be dead or in unhealthy condition during warranty period.

C. Another inspection will be conducted at end of extended warranty period, if any, to determine acceptance or rejection. Only one replacement (per tree, shrub or plant) will be required at end of warranty period, except for losses or replacements due to failure to comply with specified requirements.

PART 2 - PRODUCTS

2.01 TOPSOIL

A. Import topsoil as required to complete the landscape work. It is the Landscape installer's responsibility to verify all quantities.

B. Imported topsoil shall be natural loam, which is fertile, friable, surface soil, reasonably free of subsoil, clay lumps, brush, weeds, rhizomes, litter, roots, stumps, stones larger than 1 ½" in any dimension, and other extraneous or toxic matter harmful to plant growth. Raw field topsoil is not permissible. Topsoil found to be unsuitable will be removed and replaced by the Contractor at no additional cost to the Owner.

C. Obtain topsoil from local sources or from areas having similar soil characteristics to that found at project site. Obtain topsoil only from naturally, well-drained sites where topsoil occurs in a depth of not less than 4"; do not obtain from bogs or marshes.

2.02 SOIL AMEDMENTS

A. Organic Soil Amendment: Organic, nitrogen stabilized mulch free from deleterious materials and suitable for trees, shrubs or plants and consisting of shredded or ground bark or other well-composted, nitrogen stabilized material with no particles exceeding 3/8" in diameter.

B. Commercial Fertilizer: Complete fertilizer of neutral character, with some elements derived from organic sources and containing the following percentages of available plant nutrients:

C. For trees and shrub beds, provide fertilizer of approximately 5% total nitrogen, 10% available phosphoric acid and 5% soluble potash. Verify final NPK mix from soils fertility analysis recommendations.

D. For lawns, provide fertilizer with percentage of nitrogen required to provide not less than 1 lb. of actual nitrogen per 1,000 sq. ft. of lawn area and not less than 4% phosphoric acid and 2% potassium. Provide nitrogen to a form that will be available to lawn during initial period of growth; at least 50% of nitrogen to be organic form. Verify final NPK mix from soils fertility analysis recommendations.

2.03 HERBICIDES

A. Pre-emergent: Provide a mixture with active ingredients consisting of a "a-a-a-trifluoro-2, 6-dinito-n, n-dipropyl-p-toluidine" (1.75% of total mixture) and inactive ingredients (98.25% of total mixture). Manufacturer: "Green Gold" by Lebanon Chemical Corp. or equal.

B. Other: All other herbicides shall be approved by The Concerned Citizens of Buffalo ND prior to use.

2.04 WOOD MULCH TOP DRESSING

A. Wood mulch top dressing shall be 3-inch depth, organic shredded cedar mulch free of deleterious materials, nitrogen stabilized and suitable for top-dressing of trees, shrubs and groundcovers. Trees in lawn areas to have 3" depth by 5 ft. diameter wood mulch. Ensure that there is no lawn within the 5 ft. mulch diameter. Submit sample of wood landscape mulch topdressing and fabric to The Concerned Citizens of Buffalo ND for approval. Pebble type bark is not acceptable. Add mulch at end of maintenance period to re-establish 3-inch depth of mulch, where mulch has settled.

2.05 PLANT MATERIALS

A. Provide trees, shrubs, and other plants of size, genus, species and variety shown and scheduled for landscape work and complying with recommendations and requirements of ANSI Z60.1 "American Standard for Nursery Stock".

2.06 GRASS MATERIALS

A. Contractor will provide grass seed as follows:
Type 1 (Permanent Lawn Mixture) used for residential and commercial turf site, fertilized, and typically mowed. Use between March 1 and May 31 and between August 10 and September 30.

Type 1 Seed Mixture[1]

Common Name	Application Rate lb/acre
Creeping Red Fescue	25
Turf-type perennial ryegrass[2]	20
Turf-type perennial ryegrass[2]	20
Kentucky Bluegrass Cultivar[3]	65
Kentucky Bluegrass Cultivar[3]	65
Kentucky Bluegrass Cultivar[3]	65

[1]A commercial mixture may be used if it contains a high percentage of similar bluegrasses; it may or may not contain creeping red fescue.
[2]Choose two different cultivars of turf-type perennial ryegrass, at 20 lbs/acre each.
[3]Choose three different cultivars of Kentucky bluegrass, at 65 lbs/acre each.

2.07 OTHER MATERIALS:

A. Provide all other material as required to complete the landscape planting as shown on the drawings, details and as specified herein.

B. All materials shall be new, first quality and approved by The Concerned Citizens of Buffalo ND.

PART 3 - EXECUTION

3.01 PREPARATION

A. Preparation of Sub-Grade;

1. Thoroughly till compacted sub-grade to allow proper root development for the plant material. Till in two directions until subsoil is loosened sufficiently and large lumps are removed. Roll sub-grade sufficient to eliminate settling while maintaining a suitable sub-grade for plant material roots to penetrate.
2. Clean exposed subgrade of roots, plants, sod, trash, stones over 1-1/2" in diameter, clay lumps, discarded construction materials, and other extraneous materials harmful or toxic to plant growth.

3. Install topsoil to finish grades as indicated on grading plans and specifications. Eliminate uneven, low or high areas to achieve a smooth and uniform grade. Ensure positive drainage away from buildings and towards drainage structures.
4. Mix specified organic soil amendments and fertilizers with topsoil at rates specified. Delay mixing fertilizer if planting will not follow placing of planting soil within a few days. Spread organic soil amendment at a rate of 2 cubic yards per 1,000 sf to be planted. Spread fertilizer at the rate of 20 lbs. per 1,000 sq. ft. Thoroughly mix organic soil amendment and fertilizer into top 4" of soil.

B. Preparation of Unchanged Grades:

1. Where lawns and plants are to be planted in areas that have not been altered or disturbed by excavating, grading, or stripping operations, prepare soil for as follows: Strip existing vegetative matter, till to a depth of not less than 6"; apply organic soil amendments at the rate of 2 cubic yards per 1,000 sf and initial fertilizers as specified; remove high areas and fill in depressions; till soil to a homogeneous mixture of fine texture, free of lumps, clods, stones, roots and other extraneous matter.
2. Apply specified commercial fertilizer and organic soil amendment at rates specified and thoroughly mix into upper 4" of topsoil. Delay application of fertilizer if planting will not follow within a few days.
3. Fine grade lawn areas to smooth, even surface with loose, uniformly fine texture. Roll, rake and drag lawn areas, remove ridges and fill depressions, as required to meet finish grades. Limit fine grading to areas, which can be planted immediately after grading.
4. Moisten prepared lawn areas before planting if soil is dry. Water thoroughly and allow surface moisture to dry before planting lawns. Do not create a muddy soil condition.
5. Restore planting and lawn areas to specified condition if eroded or otherwise disturbed after fine grading and prior to planting.

C. Preparation of Lawn Areas:
1. Fine grade lawn areas as necessary to establish smooth and uniform grades. Ensure positive and even drainage to drainage structures, swales, detention areas and ponds as applicable. Remove any debris encountered as necessary. Prepare soil for as follows: Strip existing vegetative matter; remove high areas and fill in depressions; till soil to a homogeneous mixture of fine texture, free of lumps, clods, stones, roots and other extraneous matter.
2. Apply specified commercial fertilizers specified and thoroughly mix into topsoil. Delay application of fertilizer if planting will not follow within a few days.
3. Fine grade lawn areas to smooth, even surface with loose, uniformly fine texture. Roll, rake and drag lawn areas, remove ridges and fill depressions, as required to meet finish grades. Limit fine grading to areas, which can be planted immediately after grading.
4. Moisten prepared lawn areas before planting if soil is dry. Water thoroughly and allow surface moisture to dry before planting lawns. Do not create a muddy soil condition.
5. Restore planting and lawn areas to specified condition if eroded or otherwise disturbed after fine grading and prior to planting.

D. Layout individual tree and shrub locations and areas for multiple plantings. Stake locations and outline areas and secure The Concerned Citizens of Buffalo ND acceptance before start of planting work. Make minor adjustments as may be requested. Ensure drainage is away from buildings and structures at 2% minimum slope.

E. Excavation for Trees and Shrubs:

1. Excavate pits with vertical sides and with bottom of excavation slightly raised at center to provide proper drainage. Loosen hard subsoil in bottom of excavation. Scarify sides of pit. Pit width to be a minimum of twice the diameter of the root ball or as indicated on details, whichever is greater.
2. Thoroughly moisten excavations for trees and shrubs with water and allow to percolate out before planting.

3.02 PLANTING

A. Planting Trees, Shrubs and Perennials:

1. Layout: Coordinate layout of plants with The Concerned Citizens of Buffalo ND for inspection and approval prior to planting.
2. Container Removal: Remove containers with proper tools being careful to keep rootball intact.
3. Set plant material in pit as shown on details. Set plumb and faced for best appearance. Set crown slightly above surrounding grade, or as indicated on details, after settlement. Trees and shrubs will be inspected for proper planting depth. Plants found to be planted at improper depths as determined by The Concerned Citizens of Buffalo ND will be raised (or lowered) by the Contractor to the proper depths. Remove advantageous roots that have grown above the trees flare roots. Expose the flare root as necessary. Plant trees with flare roots exposed at or slightly above the adjacent grade.
4. Backfilling: Surface amended soil will be suitable for placement as top 12 inches around sides of root-ball. Backfill below this depth should not contain organic soil amendment and can be comprised of un-amended, pulverized soil.
5. Neatly trim all broken and frayed roots. Flood plant pit when half back-filled and allow to drain. Complete back-filling. Tamp as necessary but do not over compact.
6. Watering: Thoroughly water plants immediately after planting and construct water basin per details. Water all plants for the first two growing seasons as required to promote establishment. Note that there is no irrigation system. The Contractor will be required to make accommodations to hand water.
7. Pre-Emergent Herbicides: Apply granular herbicides at the rates and as recommended by the manufacturer. Do not apply pre-emergent herbicides where seeding will be done. If weeds appear in treated areas during the first year, landscaper shall return to remove all weeds at no cost to Owner.
8. Mulch Pits and Planted Areas: Provide not less than 3" thickness of mulch in tree pits and shrub planting beds. Keep mulch material away from base of trees and shrubs.
9. Prune: Thin out and shape trees and shrubs in accordance with standard horticulture practice. Prune trees to retain required height and spread. Unless otherwise directed by The Concerned Citizens of Buffalo ND, do not cut tree leaders, and remove only injured or dead branches from flowering trees, if any. Prune shrubs to retain natural character, do not shear plants.
10. Stake trees immediately after planting, as shown in details. Imbed stakes a minimum of 18" into undisturbed subsoil. Loop strap around trunk and tie to stake. Strap as shown on details.

B. Seeding New Lawns

1. Fertilizing: Apply fertilizer immediately prior to seedbed preparation. Incorporate the fertilizer into the top 2 to 3 inches of topsoil during the seedbed preparation. Equipment that results in ruts or excessive compaction will not be allowed.

2. Seedbed Preparation: Limit preparation of seedbed to areas that will be seeded immediately upon completion. Work areas accessible to field equipment to a depth of no less than 3 inches using mechanical rotary tillage equipment for the preparation of seedbed. Prepare by hand areas inaccessible to field machinery, to a depth of no less than 2 inches. Harrow ridging in excess of 4 inches due to operation of tillage equipment prior to rolling with the cultipacker. Roll the area with no less than one pass of the cultipacker prior to permanent seeding.

   Shape and fine grade to remove rills or gullies, water pockets, undesirable vegetation, and irregularities to provide a smooth, firm, and even surface true to grade and cross-section. For Type 1 (lawn seeding), prepare to a fine texture and without soil lumps. Coordinate preparation of all ditches designated for special ditch control with the seedbed preparation. Till parallel to the contours.

   Smooth the seedbed with a cultivator-type tillage tool having a rake bar or a rock rake. Pick up and remove all debris, such as rocks, stones, concrete larger than 2 inches (1/2 inch maximum for lawn seeding), or roots and other objectionable material that will interfere with the seeding operation. A spring tooth cultivator may be used in lieu of a rock picker. Remove the rock by hand after each use of the cultivator; repeat the process until the soil is relatively free of rock.

   Choose equipment to minimize soil compaction. Operate equipment in a manner to minimize displacement of soil and disturbance of the design cross-section. Roll the area with at least one pass of the cultipacker.

3. Seed Application: Prior to seeding, the seedbed will be inspected and approved by The Concerned Citizens of Buffalo ND. Use methods and procedures consistent with equipment manufacturer's recommendations; however, do not operate ground-driven equipment at speeds greater than 10 mph. On all areas accessible to machinery, sow seed with a gravity seeder, endgate cyclone seeder, or seed drill. On areas inaccessible to field machinery, the use of hand-operated cyclone seeders will be allowed, but no other hand-seeding methods will be accepted. All seeded areas will have one pass with a roller or cultipacker to firm the soil.

4. Mulching: Mulch all conventionally seeded areas the same day the seed is sown. Uniformly distribute the mulch over the required areas at a rate of 1.5 tons/acre for dry cereal straw, or native grass straw.

   Work the mulch into the soil with mulch anchoring equipment designed to anchor the mulch into the soil by means of dull blades or disks with a minimum of two passes. Operate equipment in a manner to minimize displacement of the soil and disturbance of the design cross-section.

   Use mulch anchoring equipment designed to anchor straw or hay mulch into soil by means of dull blades or disks. It should have flat blades or disks, may have cutaway edges, must have a nominal minimum diameter of 20 inches, and must be spaced at approximately 8 inch intervals. The mulch anchoring equipment must be pulled by mechanical means and weigh approximately 1,000 pounds.

3.03 MAINTENANCE

A. Begin maintenance immediately after planting. Maintenance period will begin upon final completion of all planting areas with a written notice from the landscape installer to The Concerned Citizens of Buffalo ND indicating substantial completion. Maintenance period days will be counted from May 15 to October 15.

B. Areas to be maintained are to include those areas installed as a part of this contract.

C. Maintain trees, shrubs, lawns and other plants until final acceptance or as noted on plans, but in no case less than the following period:

Two growing seasons after substantial completion of landscaping work as submitted by the landscape installer.

D. Maintain trees, shrubs and other plants by pruning, cultivating, weeding, watering and as required for healthy growth. Restore planting saucers. Tighten and repair stake supports and reset trees and shrubs to proper grades or vertical position as required. Apply pesticides only as required to keep trees and shrubs free of insects and disease. Adjust watering as weather dictates for optimum plant establishment. Do not over-water plantings.

E. Maintain lawns by watering, fertilizing, weeding, watering (hand watering as required), weekly mowing, trimming, and other operations such as rolling, re-grading and replanting as required to establish a smooth acceptable lawn, free of eroded or bare areas. Adjust watering as weather dictates for optimum lawn establishment. The contractor must periodically water by hand or truck as necessary to facilitate establishment.

F. Immediately replace all unhealthy or dead plant materials found during the 2-year warranty period.

3.04 CLEANUP AND PROTECTION

A. During planting work, keep pavements clean and work area in an orderly condition.

B. Protect planting work and materials from damage due to planting operations, operations by other contractors and trades and trespassers. Maintain protection during installation and maintenance periods. Treat, repair or replace damaged planting work as directed.

3.05 SATISFACTORY LAWNS

A. Satisfactory Lawn: A healthy, well-rooted, even-colored, viable lawn has been established, free of weeds, open joints, bare areas, and surface irregularities.

B. Repair areas that erode before lawn establishes. Replace lost topsoil, grade even, and re-seed as necessary.

C. Reestablish lawns that do not comply with requirements and continue maintenance until lawns are satisfactory.

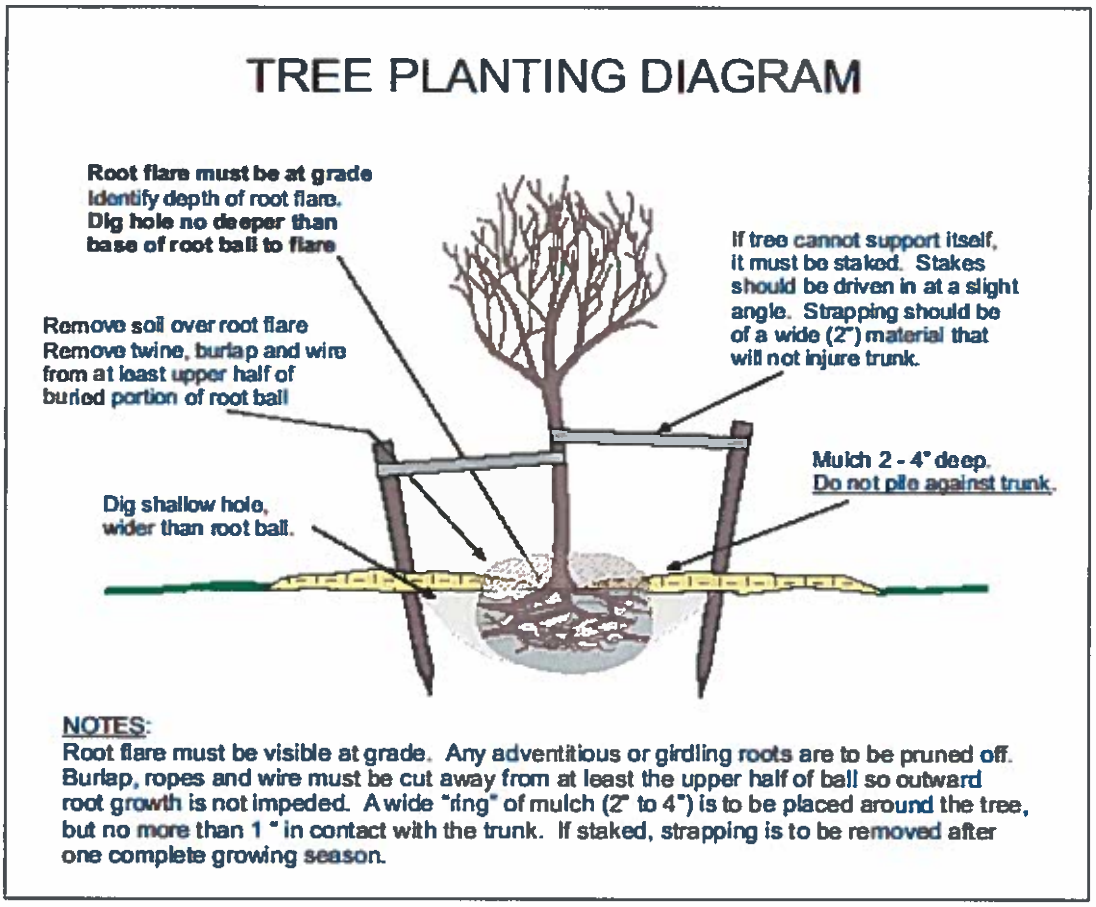
3.06 INSPECTION AND ACCEPTANCE

A. When planting work is completed, including maintenance, The Concerned Citizens of Buffalo ND will, upon request, make an inspection to determine acceptability.

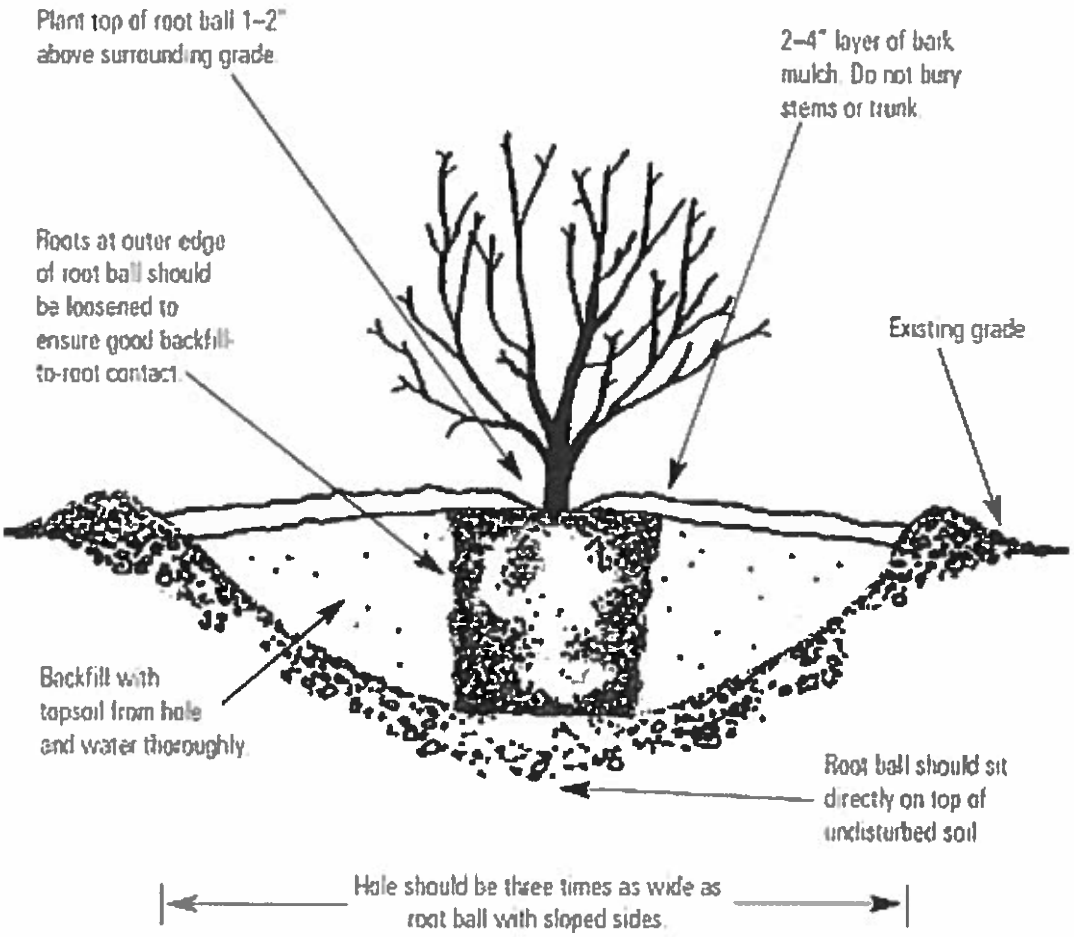
B. Where inspected planting work does not comply with requirements, replace rejected work and continue specified maintenance until re-inspected by The Concerned Citizens of Buffalo ND and found acceptable. Remove rejected plants and materials promptly from project site.

PART 2 - Drawings

2.01 Tree Planting



2.02 Shrub Planting



PART 3 – Plant Legend

Plant	Size	Qty	Spacing	Location
Red Twig Dogwood	#5 container	760	5ft	Row 1 (Outside Perimeter)
Caragana	#10 container	543	7ft	Row 2
Amur Maple, Tree Form	#25 container, 1 ¼"	190	20ft	Row 3
Cottonwood, Siouxland	#25 container, 1 ½"	76	50ft	Row 4
Elm, Siberian	#25 container, 1 ½"	109	35ft	Row 5
Colorado Blue Spruce	#25 container, 5'	190	20ft	Row 6 (Inside Perimeter)

6. Other Concerns

“The CAFO Reader”

TO: The North Dakota Department of Health

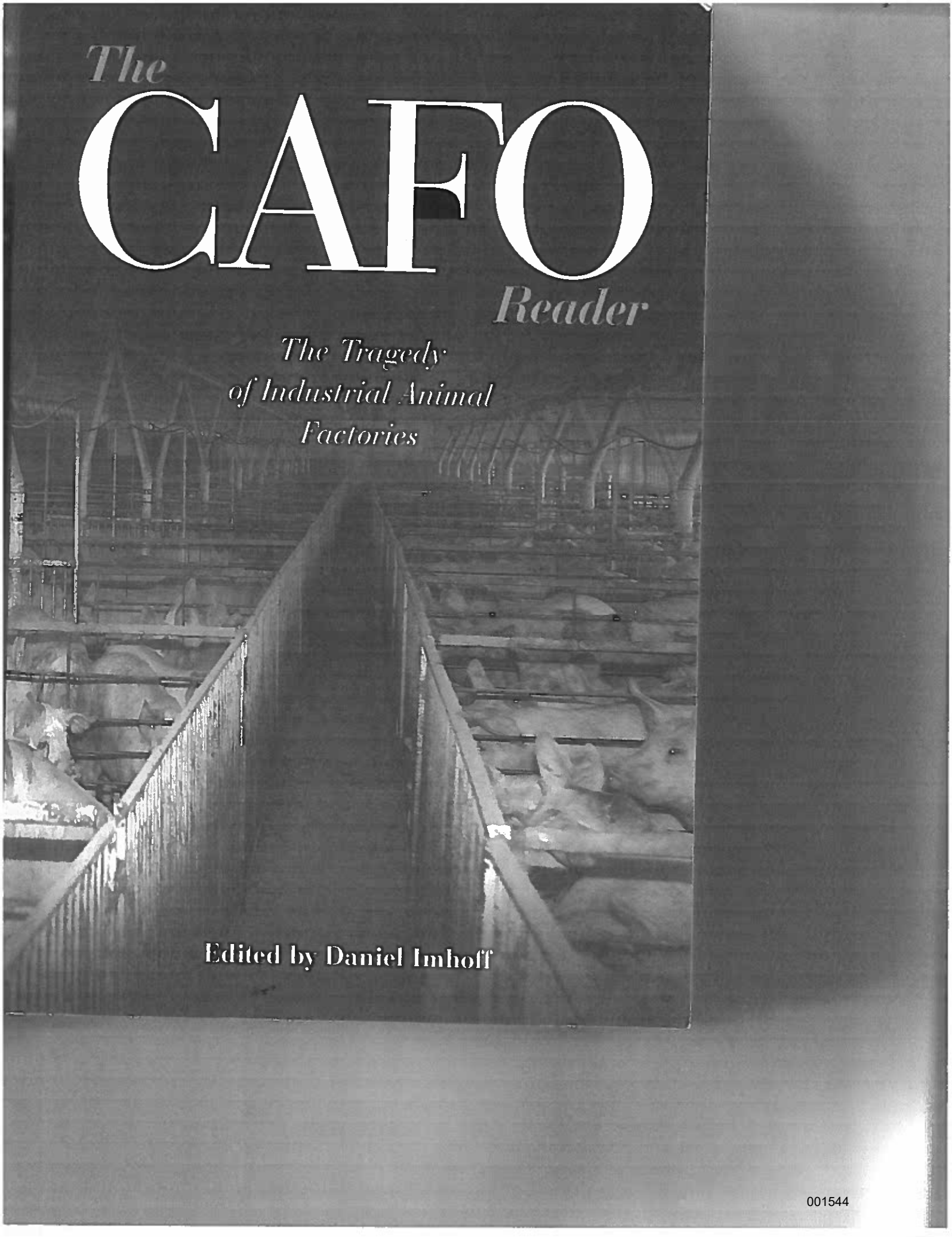
My name is Lois Smith and I have lived in Buffalo for many years. I have been the Librarian at the Margaret Fraase Public Library in Buffalo for over 10 years.

I believe in the power of education, the knowledge gained by reading and the value of the published word. I strongly recommend that the North Dakota Department of Health takes the time to read this book:

"The CAFO Reader: The Tragedy of Industrial Animal Factories"
Edited by Daniel Imhoff

. . . . This book features more than thirty essays by today's leading thinkers on food and agriculture. It provides an unprecedented overview of concentrated animal feeding operations - known as CAFO's - where increasing amounts of the world's meat, milk, eggs, and seafood are produced. The rise of the CAFO industry around the world has become one of the most pressing issues of our time.

I want to thank the Department of Health for their time to seriously consider the negative impact created by this type of factory farming. I am convinced from my research that you must not approve this permit.


The
CAFO
Reader
The Tragedy of Industrial Animal Factories
Edited by Daniel Imhoff

001544

Statement of Legal Action

To: North Dakota Department of Health
Division of Water Quality
3-17-2016
Permit Application #DNAF00853

There are two operations in the State like this one already located in Bottineau County and Nelson County. They are both farther from a town, smaller than this one, and because the counties are so sparsely populated few rural residents are affected.

The latest census indicates that Bottineau County has 6,429 residents and Nelson County has 3,126 residents. By comparison, the population of Cass County is 149,778 and if you subtract Fargo from this total there still remains 18,399 residents. Out of the 53 counties in the state, Cass County is still ranked in the top 10 highest populated counties even after taking out Fargo's population.

There are 10 homes within 2 miles of this proposed operation that will be affected with loss in property value and quality of life. Less than 3 miles, the town of Buffalo and many more rural residents will be affected.

The State of North Dakota is ranked 47th in population in the United States There is surely more appropriate sites for a hog farm of this size then here.

Due to the degree of which current residents will be affected in the value of their property and life in general, I believe it is reasonable to regard this proposed operation as a public nuisance.

If this permit is granted and the operation is built, there is no way we are putting up with the loss of quality of life while we see our property value plummet 30%-40%, without legal action.

I encourage you to deny this permit.

Roy Thompson
3517 142nd Ave. SE.
PO Box 194
Buffalo, ND 58011

We, the undersigned, have researched the impact that CAFOs such as Rolling Green Family Farms RE, LLP, and have found that such CAFOs typically have a significant negative impact on the property values of surrounding properties. If our property value is diminished as a result of the swine facility proposed by Rolling Green Family Farms RE, LLP, we will retain legal counsel and file lawsuits for nuisance and under any other pertinent legal theories to obtain damages to the loss in value to our homes and any other damages we suffer. 16 families so far.

Print Name	Signature	Date
Tim Fryer		3/16/16
GERALD MARCKS	Gerald Marcks	3/16/16
Liane Rakow Stout	Liane K. Stout	3-16-16
LEE FRAASE	Lee Fraase	3-16-16
Tom Cole		3-16-16
Craig A Wardt		3-16-16

We, the undersigned, have researched the impact of CAFOs such as Rolling Green Family Farms RE, LLP, and have found that such CAFOs typically have a significant negative impact on the property values of surrounding properties. If our property value is diminished as a result of the swine facility proposed by Rolling Green Family Farms RE, LLP, we will retain legal counsel and file lawsuits for nuisance and under any other pertinent legal theories to obtain damages to the loss in value to our homes and any other damages we suffer.

Print Name	Signature	Date
LEE FISCHER		3/15/16
ALAN DOSTERT		3/15/16
Cecil P VonBank		3/15/16
Kent Beike	Kent Beike	3-15-16
Judith VonBank	Judith VonBank	3-15-16
Randal Coon		3/15/16

Print Name	Signature	Date
Roy Thompson	Roy Thompson	3-16-16
Hal Grieve	Hal Grieve	3-16-16
CAROL DEILKE	Carol Deilke	3-16-16
TRACE ZAHN	Trace Zahn	3-16-16

7. Conclusion Letter

CONCLUSION

On behalf of the Concerned Citizens of Buffalo, we wish to thank the North Dakota Department of Health, Environmental Health Section, Division of Water Quality for granting us this hearing to present our concerns.

Upon first learning of this proposal, we decided to approach this in an intelligent manner. We hired legal and professional experts and have gathered information from all over the country concerning CAFOs and the Applicant. Our conclusion is that this proposed CAFO will have devastating negative impact to our community, could be disastrous to our environment, and that the permit is illegal.

We have produced stacks of evidence of how CAFOs will negatively impact health, water, air, and general quality of life. The mission statement of the Health Department is to protect and enhance air and water quality for all North Dakota citizens. How does permitting an out of state corporate business to set up and pollute in violation of the law in our back yard protect us? With North Dakota cutting budgets, who is going to monitor everything required, from building permits to compliance of regulations? We respectfully submit that the Health Department has not done due diligence concerning the approval of this illegal permit. With the potential for illegal pollution that's almost guaranteed, does the ND Health Department want to sign off on the real potential of a future cleanup site? This is our home and community. All parties concerned will be held responsible.

It is our opinion that information supplied to us by the Applicant has been very misleading and untruthful. Their character assassination of our neighbors is unwarranted and out of line. The track record of the Applicant in regards to CAFOs is less than savory. Their project designs are flawed, incomplete and inadequate. Their nutrient management plan does not have enough acres due to soil type and set-backs. The Applicant cannot possibly fulfill their illegal permit obligations as presented. If this proposal is so beneficial and will not harm our quality of life, then why has everything about this project been secretive and back door?

We have gathered significant information should we need to turn to the courts. We intend to have independent water, air and fly population monitors in place, have obtained information through open records laws, and will have our properties assessed to hold the Applicant responsible for any loss in value to our property that it may cause. To the Applicant, this is just another investment for corporate business. To the Health Department, it's just another permit. To us, it's our home and quality of life. To us it's personal, and we will proceed as such. If approved, this illegal permit and the proposed project will be challenged individually and by the Concerned Citizens of Buffalo in the courts and every other venue as required. This is our home, our community and we will not be just statistics in the way of corporate greed.

Lee Fischer
For the Concerned Citizens of Buffalo

JJ England

From: Rockeman, Karl H. <krockema@nd.gov>
Sent: Monday, February 08, 2016 4:55 PM
To: JJ England
Subject: RE: Rolling Green permit question

The permit is a state issued animal feeding operation approval to operate.

Karl Rockeman, P.E.
Director
Division of Water Quality
North Dakota Department of Health
(701)328-5210

From: JJ England [mailto:jj@baumstarkbraaten.com]
Sent: Monday, February 08, 2016 12:47 PM
To: Rockeman, Karl H.
Subject: Rolling Green permit question

Mr. Rockeman,

I have a quick question about the Rolling Green permit that is up for public comment. The public notice description on the Department's main public notice page at https://www.ndhealth.gov/WQ/PublicNotices.aspx states that this permit is a NDPDES permit. However, the permit itself states that it is an "approval to operate a concentrated livestock operation." *See* pg. seventeen of the pdf here https://www.ndhealth.gov/PublicComment/NDPDES20160126.pdf?v=3.

I was hoping you could offer some clarification on this. Does the Department consider this permit to be a NDPDES permit, a "state animal feeding operation permit," or an "approval to operate a concentrated livestock operation"? Thank you in advance for any help you can offer.

Sincerely,
JJ England

JJ England
BAUMSTARK BRAATEN LAW PARTNERS
109 North 4th Street, Suite 100
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Expert Report

Kathy J. Martin, PE (OK#18254)

Regarding:
Public Comment for Proposed North Dakota Livestock Permit Approval
Proposed CAFO Permit for Rolling Green Family Farms RE, LLP
Cass County, North Dakota

Prepared for:
Concerned Citizens of Buffalo
Derrick Braaten
Baumstark Braaten Law Partners
109 North 4th Street, Suite 100
Bismark, ND 58501

Prepared by:
Kathy J. Martin, PE (OK#18254)
Martin Environmental Services
3122 Tall Oaks Circle
Norman, Oklahoma 73072

Kathy J. Martin, PE (OK#18254)

March 18, 2016
Date

Seal

Opinions and Basis of Opinions

The following opinions are based on my engineering knowledge and experience, as well as my review of the CAFO permit application for Rolling Green Family Farms RE, LLP; the North Dakota Department of Health (NDDH) Public Notice, proposed Approval to Operate, and Fact Sheet; the ND Livestock Program Design Manual; applicable state code and regulations; and the published literature.

Kathy J. Martin, PE (OK#18254) has a BS in Petroleum Engineering (1987) and MS in Civil Engineering (1989) from the University of Oklahoma, worked as a permit writer for industrial wastewater for several years. Ms. Martin has drafted state and county environmental regulations for industrial wastewater and confined animal feeding operations (CAFOs) waste management, and has been performing technical and regulatory evaluations of waste management systems related to livestock production since 1997. Qualifications for Kathy J. Martin, PE (OK#18254) are provided as Attachment A.

These professional engineering opinions are held within a reasonable degree of scientific certainty and I reserve the right to supplement these opinions if additional evidence arises. References documents relied upon in this report are provided in Attachment B with index.

Proposed Facility Description

Rolling Green Family Farms RE, LLP is a Pipestone Vet sow facility with proposed animal numbers of 800 nursery, 1600 gilt replacement, 5312 gestation, and 1344 farrowing hogs. The facility is proposed to be located in the SE1/4 NW1/4 Section 4, T139N, R54W, Howes Township, Cass County, North Dakota.

Pipestone Vet has proposed similar sized sow facilities in South Dakota and Missouri.

This expert has reviewed CAFO permit applications and waste management systems proposed for the following Pipestone sow facilities:

1. Jackrabbit Farms, Davison County, SD
600 nursery, 1200 finishers/gilts, 4480 gestation, 936 farrow

2. Westside Gilts, Beadle County, SD (2014)
4480 gestation, 2136 farrow, 1200 gilt - Barry Kerkaert, Pipestone

3. Rolling Green Family Farms, Grant County, SD - Jan 2015
6600 head > 55 lbs, 1200 head < 55 lbs - Barry Kerkaert, Pipestone

4. Westside Gilts, Gregory County, SD - Dec 2013
4480 gestation 936 farrow, 600 nursery, 1200 gilt - Barry Kerkaert, Pipestone

5. Mustang Pass, Brookings County, SD - Mar 2013
4480 gestation, 2146 farrow, 1200 gilt - Luke Minion, Pipestone

6. Teton, LLC - Grant County, SD
4480 gestation, 2136 farrow, 1200 gilt - Barry Kerkaert, Pipestone

7. Trenton Farms, Grundy County, MO - Mar 2015
5120 gestation, 936 farrow, 960 gilt, 320 nursery - Luke Minion, Pipestone

Opinion 1: *It is my professional engineering opinion that the Rolling Green Family Farms RE, LLP sow facility has the potential to emit 35 tons or more of ammonia per year. The ammonia is exhausted - along with hydrogen sulfide gas, particulates, and odors - from the sow barns by ventilation fans (wall and pit) that are designed without air emission or odor control technology. These uncontrolled emissions of ammonia, hydrogen sulfide gas, particulates, and odor can and will travel off-site and into the surrounding community according to atmospheric conditions.*

Basis for Opinion 1:

a. In the Rolling Green permit application, the waste calculations assume a 20 percent loss of nitrogen from the deep pit storage of manure under the barns. Using the amount of nitrogen generated per day, the total amount of nitrogen generated per year and the amount lost due to volatilization can be determined as follows:

778.8 lbs N/day x 365 days/yr = 284,336 lbs N/yr

284,336 lbs N/yr (17 NH3/14 N) x 0.20 volatilized = 69,052 lbs NH3 volatilized

69,052 lbs NH3/yr x ton/2000 lbs = 34.5 tons/yr ammonia volatilized

b. Wind roses for the Fargo, ND indicate a predominant wind direction from the NNW and the SSE from January to June.[1] From June to September the predominant wind direction is from the SSE with maximum wind speeds in August and September exceeding 27 mph. The remainder of the year has predominant wind patterns reverting back to NNW and SSE at about 14 to 16% of the time, respectively.

c. The town of Buffalo is located approximately 2.8 miles northwest of the proposed site and would be in the predominant wind pattern "from the SSE" throughout the year (*see* Figure 1).

[1] *See* wind rose data attachment. Available online at: https://www.ndsu.edu/ndsco/data/wind/fargo/#c342826

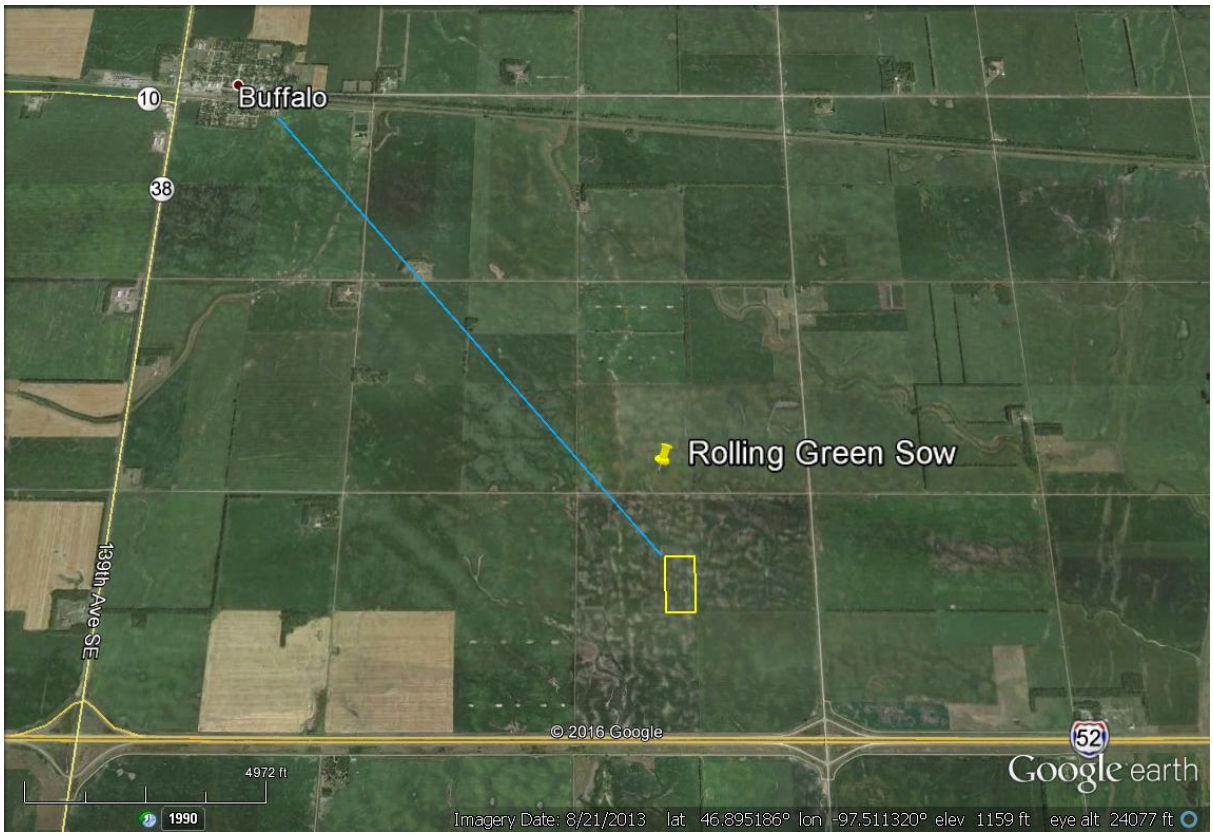


Figure 1 – Google Earth image of proximity of Buffalo, ND to proposed sow facility.

d. A two year study on emissions during slurry removal from hog facilities with deep pit manure storage indicates significant increases in emissions of ammonia, hydrogen sulfide, and odor during agitation and removal of slurry prior to land application.[2] Similarly, ammonia emissions increased 4.6 times the concentration measured prior to agitation and removal. Odor emissions increased by a factor of 5.6 times. Hydrogen sulfide gas increased *61.0 times* the pre-agitation concentration.

e. The Natural Resource Conservation Service (NRCS) publishes Conservation Practice Standards for various best management practices related to agriculture and livestock production. The NRCS-ND Standard 371 Air Filtration and Scrubbing describes methods to "control gaseous and particulate emissions from ventilated structures" for the purpose of reducing emissions of particulates, volatile organic compounds (VOCs), ammonia, and odorous sulfur compounds.

[2] Hoff et al (2006) "Emissions of Ammonia, Hydrogen Sulfide, and Odor before, during and after Slurry Removal from a Deep-Pit Swine Finisher", Journal of Air & Waste Mgmt Assoc Vol 56: 581-590. https://engineering.purdue.edu/ABE/People/Papers/albert.j.heber.1/slurryremove

Standard 371 includes a brief discussion of biofilters and design and construction criteria including characteristics of air flow from the ventilation fans, the expected concentration of air pollutants, the types of pollutants to be treated, types of filter media, and minimum requirements for plans and specifications.[3]

f. The Pipestone Vet attempt to control air emissions at the Jackrabbit sow facility in Davison County, South Dakota has not been successful nor did those efforts rise to the adequacy of a biofilter. The Jackrabbit sow facility was designed for 600 nursery, 1200 gilt/finishers, 4480 gestation, and 936 farrowing. This expert attended the Davison County hearing where Pipestone representatives volunteered to install biofilters on the Jackrabbit hog barns. Rather than installing proven biofilter technology, the facility was equipped with what can only be described as a large windsock with dubious odor and emission control capabilities. (*see* Figure 2)

Figure 2 – Fabric "socks" installed on exhaust fans at Jackrabbit Farms (Pipestone sow facility) in Davison County, SD.

[3] See NRCS-ND Conservation Practice Standard 371 – Air Filtration and Scrubbing (2015)

g. North Dakota State University has performed research on odors and emissions of ammonia and hydrogen sulfide from large hog facilities in North Dakota from May 2009 to October 2010.[4] Two commercial swine operations were studied – one with shallow pit and outdoor manure lagoon and the other with deep pit manure storage under barns. Both facilities housed 5000 head and were gestation/farrowing swine facilities. The deep pit barn manure storage included the drainage of manure from the farrowing barn to the gestation barn in much the same was as proposed by Pipestone Vet for Rolling Green sow facility.

This was not a continuous monitoring study and only twelve samples were taken per sampling event that occurred between 10 am and noon and from one pit fan. Odor emission rates were determined to be approximate 5 OU/sec/m^2 for the deep pit farrowing barn and 19 OU/sec/m^2 for the gestation barn. The ammonia emission rates were determined to be 3 g/day/AU for the farrowing barn and 32 g/day/AU for the gestation barn.

Emission rates for Rolling Green sow facility can be calculated as follows:

5312 gest sows x 400 lbs/sow x kg/2.2 lbs x AU/500 kg = 1931 AU (study unit)

32 g NH3/day/AU x 1931 AU x 365 days/yr = 22,554,080 g NH3/yr

x 1lb/454 g = 49,678 lbs NH3/yr for gestation barn

Similarly, the emissions for the farrowing barn can be calculated as follows:

1344 gest sows x 400 lbs/sow x kg/2.2 lbs x AU/500 kg = 489 AU (study unit)

3 g NH3/day/AU x 489 AU x 365 days/yr = 535,455 g NH3/yr

x 1lb/454 g = 1179 lbs NH3/yr for gestation barn

Emissions (not including gilt barn) = 50,857 lbs NH3/year or 25 tons per year

h. A more lengthy study was done in Central Iowa where emissions from a sow facility were determined using a mobile air emission monitoring unit from January to May 2011.[5] The monitored portion of the facility included a deep-pit breeding barn (1800 head), a deep-pit gestation barn (1800 head), and two shallow-pit farrowing rooms (40 farrowing crates per room). The shallow pit farrowing rooms were flushed every three weeks. Exhaust air samples were taken from four of the lowest ventilation rate fans and

[4] Rahman and Newman (2010) "Odor, Ammonia, and Hydrogen Sulfide Concentration and Emissions from Two Farrowing-Gestation Swine Operations in North Dakota", Applied Engr in Agriculture Vol 28(1): 107-115.
[5] Stinn, Xin, Li, et al "Quantification of Greenhouse Gas and Ammonia Emissions from a Midwestern Swine Breeding/Gestation/Farrowing Facility", ASABE Proceedings Paper No. 1111151.

composited to represent pit fan exhaust emissions. Results from the study indicate the following average daily emissions per animal unit (AU = 500 kg body mass): 31.9 g NH3 for sows in the breeding/early gestation barn (1652 sows) and 76.9 g NH3 for shallow pit farrowing rooms (80 sows). The authors explained their higher emission rates as compared to other published rates as due to "the nearly continuous sampling employed as compared to intermittent sampling used in other studies."

Emission rates for Rolling Green sow facility can be calculated as follows:

5312 gest sows x 400 lbs/sow x kg/2.2 lbs x AU/500 kg = 1931 AU (study unit)

31.9 g NH3/day/AU x 1931 AU x 365 days/yr = 22,483,598 g NH3/yr

x 1lb/454 g = 49,523 lbs NH3/yr for gestation barn

Similarly, the emissions for the farrowing barn can be calculated as follows:

1344 gest sows x 400 lbs/sow x kg/2.2 lbs x AU/500 kg = 489 AU (study unit)

76.9 g NH3/day/AU x 489 AU x 365 days/yr = 13,697,428 g NH3/yr

x 1lb/454 g = 30,170 lbs NH3/yr for gestation barn

Emissions (not including gilt barn) = 76,693 lbs NH3/year or 38 tons per year

i. A 2008 study by Iowa State University identified 295 compounds associated with emissions from liquid swine manure in nursery and finisher facilities.[6] The emissions were composed of volatile fatty acids, alcohols, aldehydes, aromatics, esters, ethers, fixed gases, hydrocarbons, ketones, nitrogen compounds, phenols, and sulfur compounds. A table of all of the compounds detected is provided in the publication including odor detection thresholds, odor descriptions, and references to other studies that detected the same compound.

Figure 3 below shows the distribution of 77 of the 295 compounds detected that also have published odor thresholds. Nearly half of these compounds are considered offensive based on odor descriptors from the 2008 study. The authors explain that malodorous compounds are the result of microbial degradation in an anaerobic environment, such as that found in deep pit liquid manure storage systems.[7]

[6] Lo, Koziel, Cai, Hoff, et al (2008) "Simultaneous Chemical and Sensory Characterization of Volatile Organic Compounds and Semi-Volatile Organic Compounds Emitted from Swine Manure…", J. Enviro Quality 37:521-534. http://www.pubpdf.com/pub/16297922/Characterization-of-volatile-organic-compounds-and-odorants-associated-with-swine-barn-particulate-m

[7] Hamilton and Arogo "Understanding Farmstead Odors: An Annotated Review" Prof Animal Scientist 15:203-210. http://www.professionalanimalscientist.org/article/S1080-7446(15)31765-4/pdf

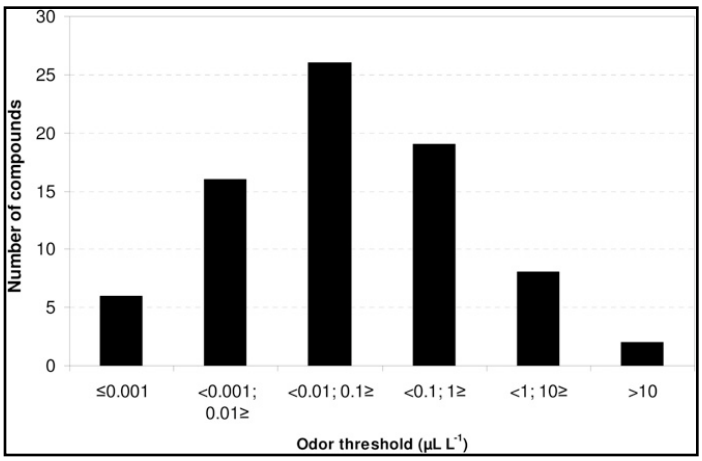


Figure 3 - Distribution of odor threshold for 77 of 295 compounds emitted from swine manure (from the publication).

j. The Odor Control Plan in Section 9C of the permit application does not include provisions for biofilters or any control technology on the ventilation fans for any of the three livestock barns. The plan states "vegetative barriers is proposed as part of the plan to reduce odor." Sheet 6 indicates the proposed tree row will be planted around the perimeter of the facility footprint. The barrier is not described with respect to the type of trees to be planted, the calculated distance from the ventilation fans that will insure odor control by adsorption or dust filtration or if the tree barrier is meant to change exhaust elevation for greater dispersion in higher elevations.

Opinion 2: *It is my professional engineering opinion that the hydrogeologic study, including soil borings and analysis, does not adequately identify the shallow ground water system(s) below the footprint of the proposed sow facility. The potential adverse impacts of a shallow groundwater system in contact with the subsurface manure storage structure are important with respect to the stability of the structure and the assurance that the system can safely store millions of gallons of feces and urine.*

Basis of Opinion 2:

a. On page 26 of the Design Manual it states "Soil evaluations should be spaced throughout the proposed facility to enable an accurate assessment of the subsurface geology."

b. Seven soil borings were made within the footprint of the proposed sow facility. Borings 1 to 4 represent the area north to south under the gilt developer barn and the gestation barn. Borings 5 to 7 represent the area north to south with Boring 5 and 7 located north and south of the farrowing barn, respectively, and only Boring 6 placed under the farrowing barn. Boring 5 is basically west of Borings 1 and 2. Boring 6 is west of Boring 3. Boring 7 is west and south of Boring 4 and would represent location

of proposed expansion of farrowing barn in Phase II. All borings were drilled to a depth of 23.5 feet below grade except for Borings 4 and 7 which were only 18.5 feet.

c. A zone of silty sand, described as water-bearing, was intercepted in five of the seven borings and a zone of clayey sand was intercepted at similar elevation in a sixth boring.

The east side of the property is described by Borings 1 through 4 as follows:

> At Boring 1 (Gilt Development Barn) this zone has a thickness of three feet and occurs between 1139.4 and 1136.4 feet elevation.
>
> At Boring 2 (north end of Gestation Barn), this zone has a thickness of one foot and occurs between 1131.8 and 1130.8 feet elevation.
>
> Boring 3 (center of Gestation Barn) shows wet clayey sand with a thickness of three feet at 1136.5 to 1133.5 feet elevation, which is a similar depth as the silty sand material described in Borings 1 and 2.
>
> At Boring 4 (south end of Gestation Barn), the silty sand zone has a thickness of 6.5 feet and occurs at 1131.8 to 1125.3 (TD of boring) feet elevation.

The west side of the property is described by Borings 5 through 7 as follows:

> At Boring 5 (north of farrow barn), the silty sand zone has a thickness of eleven feet and occurs from 1134.0 to 1123.0 (TD of boring) feet elevation.
>
> Boring 6 (center of farrowing barn) does not have either the silty sand or the clayey sand zone at the expected elevations, although water level was recorded at 1139 and 1136.
>
> At Boring 7(south of farrowing barn), the silty sand zone has a thickness of two feet and occurs at 1131.0 to 1129.0 feet elevation.

d. On page 2 of the Fact Sheet prepared by NDDH the discussion of aquifers states that the two closest glacial drift aquifers are at least five miles from the proposed site. Then the fact sheet goes on to describe those aquifers even though the agency just stated they do not exist at the proposed site. What the Fact Sheet does not explain is (a) the significance of the water-bearing silty sand strata and (b) why the applicant used the label “Carlile Formation” for that strata as found in the boring logs for Boring 1 (1135.4 elev), Boring 2 (1130.8 elev), Boring 3 (1127.5 elev), and Boring 4 (1131.0 elev).

e. The term “Carlile Formation” is not defined or discussed in the Fact Sheet or the permit application. According to the North Dakota Geological Survey (NDGS) analysis of the subsurface geology in Cass County, “the younger Cretaceous deposits that are present farther west (Carlile Shale, Niobrara Formation, and Pierre Shale) are not

known to be present in the county."[8] Regardless as to whether the formation exists in the county, a shale formation or even the erosion by-products would not be described as "silty sand".

The NDGS describes Cass County as "completely covered with glacial drift" of the Pleistocene with major subsurface units of buried outwash, un-differentiated stratified drift, older till, and buried lake deposits. Of those subsurface units, the un-differentiated stratified drift best matches the soil boring lithology of fine to coarse sand overlain by 10 feet or more of till. The NDGS describes their investigation of this lithology in T142 R53W as follows: "the silt and sand deposits are not known to be continuous, but the similarity of stratigraphic position suggests that they may represent a single large body of stratified drift. The deposits are known to range in thickness from 10 to 78 feet."

On page 5 of the Fact Sheet, the department claims "the facility does not appear to be located over an aquifer." This statement belies the shallow water-bearing silty sand as a localized, if not discontinuous regional shallow groundwater system.

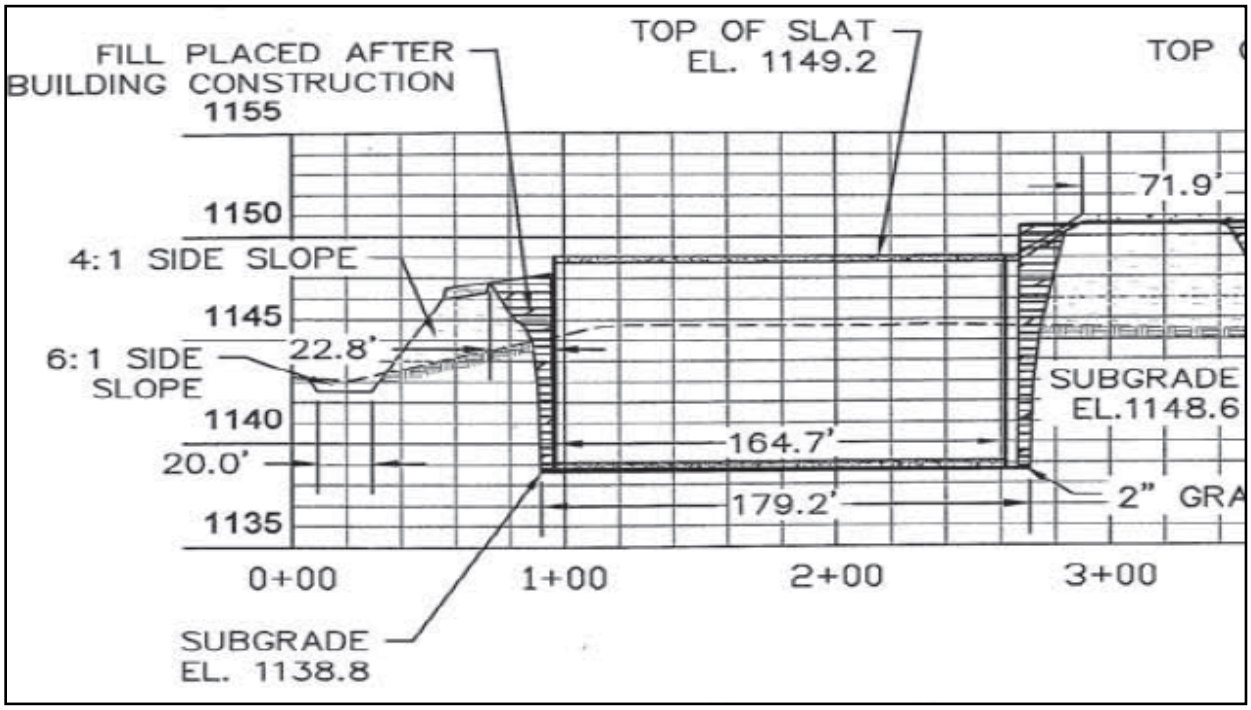


Figure 4 – Close-up of Sheet 8 labeled "cross-section A6-A6' of gilt development barn deep pit and existing grade.

[8] Klausing (1968) "Geology and Ground Water Resources of Cass County, North Dakota Part 1 Geology", North Dakota Geological Survey, Bulletin 47- County Ground Water Studies 8. https://pubs.er.usgs.gov/publication/70046311

f. Rule 33-16-03.1-07(4)(j) requires “site-specific information on topography, surface water, ground water, and soil geology”. Cross-section drawings of the various barns show the intersection between existing grade and expected depth of manure storage structures (*see* Figures 4 and 5). However, the drawings and narrative are vague with respect to the interception between the water-bearing zones and the manure storage structures.

In Section 8 of the permit application, the applicant summarizes the “water elevations in relation to the topographical elevations” in a table, but does not indicate the thicknesses of the silty sand zones, only the top elevation of the strata. No narrative is provided that would explain how the placement of the planned drain tile underneath the gestation and gilt isolation barns would be sufficient to drain a water-bearing strata that has been measured up to eleven feet thick.

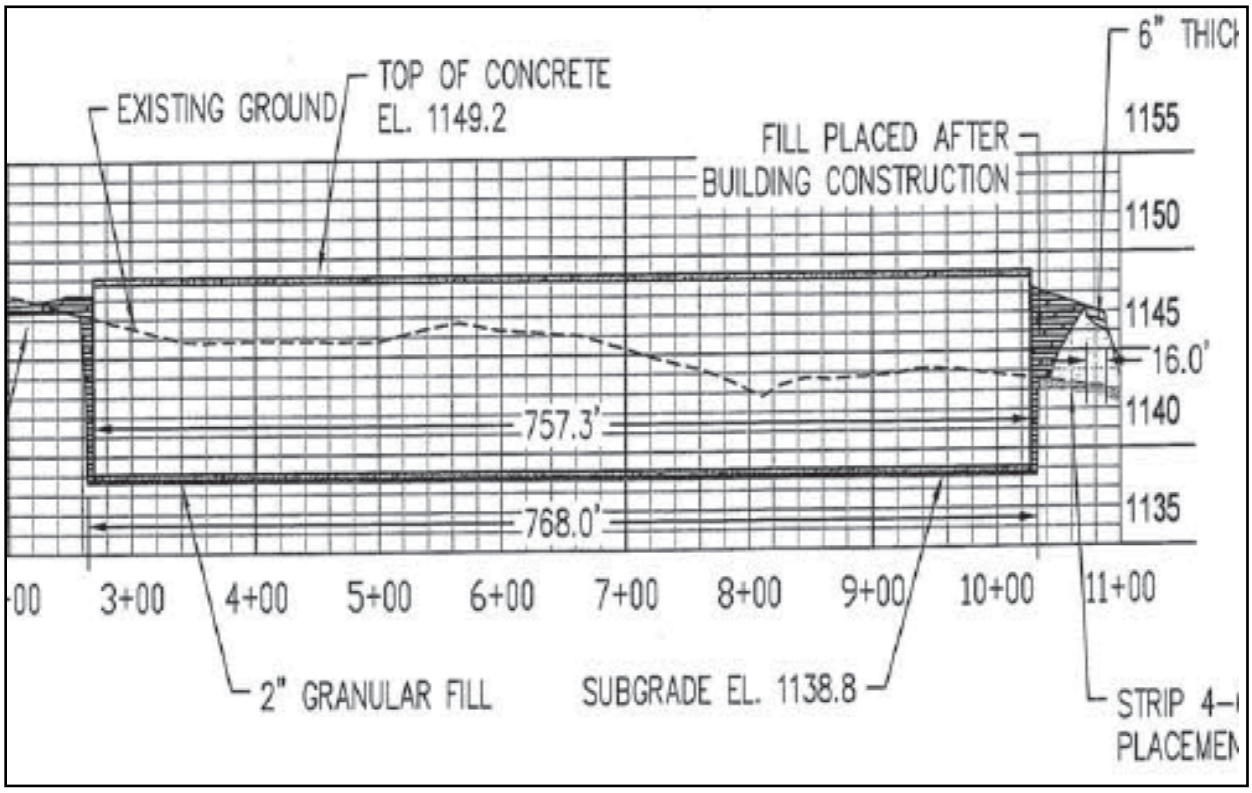


Figure 5 – Close-up of Sheet 8 showing length of gestation barn and existing grade.

f. On page 5 of the Fact Sheet, the department states:

> “Drain tile will be placed under the deep pits of the gestating barn and the isolation barn that will serve a dual purpose: (1), it will collect any dirty water which may escape from the deep pits, thereby acting as a leak detection system, and (2), it will collect any clean water from outside water sources from applying

pressure to the walls as well as premature deterioration of the concrete. Water collected in the drain tile will be collected in a shallow containment pond."

The department is referring to the drain tiles drawn in Sheet 4 of the permit application (proposed site subgrade plan view), which are described as 4 inch tile that run along the length of the gestation barn (north/south) and the isolation barn (east/west). The plan directs liquids collected from the drain tiles to a lift station and then discharges to an earthen impoundment located directly north of the farrowing barn. (*see* Figure 6)

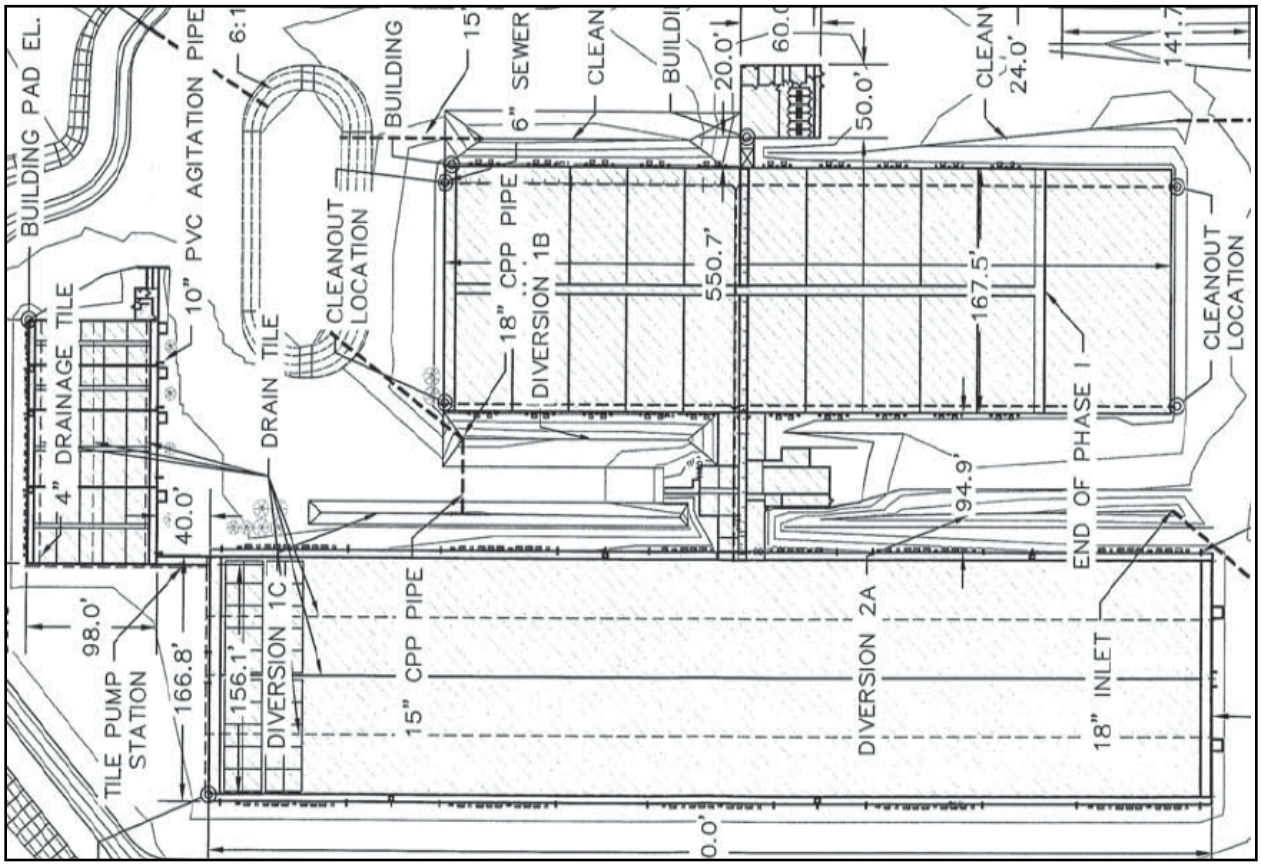


Figure 6 – Close-up of Sheet 4 showing the proposed location of subsurface drain tiles.

The earthen impoundment is in the approximate location of Boring 5, which is the boring location where the silty sand strata was determined to be at least eleven feet thick. The bottom of the silty sand and thus the total thickness is not known because the Boring 5 was terminated at 1123.0 elevation with no strata change noted before TD.

There are several concerns about the proposed location of the surface impoundment. First, there is no discussion in the permit application narrative, nor in the department Fact Sheet, about the seepage from the surface impoundment moving in the subsurface directly back into the strata that is supposedly being drained by the drain tiles. Second,

the impoundment itself is not represented in the design calculations with respect to storage capacity, mechanisms to prevent overtopping, and control measures should the ground water become contaminated with leaking feces and urine from the manure storage structures.

g. Part 8 of the Design Manual on page 51 states "The department may require a ground water monitoring program be implemented for livestock facilities that meet any of the conditions listed in Section 4.3…" Section 4.3.1, on page 25 of the Design Manual, states "Larger facilities or those located in sensitive ground water areas generally require more information to adequately evaluate the site."

The proposed facility places reliance upon drain tiles and the surface impoundment as the "solution" to shallow groundwater and its potential adverse impact to the deep pit manure storage structure stability and integrity. Considering the importance of said reliance, the department must require a more thorough evaluation of the subsurface including a full delineation of the lateral and vertical extent of the silty sand. The department must require a detailed plan for the earthen impoundment including expected volumes pumped from the subsurface, the necessary storage volume, discussion of disposal options, and mechanisms to prevent overtopping.

h. The site investigation did not include a soil boring under the proposed animal mortality compost facility located in the southeast corner of the proposed site.

Opinion 3: *It is my professional engineering opinion that the Rolling Green livestock facility permit application does not contain sufficient design information for the proposed animal mortality compost facility as required by state guidelines for composting of dead animals and the requirements in state regulations.*

Basis of Opinion 3:

a. State Guideline 32 for Composting Poultry and Other Dead Animals identifies the relevant state code for the design and operation of a mortality compost facility as NDCC Chapter 23-29 and regulation as NDAC Article 33-20.[9] The guideline refers to a pre-application procedure so the department can determine if the proposed site is suitable, as well as steps taken to apply for and receive a permit for animal mortality composting. There are requirements to prevent leachate from contaminating surface and ground water, personnel training, operation and maintenance plan, inspection, contingencies, safety procedures, record-keeping and annual reporting, groundwater monitoring, and a written closure plan.

[9] North Dakota Department of Health – Division of Waste Management (2009) Guideline 32 – "Composting Poultry and Other Dead Animals".
http://www.ndhealth.gov/wm/publications/Guideline32CompostingPoultryAndOtherDeadAnimals.pdf

b. The NRCS Standard 316 for Animal Mortality Facility includes standards for composting including NRCS Standard 317 Composting Facility and the National Engineering Handbook (NEH) Part 637 Chapter 2 (Composting) section 637.0211 (Dead Animal Composting).[10]

c. NEH Part 637.0211 contains the calculations required to properly size the primary bin space, to determine appropriate sizes and heights of the bins and to provide for secondary bin space.[11] The permit application does not contain design calculations for the proper sizing of the animal mortality compost facility using expected mortality rates and the average weight of mortality.

[10] NRCS-ND (2004) Conservation Practice Standard 316 Animal Mortality Facility. http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/fotg/

[11] NEH Part 637 Chapter 2 Composting. http://www.wcc.nrcs.usda.gov/ftpref/wntsc/AWM/neh637c2.pdf

Attachment A - Curriculum vitae

KATHY J. MARTIN, PE

3122 Tall Oaks Circle · Norman, Oklahoma 73072 · Cell: (405) 819-7626 Email: kjm2@aol.com

CURRENT OCCUPATION

ENVIRONMENTAL CONSULTANT, PRESIDENT, MARTIN ENVIRONMENTAL SERVICES, LLC NORMAN, OK
Professional Engineer in Civil Engineering - providing expertise in environmental permits for air quality, non-hazardous industrial wastewater, and closure of surface impoundments. Perform engineering review and critique of permit applications submitted by livestock facilities to state and federal regulatory agency with respect to wastewater treatment technology and compliance with environmental regulations.

EDUCATION

UNIVERSITY OF OKLAHOMA
M.S. Civil Engineering, 1989
Thesis: The Removal of Polychlorinated Biphenyls from Topsoil Using Nonionic Surfactants

UNIVERSITY OF OKLAHOMA
B.S. Petroleum Engineering, 1987
National Dean's List, 1986-87

EXPERIENCE

HYDRAULIC FRACTURING AND INJECTION WELL ISSUES
As Martin Environmental Services, 2009 to present
Provide guest lecturer and other speaking arrangements regarding potential environmental impacts of hydraulic fracturing of shale gas and shale oil formations. Perform technical and regulatory review of salt water injection well permit applications to determine if regulatory and environmental concerns are adequately addressed.

MOBILE MEAT HARVESTING UNIT
Team member, 2010 to present
Provide technical assistance in developing water and wastewater treatment strategies including potable water treatment, slaughter waste treatment and disposal, HAACP, and other USDA requirements for small slaughterhouses.

ADJACENT LANDOWNERS TO LIVESTOCK FACILITIES
Subcontracted as Martin Environmental Services, June 1997 to present
Perform technical and regulatory review of approximately 150 CAFO permit applications in 21 states nationally to determine if the application is sufficient for a permit writer to draft a permit. The purpose was to determine if there were technical and/or regulatory deficiencies in the application and prepare a written report for use in administrative proceedings by concerned citizens and adjacent landowners.

SEWARD COUNTY COMMISSIONERS, SEWARD COUNTY, KANSAS
Subcontracted as Martin Environmental Services, June - October 1998
Drafted environmental regulations for confined animal feeding operations (CAFOs) with respect to the design, construction, operation, maintenance, and closure of surface impoundments and the disposal of CAFO waste by land application. The resulting work product was a set of regulations that is a complete permitting program including public notice, hearings, permit application processes and fees, as well as provisions for compliance and enforcement.

DEPARTMENT OF ENVIRONMENTAL QUALITY
Environmental Engineer II, July 1, 1993 to November 1, 1996
Special training in areas of Air Quality and Hazardous Waste permits and regulatory requirements. Provided technical and regulatory assistance to business and industry with respect to environmental permits issued by the ODEQ in water quality, air quality, and solid waste programs.

OKLAHOMA WATER RESOURCES BOARD
Environmental Engineer I, April 1990 to June 30, 1993
Special training in areas of industrial wastewater disposal permits and inspections. Drafted state regulations for surface impoundments and land application of non-hazardous industrial wastewater. Issued state permits for non-discharge facilities. Project officer of Tar Creek Superfund Site.

TECHNICAL EXPERTISE

- 17 years continuing education regarding CAFO waste management systems
- Extensive research and knowledge of lagoon liner systems and waste/liner compatibility
- 13 years continuing education regarding pathogen transport and fate from CAFOs
- 15 years continuing education regarding air pollution and odors from CAFOs
- Other topics of continuing education: GPS, perimeter tile design, concrete, flow meters, backflow prevention, fate and transport, and soil science
- Drafted Oklahoma state regulations for permitting of surface impoundments and disposal by land application used by facilities with non-hazardous industrial wastewater
- Drafted county regulations for CAFO impoundments and land application of manure
- Familiarity with CAFO regulations in AR, CA, CO, GA, IA, ID, IL, IN, KS, KY, MO, MS, ND, NE, NM, OK, PA, SD, TX, UT, and WY
- Professional Engineer in Oklahoma (No. 18254) February 1997 to present; Professional Engineer in New Mexico 2012 (No. 21522)
- Coordinated Superfund activities between USGS, Oklahoma State and EPA
- Interacted with State Legislators (OK and KS) on technical issues related to CAFOs
- Provide expert testimony regarding CAFO waste management systems in Arkansas, Indiana, Kansas, Kentucky, Missouri, Nebraska, New Mexico, Oklahoma, and Utah
- Provide technical and regulatory reviews of CAFO permit applications in AR, CA, CO, GA, IA, ID, IL, IN, KS, KY, MO, MS, ND, NE, NM, OK, PA, SD, TX, UT, WI, and WY
- Graduate Degree coursework included: Groundwater Protection, Groundwater Seepage, Groundwater Modeling, Groundwater Pollution Control, Air Pollution Controls, Air Pollution Engineering, Environmental Impact Assessment, Risk Assessment, Industrial Hygiene, Reservoir Dam Engineering, Open Channel Flow, Chemical and Biological Aspects of Environmental Engineering, Advanced Wastewater Treatment, Soil Classification, Soil Science, Hazardous Waste Control, Solid Waste Engineering/Landfill Design, Land Use Management, Surfactants and Colloidal Science, Corrosion Engineering, Field Applications, and Nonparametric Statistics.
- Three years Chinese language
- Ten years leadership positions in local, state, and national organizations
- Developed state-wide foundry and metal casting facility environmental program in Oklahoma -- and trained state agencies in Louisiana and Arkansas to do the same.
- Active contributor to proposed regulatory language with respect to CAFOs at local, state, and federal levels, especially OK, KS, NE, CO, NM, IN, and IL.
- Provided lectures on CAFO environmental issues to groups in Oklahoma, Kansas, Nebraska, Indiana, Pennsylvania and Utah to groups as large as 600 people at a time.

ORGANIZATIONS AND BOARD POSITIONS

- STRONGER NATIONAL BOARD MEMBER – ENVIRONMENTAL STAKEHOLDER (2006-2010)
- DEQ Hazardous Waste Management Council - governor appointed member (past)
- STRONGER Audit Team - Oil and Gas Environmental Regulations in Oklahoma (2005), Kentucky (2006) and Tennessee (2007)
- Oklahoma Corporation Commission - Citizen Advisory Board member (past)
- Oklahoma Society of Environmental Professionals – Past President, Past Newsletter Editor, Past Secretary, Past Engineering Board Member
- American Society of Agricultural and Biological Engineers (ASABE) – member
- Society of Petroleum Engineers - Past Executive Committee two years, member 10 years
- National Association of Professional/Graduate Students - Past Board member and National Conference Chairperson
- Graduate Student Senate, University of Oklahoma - Past Chair two years, Past Vice Chair, Past Senator for Civil Engineering Department
- Oklahoma Chapter of Sierra Club - past member, 1 year
- Engineering Club of Oklahoma City - past member, 6 years
- OU Petroleum Engineers Club - past Vice President, member 4 years
- OU Society of Women Engineers - past President, member 7 years
- OU Engineer's Club - Loyal Knight of St. Pat, member 7 years

Attachment B – References to Expert Report

1. Wind Rose for January to December

2. Wind Rose Daily Observations for January to December 2012

3. Hoff et al (2006) “Emissions of Ammonia, Hydrogen Sulfide, and Odor before, during and after Slurry Removal from a Deep-Pit Swine Finisher”, Journal of Air & Waste Mgmt Assoc Vol 56: 581-590.

4. NRCS-ND Conservation Practice Standard 371 – Air Filtration and Scrubbing (2015)

5. Rahman and Newman (2010) “Odor, Ammonia, and Hydrogen Sulfide Concentration and Emissions from Two Farrowing-Gestation Swine Operations in North Dakota”, Applied Engr in Agriculture Vol 28(1): 107-115.

6. Stinn, Xin, Li, et al “Quantification of Greenhouse Gas and Ammonia Emissions from a Midwestern Swine Breeding/Gestation/Farrowing Facility”, ASABE Proceedings Paper No. 1111151.

7. Lo, Koziel, Cai, Hoff, et al (2008) “Simultaneous Chemical and Sensory Characterization of Volatile Organic Compounds and Semi-Volatile Organic Compounds Emitted from Swine Manure…”, J. Enviro Quality 37:521-534.

8. Hamilton and Arogo “Understanding Farmstead Odors: An Annotated Review” Prof Animal Scientist 15:203-210.

9. Klausing (1968) “Geology and Ground Water Resources of Cass County, North Dakota Part 1 Geology”, North Dakota Geological Survey, Bulletin 47- County Ground Water Studies 8.

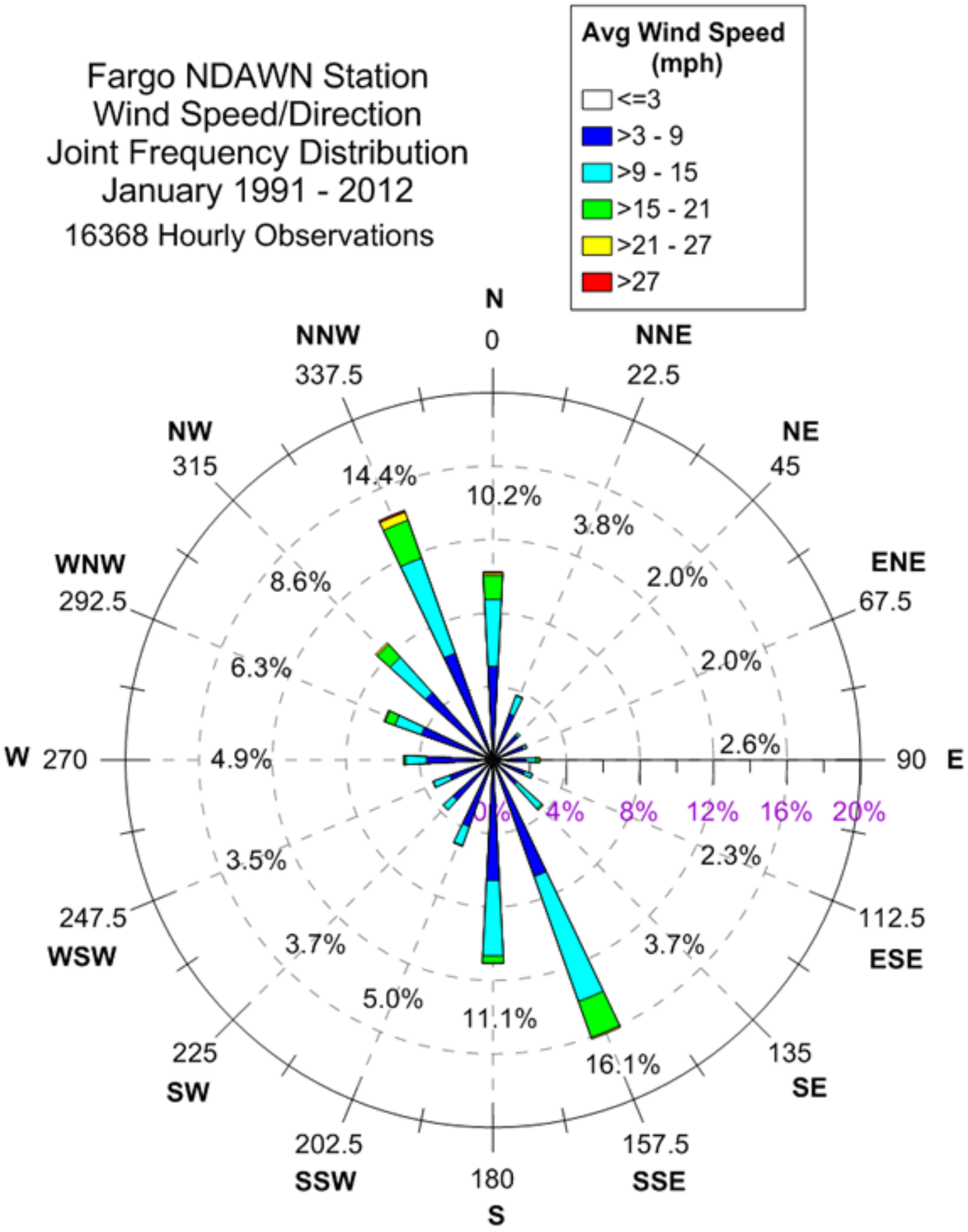
10. North Dakota Department of Health – Division of Waste Management (2009) Guideline 32 – “Composting Poultry and Other Dead Animals”.

11. NRCS-ND (2004) Conservation Practice Standard 316 Animal Mortality Facility.

12. NEH Part 637 Chapter 2 Composting.

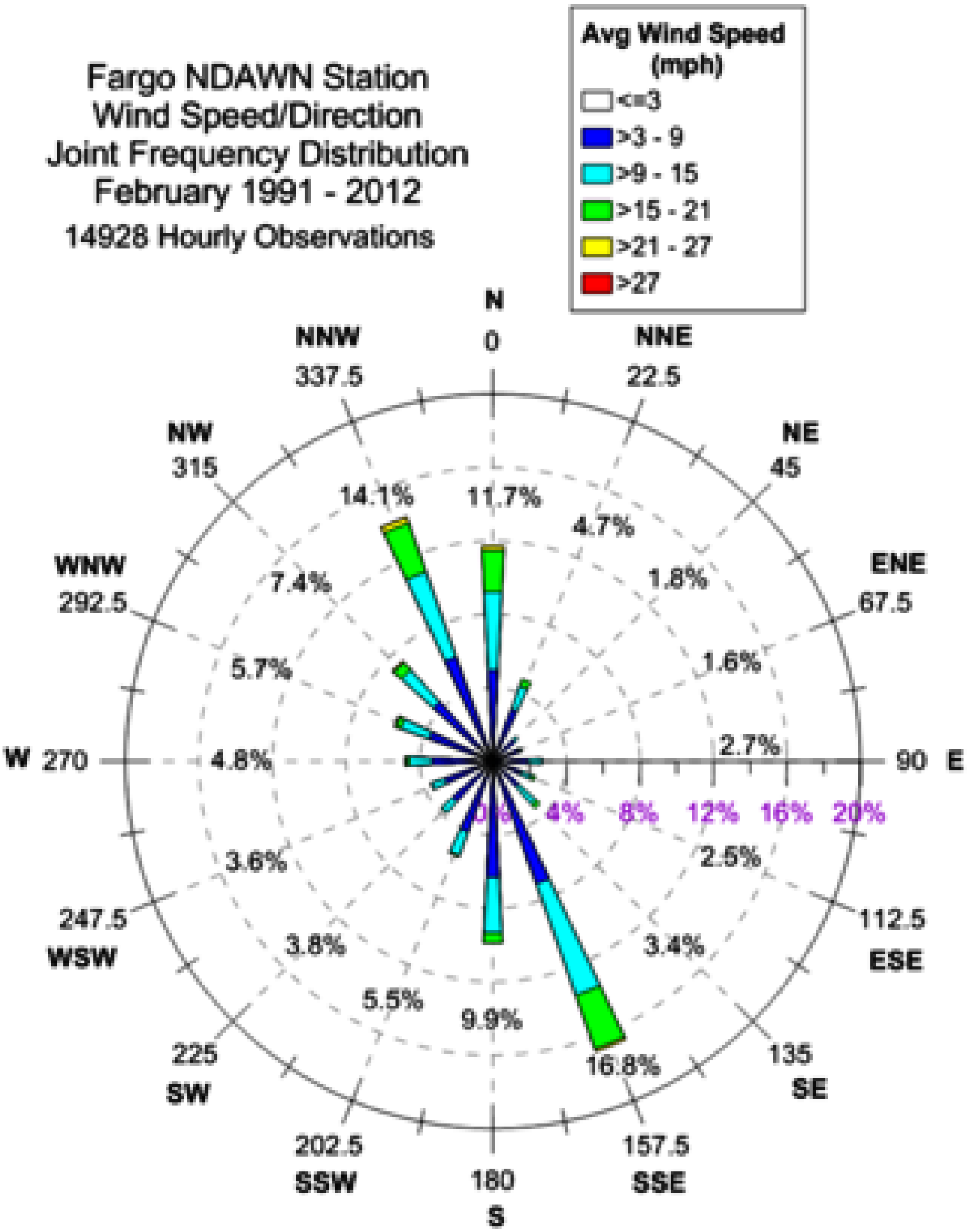
Fargo NDAWN Station
Wind Speed/Direction
Joint Frequency Distribution
January 1991 - 2012

16368 Hourly Observations



001571

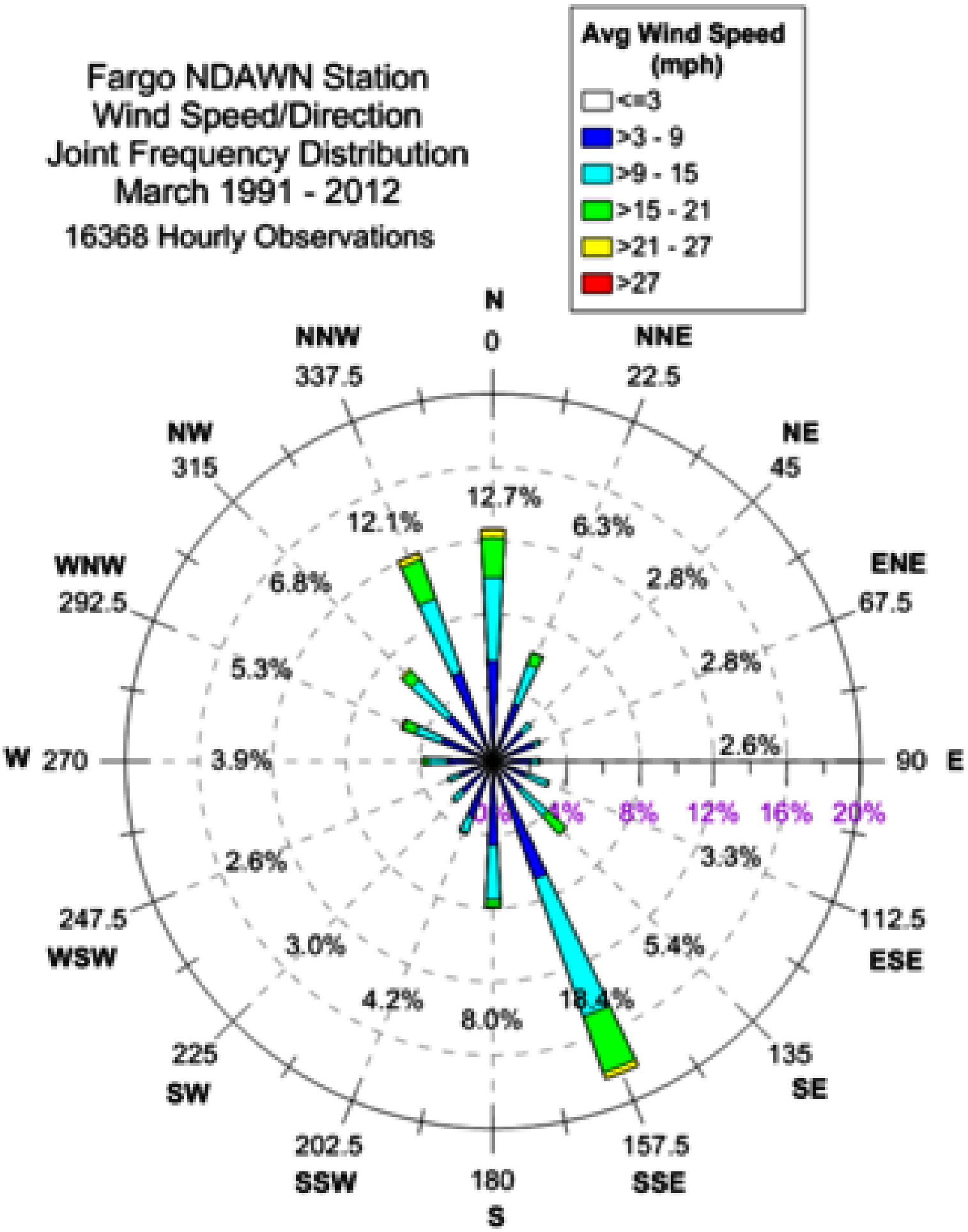
Fargo NDAWN Station
Wind Speed/Direction
Joint Frequency Distribution
February 1991 - 2012
14928 Hourly Observations



001572

Fargo NDAWN Station
Wind Speed/Direction
Joint Frequency Distribution
March 1991 - 2012

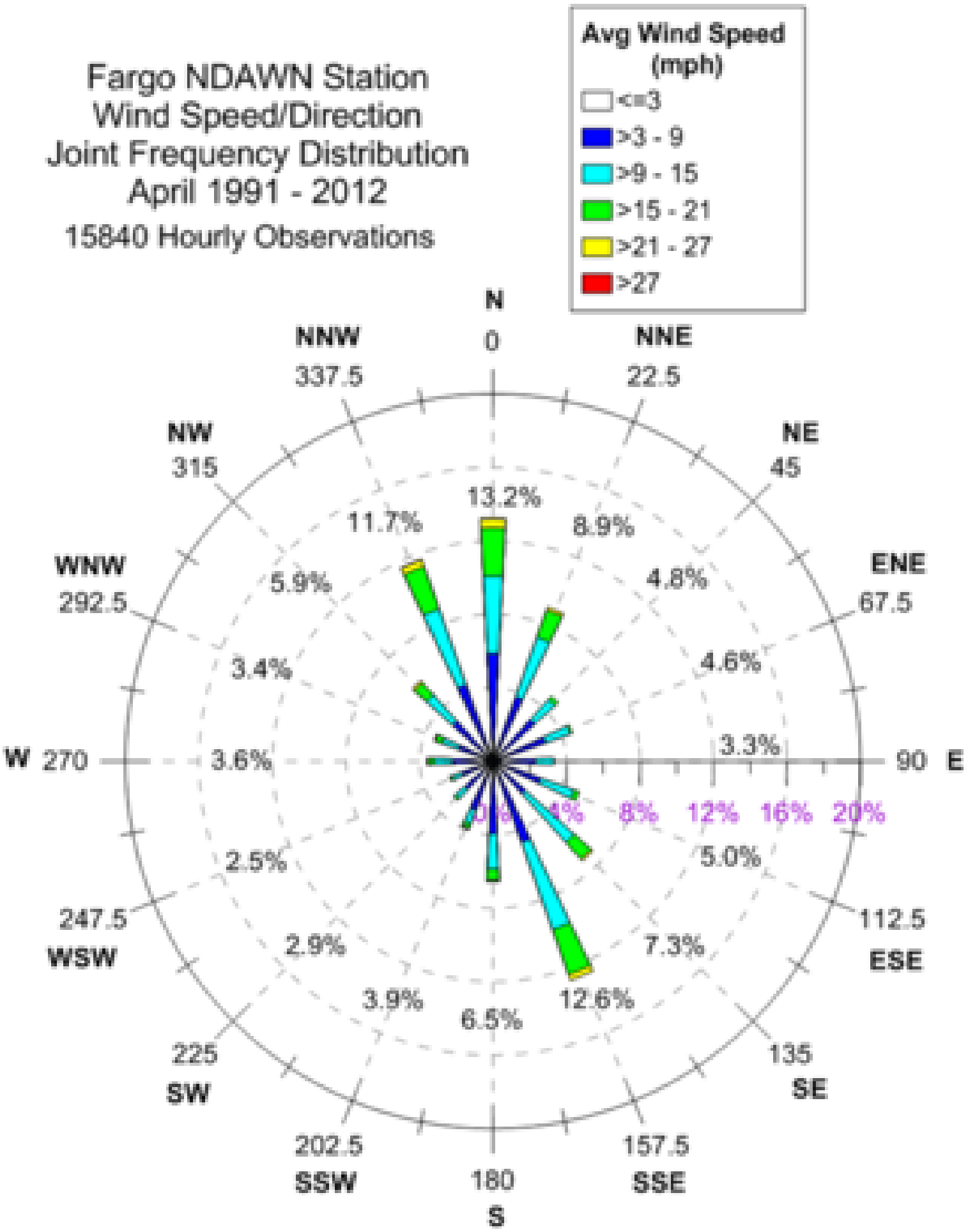
16368 Hourly Observations



001573

Fargo NDAWN Station
Wind Speed/Direction
Joint Frequency Distribution
April 1991 - 2012

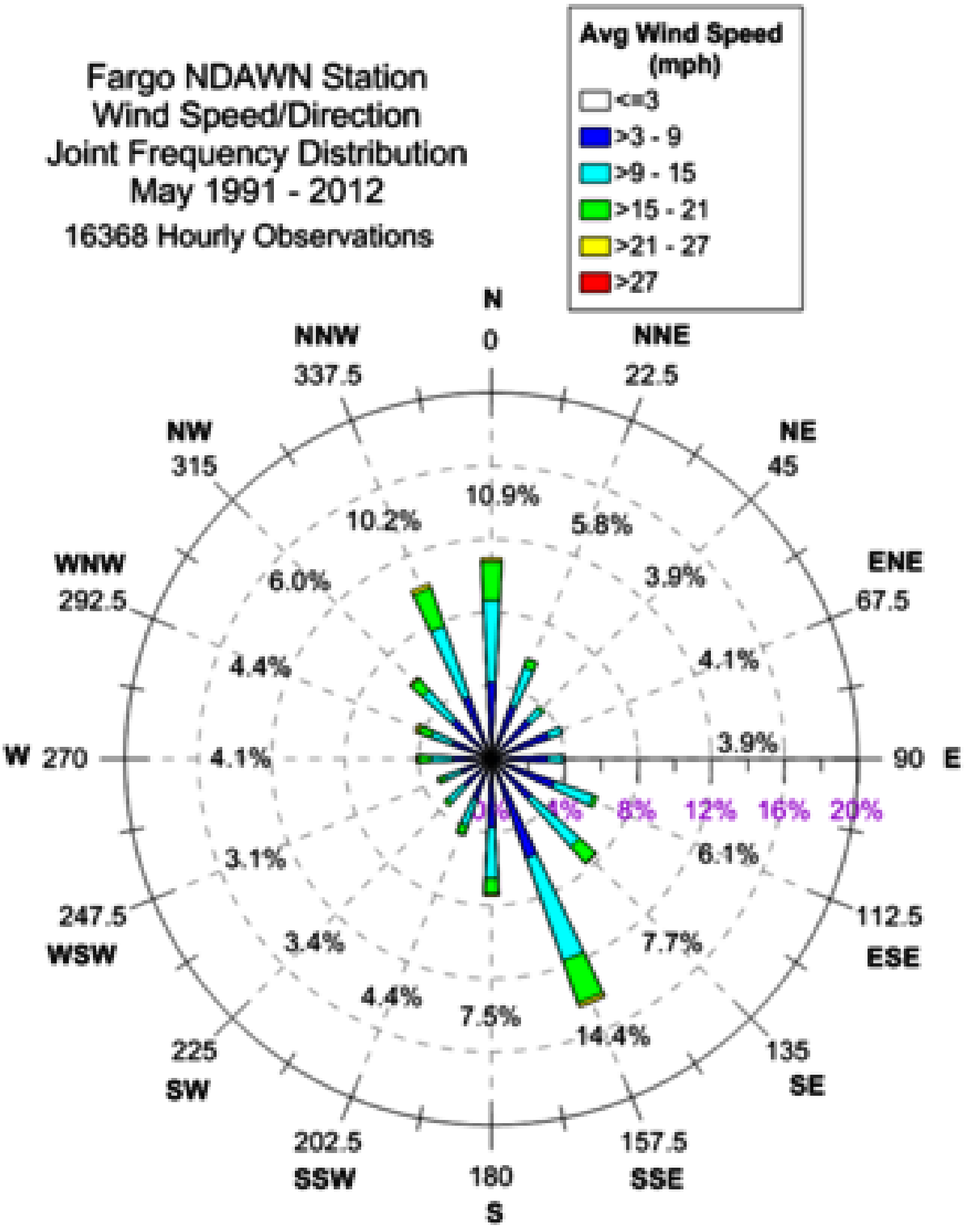
15840 Hourly Observations



001574

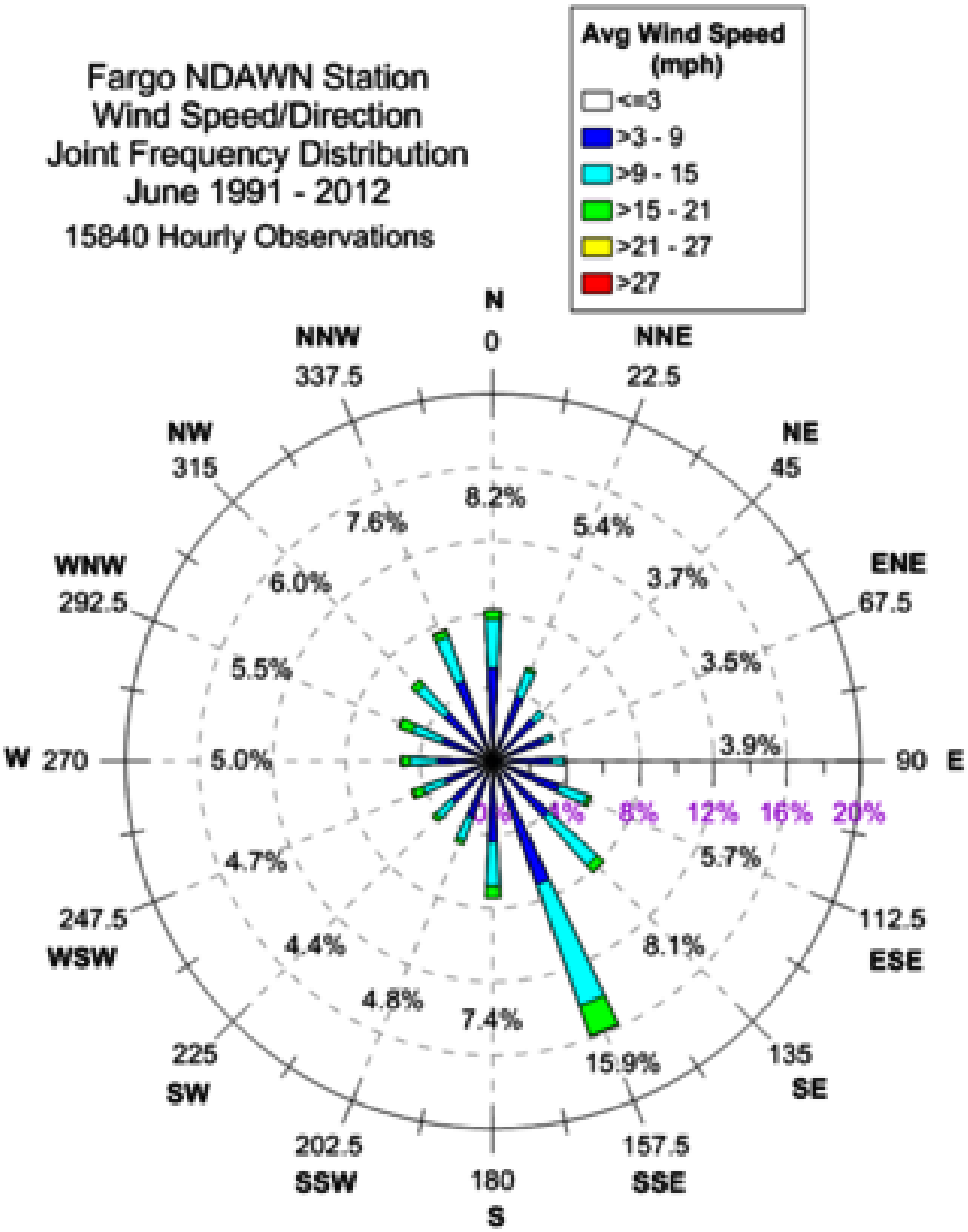
Fargo NDAWN Station
Wind Speed/Direction
Joint Frequency Distribution
May 1991 - 2012

16368 Hourly Observations



001575

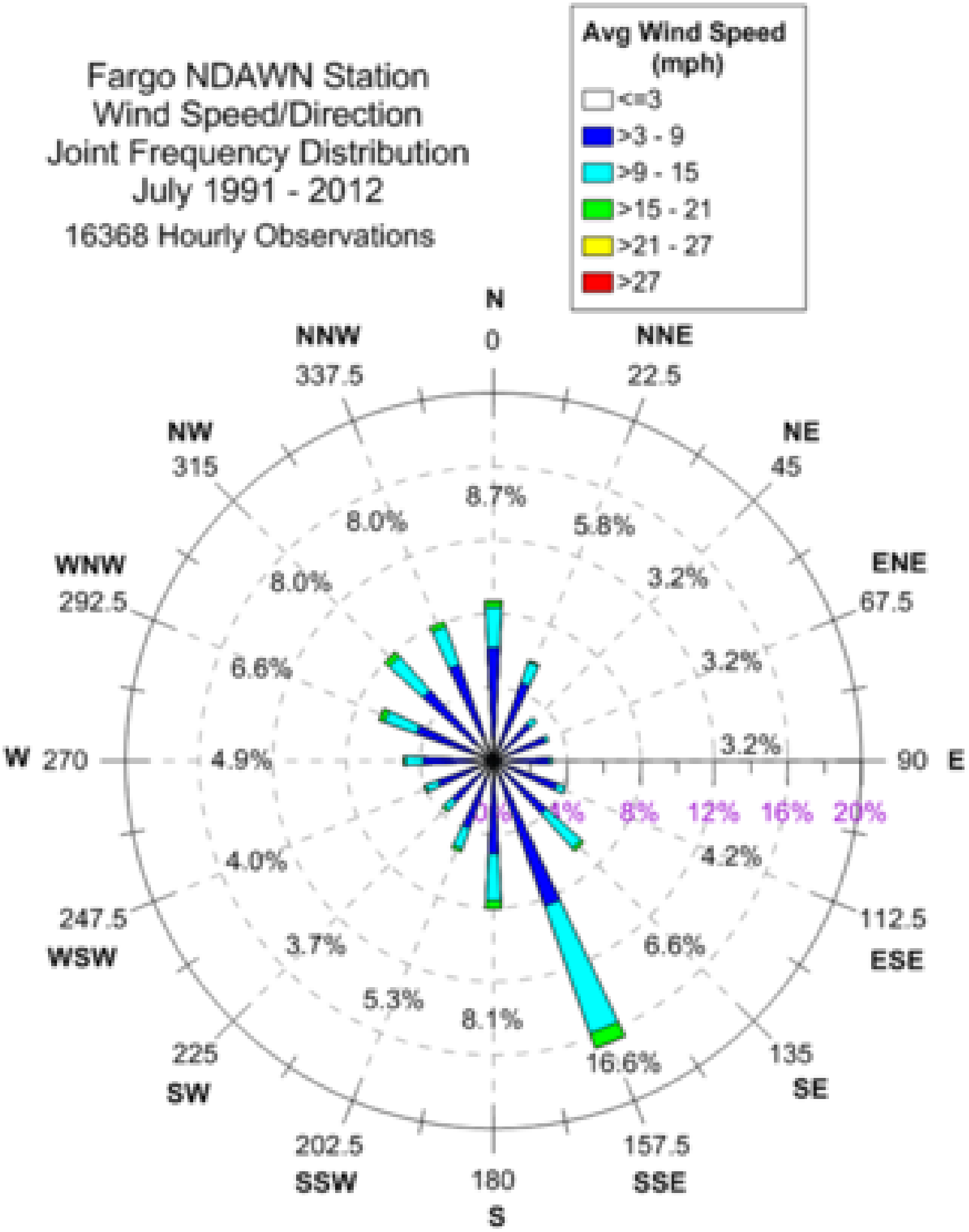
Fargo NDAWN Station
Wind Speed/Direction
Joint Frequency Distribution
June 1991 - 2012
15840 Hourly Observations



001576

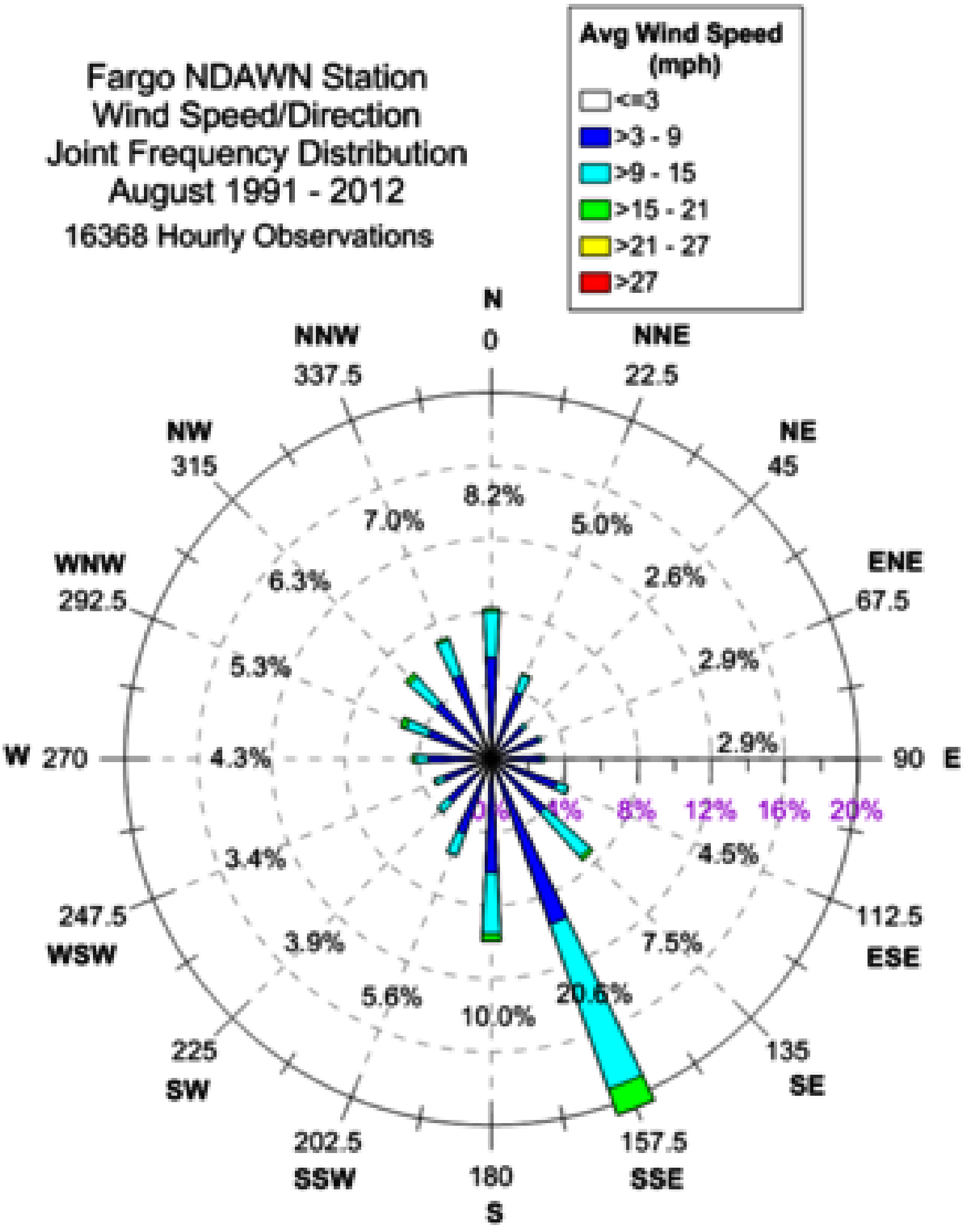
Fargo NDAWN Station
Wind Speed/Direction
Joint Frequency Distribution
July 1991 - 2012

16368 Hourly Observations



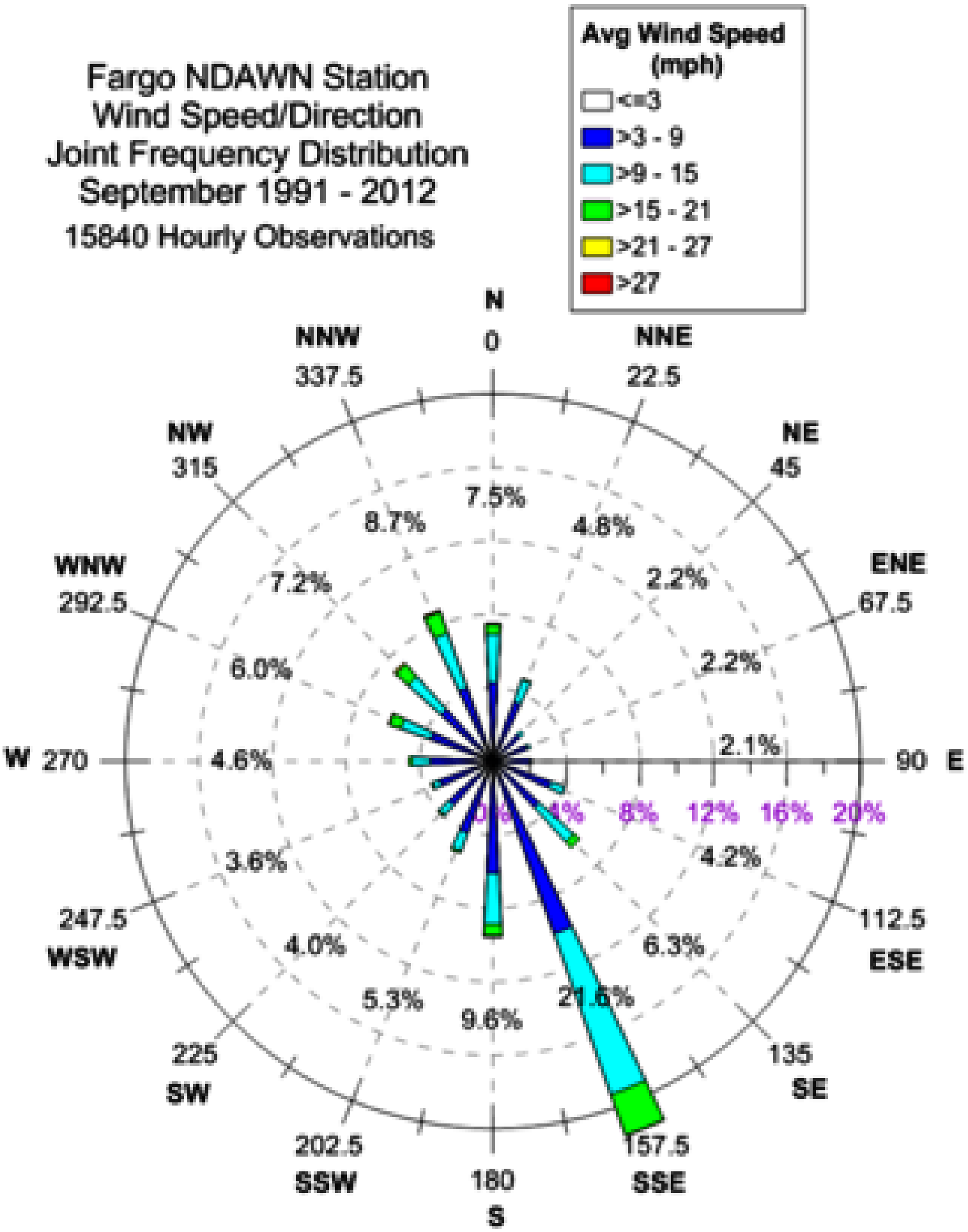
001577

Fargo NDAWN Station
Wind Speed/Direction
Joint Frequency Distribution
August 1991 - 2012
16368 Hourly Observations



001578

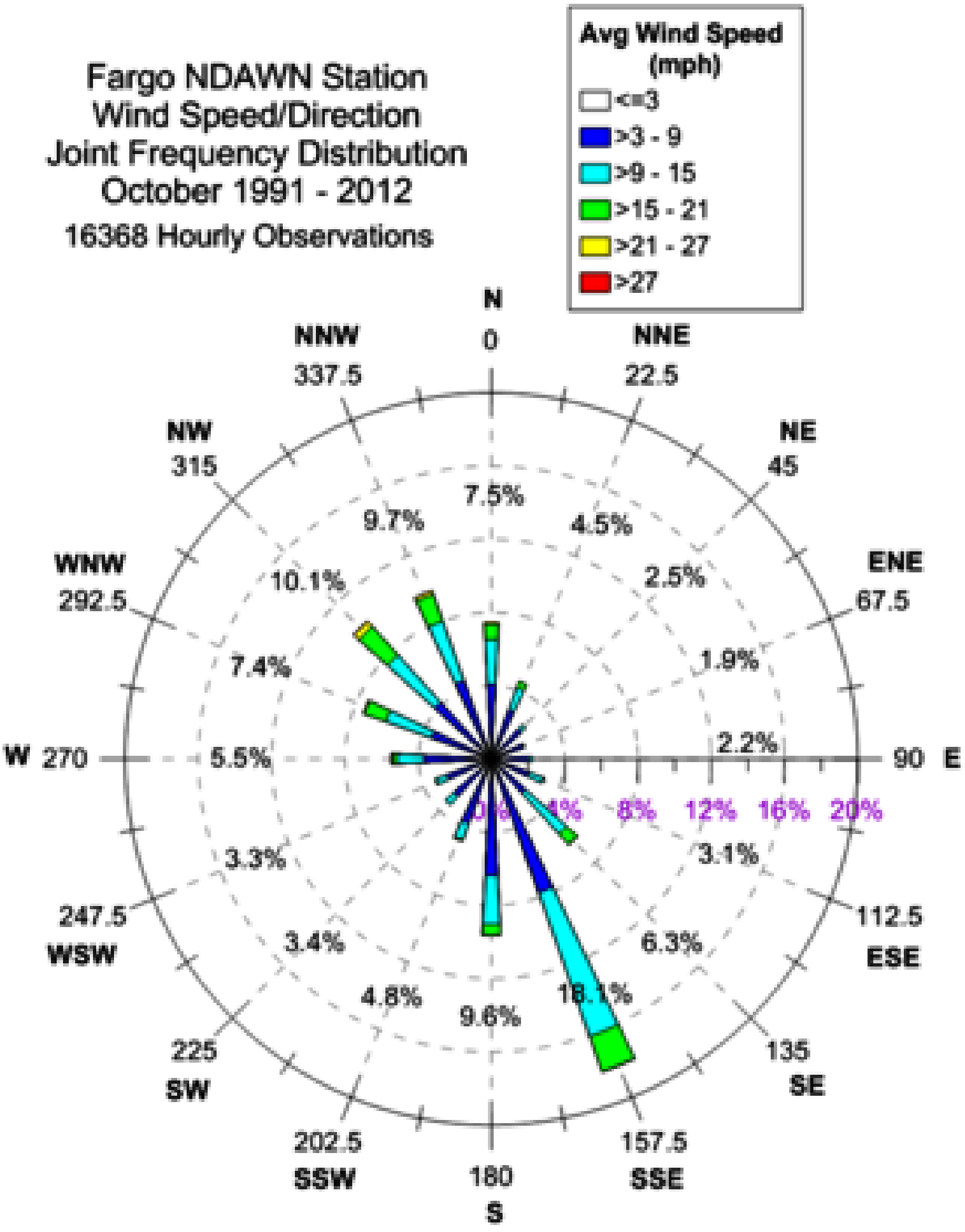
Fargo NDAWN Station
Wind Speed/Direction
Joint Frequency Distribution
September 1991 - 2012
15840 Hourly Observations



001579

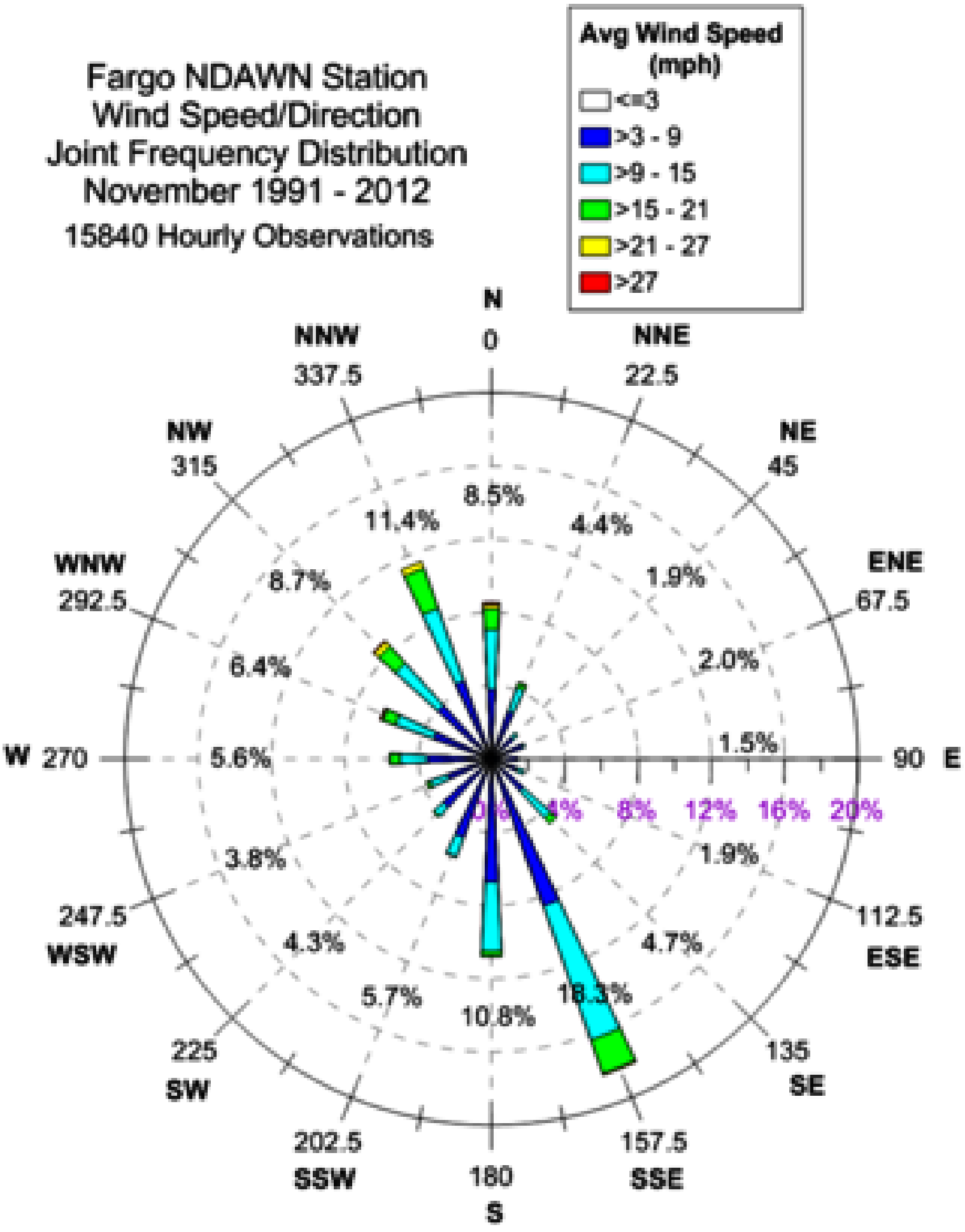
Fargo NDAWN Station
Wind Speed/Direction
Joint Frequency Distribution
October 1991 - 2012

16368 Hourly Observations



001580

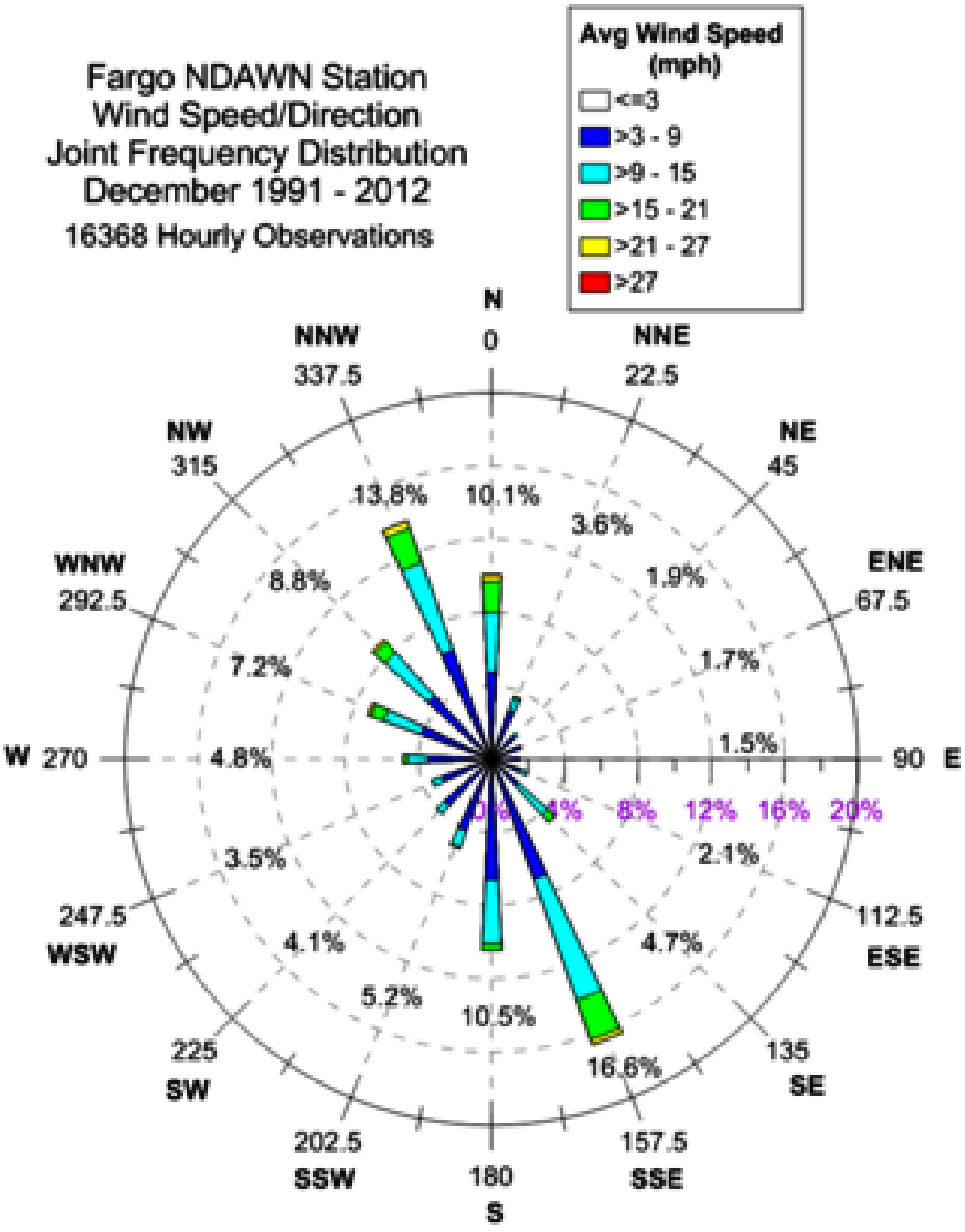
Fargo NDAWN Station
Wind Speed/Direction
Joint Frequency Distribution
November 1991 - 2012
15840 Hourly Observations



001581

Fargo NDAWN Station
Wind Speed/Direction
Joint Frequency Distribution
December 1991 - 2012

16368 Hourly Observations



001582

FARGO NW Daily Observations from March 1, 2014 to March 31, 2014
North Dakota Agricultural Weather Network (NDAWN)

Year	Mo	Da	Max Temp (F)	Min Temp (F)	Avg Soil Temp (F)	Avg Turf Temp (F)	Avg Wind Spd (MPH)	Max Wind Spd (MPH)	Avg Wind Dir (deg)	Avg Wind DirSD (deg)	Total Solar Rad (Lys)	Total PET (inch)	Rain fall (inch
2014	3	1	-8.8	-17.6	7.2	8.3	7.6	17	339	22	346	0.01	
2014	3	2	3.4	-17.8	6.2	6.9	6.3	16	292	29	359	0.02	
2014	3	3	8.8	-8.4	8.8	11.0	6.7	16	143	25	155	0.02	
2014	3	4	14.4	2.7	14.2	15.1	6.4	12	47	40	262	0.03	
2014	3	5	22.6	0.4	16.0	17.4	11.9	30	163	31	247	0.05	
2014	3	6	34.7	15.0	20.5	20.8	15.8	34	164	12	282	0.07	
2014	3	7	32.5	5.0	22.2	22.3	13.4	25	345	16	236	0.07	
2014	3	8	27.4	3.2	20.2	20.8	7.0	21	195	49	283	0.05	
2014	3	9	46.9	23.4	27.4	27.1	7.2	19	194	30	240	0.08	
2014	3	10	47.5	34.3	31.5	29.9	6.8	17	275	25	270	0.07	
2014	3	11	34.4	17.8	32.0	30.1	10.6	25	4	13	315	0.07	
2014	3	12	32.7	14.5	31.6	29.8	7.5	17	149	57	208	0.06	
2014	3	13	58.3	28.8	33.4	29.9	9.8	22	245	45	353	0.15	
2014	3	14	36.9	14.3	32.2	30.8	12.0	26	345	34	245	0.07	
2014	3	15	20.7	6.6	29.9	29.3	11.1	23	18	13	365	0.06	
2014	3	16	31.0	2.3	25.5	25.9	10.8	31	168	36	244	0.09	
2014	3	17	42.7	27.6	29.4	28.2	8.0	20	91	66	200	0.07	
2014	3	18	32.6	28.5	30.9	29.7	10.2	17	360	13	115	0.03	
2014	3	19	42.4	23.5	30.6	29.7	6.1	17	316	39	239	0.07	
2014	3	20	47.3	23.9	31.8	30.2	6.6	23	144	22	219	0.07	
2014	3	21	39.5	10.0	30.8	31.4	18.2	40	348	32	273	0.09	
2014	3	22	18.2	8.0	22.3	27.9	9.9	28	344	19	317	0.05	
2014	3	23	26.4	5.3	23.0	25.8	4.6	21	330	52	394	0.06	
2014	3	24	31.3	11.8	26.0	27.3	9.7	33	325	33	323	0.08	
2014	3	25	27.7	3.1	25.6	26.8	6.3	19	311	37	431	0.08	
2014	3	26	45.0	19.8	27.9	27.7	10.9	27	128	34	314	0.17	
2014	3	27	33.1	17.3	29.9	29.3	15.9	29	9	15	254	0.09	
2014	3	28	31.2	11.6	27.5	27.9	6.6	19	16	39	344	0.09	
2014	3	29	45.4	24.2	30.6	29.3	14.3	34	161	13	431	0.18	
2014	3	30	48.9	32.9	32.9	30.7	10.3	24	31	61	258	0.10	
2014	3	31	36.2	15.9	31.2	30.7	22.7	43	8	13	32	0.04	
Averages			32.0	12.5	25.5	25.4	10.0	24			276		
Totals												2.24	(3
Max			58.3	34.3	33.4	31.4	22.7	43			431	0.18	(3
Min			-8.8	-17.8	6.2	6.9	4.6	12			32	0.01	(3
Std. Dev.			14.3	13.2	7.8	6.8	4.1	7			86	0.04	

E = estimated value
M = missing value
The number of missing values is indicated in parentheses.

001583

FARGO NW Daily Observations from April 1, 2014 to April 30, 2014
North Dakota Agricultural Weather Network (NDAWN)

Year	Mo	Da	Max Temp (F)	Min Temp (F)	Avg Soil Temp (F)	Avg Turf Temp (F)	Avg Wind Spd (MPH)	Max Wind Spd (MPH)	Avg Wind Dir (deg)	Avg Wind DirSD (deg)	Total Solar Rad (Lys)	Total PET (inch)	Rain fall (inch
2014	4	1	25.3	11.0	28.0	29.5	12.6	33	343	17	480	0.08	0.0
2014	4	2	35.0	10.0	28.3	28.6	4.9	12	28	29	398	0.07	0.0
2014	4	3	37.1	30.0	31.7	30.5	6.3	17	23	25	145	0.03	0.0
2014	4	4	34.5	27.5	31.6	30.8	9.9	25	342	34	137	0.05	0.0
2014	4	5	58.2	27.7	34.3	31.1	9.4	22	169	41	478	0.17	0.0
2014	4	6	61.9	28.2	38.6	31.5	4.0	20	190	54	449	0.13	0.0
2014	4	7	53.7	33.9	39.9	32.0	7.3	21	345	33	424	0.12	0.0
2014	4	8	54.6	29.4	40.1	33.7	7.5	20	268	69	452	0.15	0.0
2014	4	9	78.0	35.9	43.4	36.0	11.6	38	227	56	429	0.33	0.0
2014	4	10	58.2	35.9	41.0	36.2	12.0	31	289	26	499	0.27	0.0
2014	4	11	61.2	36.5	44.5	38.3	7.0	19	60	79	413	0.17	0.0
2014	4	12	60.3	37.5	45.0	39.6	9.3	26	77	67	311	0.13	0.2
2014	4	13	37.5	24.1	34.6	34.6	17.2	33	352	12	326	0.11	0.0
2014	4	14	30.8	15.1	31.3	31.7	9.9	25	358	16	385	0.10	0.0
2014	4	15	33.3	12.5	30.8	31.6	5.6	20	133	44	438	0.10	0.0
2014	4	16	38.0	26.3	31.5	31.6	10.1	20	63	26	206	0.10	0.0
2014	4	17	45.9	19.2	34.9	32.5	5.1	14	4	39	547	0.15	0.0
2014	4	18	53.5	33.0	37.8	35.0	13.3	41	131	19	327	0.21	0.0
2014	4	19	68.7	41.7	46.9	39.7	13.6	50	208	57	468	0.31	0.0
2014	4	20	75.0	31.9	47.4	41.4	6.4	23	173	40	528	0.28	0.0
2014	4	21	56.9	36.1	45.7	41.4	9.5	28	332	30	462	0.21	0.0
2014	4	22	63.8	30.5	45.7	40.6	5.0	16	126	37	484	0.19	0.0
2014	4	23	49.4	39.9	40.6	39.5	13.8	31	133	16	46	0.08	0.4
2014	4	24	53.7	38.2	42.2	38.3	4.6	19	144	45	157	0.05	0.2
2014	4	25	52.5	38.0	45.0	39.9	6.5	16	15	38	319	0.10	0.0
2014	4	26	54.6	34.2	42.7	39.7	8.8	23	109	23	394	0.17	0.0
2014	4	27	42.8	37.7	39.3	38.4	12.7	29	103	17	72	0.05	0.8
2014	4	28	41.1	37.9	38.3	37.1	12.0E	26E	99	18	62	0.04	1.1
2014	4	29	53.5	36.8	43.7	38.7	15.7E	33E	19	15	526	0.21	0.0
2014	4	30	42.4	37.2	39.5	38.2	15.1	28	355	16	116	0.05	0.0
Averages			50.4	30.5	38.8	35.6	9.6	25			349		
Totals												4.21	3.1
Max			78.0	41.7	47.4	41.4	17.2	50			547	0.33	1.1
Min			25.3	10.0	28.0	28.6	4.0	12			46	0.03	0.0
Std. Dev.			13.1	8.9	5.8	4.0	3.7	8			156	0.08	

E = estimated value
M = missing value
The number of missing values is indicated in parentheses.

001584

FARGO NW Daily Observations from May 1, 2014 to May 31, 2014
North Dakota Agricultural Weather Network (NDAWN)

Year	Mo	Da	Max Temp (F)	Min Temp (F)	Avg Soil Temp (F)	Avg Turf Temp (F)	Avg Wind Spd (MPH)	Max Wind Spd (MPH)	Avg Wind Dir (deg)	Avg Wind DirSD (deg)	Total Solar Rad (Lys)	Total PET (inch)	Rain fall (inch
2014	5	1	55.2	38.1	44.4	39.6	12.3	28	349	26	459	0.17	0.0
2014	5	2	61.4	43.6	46.8	42.1	12.4	34	334	46	485	0.24	0.0
2014	5	3	52.8	31.5	44.3	42.1	10.0	26	323	20	459	0.17	0.0
2014	5	4	49.5	30.0	42.3	40.5	4.9	16	41	37	354	0.12	0.0
2014	5	5	60.3	39.4	50.1	43.8	6.0	13	41	29	474	0.16	0.0
2014	5	6	64.4	48.4	49.1	45.3	7.8	21	117	25	244	0.18	0.0
2014	5	7	62.6	45.3	49.9	46.1	8.3	20	52	53	237	0.14	0.0
2014	5	8	48.1	43.3	45.1	43.9	13.7	25	5	15	54	0.02	0.3
2014	5	9	60.4	43.4	48.9	44.7	10.8	24	327	29	489	0.22	0.1
2014	5	10	68.2	38.5	48.3	45.1	8.7	24	141	20	437	0.24	0.0
2014	5	11	59.6	45.4	50.9	47.1	7.1	20	312	68	156	0.07	0.1
2014	5	12	45.7	40.8	43.7	43.9	16.5	32	344	13	66	0.03	0.4
2014	5	13	50.9	36.1	43.3	42.3	11.8	27	316	17	257	0.13	0.0
2014	5	14	44.7	34.1	40.2	40.5	8.3	20	351	20	300	0.11	0.0
2014	5	15	50.6	35.4	43.0	41.2	5.8	18	9	32	337	0.13	0.0
2014	5	16	61.4	31.3	46.8	42.6	4.2	28	314	57	549	0.19	0.0
2014	5	17	70.9	37.1	48.6	45.1	6.0	23	228	63	414	0.23	0.0
2014	5	18	73.4	47.1	53.8	48.3	8.1	20	176	25	500	0.29	0.0
2014	5	19	64.9	52.8	54.9	50.5	13.8	31	146	15	274	0.16	0.4
2014	5	20	74.5	48.1	57.5	52.3	9.3	26	284	34	581	0.27	0.0
2014	5	21	65.4	48.1	55.6	52.6	9.7	21	349	27	479	0.22	0.0
2014	5	22	74.4	39.1	58.7	54.0	3.4	10	64	69	646	0.24	0.0
2014	5	23	82.0	54.7	59.8	56.2	10.7	25	154	21	532	0.39	0.0
2014	5	24	88.4	60.2	64.7	58.6	11.6	29	188	20	570	0.45	0.0
2014	5	25	86.4	60.3	64.7	59.4	9.7	26	179	37	514	0.35	0.0
2014	5	26	83.5	57.2	66.4	60.4	7.0	18	15	23	484	0.24	0.0
2014	5	27	87.9	55.3	69.4	62.6	3.9	15	45	77	527	0.25	0.0
2014	5	28	88.6	63.8	71.9	64.8	8.2	18	172	26	604	0.35	0.0
2014	5	29	89.4	64.2	70.3	63.9	11.3	26	160	18	640	0.50	0.0
2014	5	30	92.2	65.3	71.0	63.7	9.5	25	142	65	471	0.35	0.0
2014	5	31	71.4	64.2	66.2	62.4	5.6	12	6	26	123	0.04	0.1
Averages			67.4	46.5	53.9	49.9	8.9	23			410		
Totals												6.65	1.9
Max			92.2	65.3	71.9	64.8	16.5	34			646	0.50	0.4
Min			44.7	30.0	40.2	39.6	3.4	10			54	0.02	0.0
Std. Dev.			14.5	10.8	9.8	8.3	3.2	6			165	0.12	

E = estimated value
M = missing value
The number of missing values is indicated in parentheses.

001585

FARGO NW Daily Observations from June 1, 2014 to June 30, 2014
North Dakota Agricultural Weather Network (NDAWN)

Year	Mo	Da	Max Temp (F)	Min Temp (F)	Avg Soil Temp (F)	Avg Turf Temp (F)	Avg Wind Spd (MPH)	Max Wind Spd (MPH)	Avg Wind Dir (deg)	Avg Wind DirSD (deg)	Total Solar Rad (Lys)	Total PET (inch)	Rain fall (inch
2014	6	1	78.1	62.3	68.6	63.4	3.7	12	22	53	291	0.11	0.0
2014	6	2	67.2	51.9	63.3	62.4	9.7	32	322	33	263	0.12	0.0
2014	6	3	77.9	50.6	66.0	61.2	4.3	13	241	57	536	0.23	0.0
2014	6	4	82.2	59.2	70.1	63.6	5.4	16	164	31	539	0.28	0.0
2014	6	5	76.0	60.4	68.1	63.3	7.6	23	167	48	401	0.19	0.5
2014	6	6	64.6	53.0	61.0	61.2	7.9	22	324	27	321	0.17	0.0
2014	6	7	71.9	51.5	63.3	60.4	5.4	19	338	38	528	0.24	0.0
2014	6	8	76.5	46.9	63.8	60.0	6.3	20	202	33	571	0.30	0.0
2014	6	9	79.5	53.0	67.7	62.0	6.4	23	234	47	609	0.31	0.0
2014	6	10	82.0	55.6	69.7	63.2	7.4	20	185	30	590	0.33	0.0
2014	6	11	69.4	52.0	63.6	61.8	9.4	29	4	53	107	0.10	0.8
2014	6	12	70.1	49.7	60.3	59.4	11.8	30	327	22	564	0.29	0.0
2014	6	13	76.1	47.7	63.7	60.5	7.5	23	150	44	504	0.28	0.0
2014	6	14	70.8	57.2	62.4	60.8	12.0	32	131	28	252	0.14	0.6
2014	6	15	72.2	58.7	62.5	60.4	10.7	28	237	41	296	0.16	1.1
2014	6	16	77.1	56.5	63.9	60.8	6.3	16	149	53	404	0.20	0.0
2014	6	17	81.4	59.3	68.0	64.3	7.9	19	46	19	574	0.28	0.0
2014	6	18	82.5	62.8	68.3	65.6	10.0	26	87	26	462	0.28	0.6
2014	6	19	75.3	58.5	66.7	63.9	7.6	27	136	66	210	0.10	0.5
2014	6	20	81.4	56.5	69.6	64.8	6.6	19	183	58	584	0.26	0.0
2014	6	21	87.9	62.6	71.5	67.9	7.5	30	166	41	525	0.29	0.1
2014	6	22	81.5	62.5	71.9	69.8	7.6	23	256	43	607	0.29	0.0
2014	6	23	80.8	60.1	70.1	70.0	6.4	19	279	25	553	0.25	0.0
2014	6	24	69.8	61.1	66.3	68.3	8.7	20	328	17	259	0.11	0.0
2014	6	25	74.8	60.5	67.2	67.1	5.9	17	93	63	300	0.12	0.0
2014	6	26	83.1	59.5	67.2	66.4	9.8	24	133	18	300	0.19	0.1
2014	6	27	84.9	69.0	71.2	68.9	10.5	29	140	23	361	0.19	0.4
2014	6	28	80.7	68.2	72.1	69.8	12.8	37	175	29	414	0.21	0.1
2014	6	29	81.1	64.5	69.4	68.8	15.5	38	219	19	537	0.34	0.0
2014	6	30	74.7	64.2	65.4	67.0	16.0	35	245	19	393	0.26	0.1
Averages			77.1	57.9	66.8	64.2	8.5	24			429		
Totals												6.62	5.5
Max			87.9	69.0	72.1	70.0	16.0	38			609	0.34	1.1
Min			64.6	46.9	60.3	59.4	3.7	12			107	0.10	0.0
Std. Dev.			5.6	5.7	3.4	3.4	3.0	7			141	0.07	

E = estimated value
M = missing value
The number of missing values is indicated in parentheses.

001586

FARGO NW Daily Observations from July 1, 2014 to July 31, 2014
North Dakota Agricultural Weather Network (NDAWN)

Year	Mo	Da	Max Temp (F)	Min Temp (F)	Avg Soil Temp (F)	Avg Turf Temp (F)	Avg Wind Spd (MPH)	Max Wind Spd (MPH)	Avg Wind Dir (deg)	Avg Wind DirSD (deg)	Total Solar Rad (Lys)	Total PET (inch)	Rain fall (inch
2014	7	1	64.8	54.1	60.8	64.6	12.5	31	329	23	211	0.10	0.1
2014	7	2	72.0	49.7	63.7	64.9	6.0	17	338	24	579	0.23	0.0
2014	7	3	77.1	49.1	67.3	66.1	3.2	13	114	52	584	0.22	0.0
2014	7	4	83.6	62.6	67.9	66.7	12.9	30	155	18	430	0.30	0.0
2014	7	5	94.7	67.0	76.7	70.7	9.9	36	190	32	610	0.36	0.0
2014	7	6	83.3	69.1	75.7	72.7	9.1	24	302	47	616	0.32	0.0
2014	7	7	81.6	60.7	71.9	70.9	9.4	28	291	21	447	0.27	0.0
2014	7	8	75.0	58.8	69.5	68.6	9.1	29	318	27	596	0.29	0.0
2014	7	9	76.9	56.7	72.4	69.0	5.6	18	348	43	653	0.27	0.0
2014	7	10	84.1	59.4	71.2	68.5	7.9	22	142	29	380	0.23	0.5
2014	7	11	87.5	65.1	76.5	72.3	6.1	15	318	67	603	0.28	0.0
2014	7	12	81.8	58.8	73.5	70.7	6.6	24	288	41	495	0.24	0.0
2014	7	13	75.2	53.3	69.5	67.9	9.7	28	300	22	568	0.32	0.0
2014	7	14	68.4	49.8	64.2	64.5	13.5	28	339	15	409	0.23	0.0
2014	7	15	72.8	46.7	67.4	64.5	5.2	18	359	29	597	0.23	0.0
2014	7	16	78.9	51.3	71.5	66.6	3.3	16	157	72	558	0.22	0.0
2014	7	17	82.5	62.0	74.4	68.2	6.9	18	184	23	475	0.28	0.0
2014	7	18	85.5	63.5	75.8	68.6	13.9	32	167	16	563	0.37	0.0
2014	7	19	81.5	61.1	76.7	70.3	5.2	14	209	69	553	0.25	0.0
2014	7	20	94.0	67.9	80.7	72.3	9.3	22	177	35	531	0.31	0.0
2014	7	21	92.2	67.2	81.3	74.3	9.0	43	151	50	433	0.24	0.6
2014	7	22	77.7	61.0	74.8	72.2	9.2	23	336	27	606	0.27	0.0
2014	7	23	78.7	56.4	75.0	70.5	4.2	12	21	42	544	0.21	0.0
2014	7	24	78.2	63.3	73.0	69.3	9.0	26	140	25	373	0.21	0.0
2014	7	25	82.0	62.3	75.4	70.3	5.9	21	216	77	433	0.20	0.0
2014	7	26	82.1	57.9	74.6	69.3	10.4	33	259	34	562	0.33	0.0
2014	7	27	67.8	57.6	68.3	66.8	11.5	29	328	22	217	0.13	0.0
2014	7	28	74.8	56.9	69.4	66.3	4.8	15	324	27	372	0.17	0.0
2014	7	29	79.1	51.3	70.8	66.4	4.1	16	326	38	511	0.21	0.0
2014	7	30	81.2	54.5	73.1	67.4	3.7	15	306	33	540	0.22	0.0
2014	7	31	83.2	55.5	74.5	68.7	3.6	13	328	62	499	0.21	0.0
Averages			79.9	58.4	72.2	68.7	7.8	23			502		
Totals												7.72	1.3
Max			94.7	69.1	81.3	74.3	13.9	43			653	0.37	0.6
Min			64.8	46.7	60.8	64.5	3.2	12			211	0.10	0.0
Std. Dev.			7.0	6.0	4.7	2.6	3.2	8			110	0.06	

E = estimated value
M = missing value
The number of missing values is indicated in parentheses.

001587

FARGO NW Daily Observations from August 1, 2014 to August 31, 2014
North Dakota Agricultural Weather Network (NDAWN)

Year	Mo	Da	Max Temp (F)	Min Temp (F)	Avg Soil Temp (F)	Avg Turf Temp (F)	Avg Wind Spd (MPH)	Max Wind Spd (MPH)	Avg Wind Dir (deg)	Avg Wind DirSD (deg)	Total Solar Rad (Lys)	Total PET (inch)	Rain fall (inch
2014	8	1	82.3	58.8	76.0	70.1	4.1	15	3	43	527	0.22	0.0
2014	8	2	86.1	57.2	76.1	70.4	3.6	16	79	63	456	0.21	0.0
2014	8	3	80.4	63.2	75.6	71.4	6.8	16	19	24	498	0.23	0.1
2014	8	4	77.9	51.7	72.7	69.0	5.2	16	40	30	565	0.24	0.0
2014	8	5	81.3	53.4	73.7	69.0	3.7	14	120	50	461	0.20	0.0
2014	8	6	81.8	57.5	73.1	68.9	4.0	13	112	35	346	0.17	0.0
2014	8	7	82.6	64.6	75.7	69.8	7.1	20	149	17	503	0.26	0.0
2014	8	8	83.8	62.4	76.7	70.7	7.8	18	149	16	501	0.26	0.0
2014	8	9	81.0	67.8	74.9	70.3	6.7	20	132	24	278	0.17	0.0
2014	8	10	78.4	60.7	72.6	69.2	7.3	22	347	23	314	0.16	0.0
2014	8	11	76.6	54.6	70.5	67.7	8.7	25	348	18	571	0.28	0.0
2014	8	12	83.7E	46.8E	73.0E	67.6E	4.2E	15E	269E	40E	601E	0.25	0.0
2014	8	13	83.2	58.1	76.7	70.3	4.5	12	35	40	524	0.24	0.0
2014	8	14	81.5	67.0	75.7	70.4	9.6	23	137	16	340	0.22	0.0
2014	8	15	86.1	67.0	79.4	72.5	8.0	17	147	17	470	0.23	0.0
2014	8	16	87.2	67.8	80.7	74.0	5.2	18	65	57	396	0.18	0.2
2014	8	17	77.9	65.0	75.5	73.3	5.8	15	126	30	263	0.10	0.1
2014	8	18	77.4	63.7	73.6	71.6	6.1	15	238	65	313	0.12	0.0
2014	8	19	82.3	59.9	75.7	71.7	4.1	17	357	68	490	0.19	0.0
2014	8	20	85.0	66.9	76.7	72.6	8.4	19	132	20	422	0.23	0.0
2014	8	21	80.0	65.6	74.3	72.1	4.7	20	114	41	178	0.08	0.0
2014	8	22	73.3	62.6	71.0	69.9	6.3	17	341	23	148	0.06	0.0
2014	8	23	73.0	64.2	69.9	69.1	7.3	21	58	42	110	0.05	0.0
2014	8	24	80.6	65.0	74.5	70.6	10.4	23	181	32	454	0.24	0.5
2014	8	25	66.2E	53.8E	65.0	65.4	11.7	25	243	30	205	0.15	0.0
2014	8	26	70.4	48.6	67.3	64.5	4.3	14	264	39	382	0.14	0.0
2014	8	27	75.8	51.6	68.3	65.7	4.6	13	140	34	400	0.15	0.0
2014	8	28	72.5	64.9	68.5	66.6	9.0	18	139	14	165	0.10	0.0
2014	8	29	76.3	61.3	69.7	67.6	5.5	26	332	54	181	0.08	0.0
2014	8	30	71.3	55.5	69.1	66.7	7.2	18	26	66	294	0.12	0.0
2014	8	31	74.4	57.3	66.9	66.1	7.6	24	183	61	156	0.08	0.2
Averages			79.0	60.1	73.2	69.5	6.4	18			371		
Totals												5.41	1.4
Max			87.2	67.8	80.7	74.0	11.7	26			601	0.28	0.5
Min			66.2	46.8	65.0	64.5	3.6	12			110	0.05	0.0
Std. Dev.			5.1	5.9	3.8	2.4	2.1	4			144	0.07	

E = estimated value
M = missing value
The number of missing values is indicated in parentheses.

001588

FARGO NW Daily Observations from September 1, 2014 to September 30, 2014
North Dakota Agricultural Weather Network (NDAWN)

Year	Mo	Da	Max Temp (F)	Min Temp (F)	Avg Soil Temp (F)	Avg Turf Temp (F)	Avg Wind Spd (MPH)	Max Wind Spd (MPH)	Avg Wind Dir (deg)	Avg Wind DirSD (deg)	Total Solar Rad (Lys)	Total PET (inch)	Rain fall (inch
2014	9	1	78.4	51.5	67.3	65.7	5.2	21	266	57	444	0.18	0.0
2014	9	2	79.9	53.8	68.5	65.5	7.8	23	200	18	467	0.25	0.0
2014	9	3	78.9	57.4	70.4	66.7	6.5	17	127	34	379	0.17	0.0
2014	9	4	75.3	52.9	69.2	67.3	9.5	31	295	60	342	0.17	1.5
2014	9	5	70.6	47.7	64.7	64.5	7.8	17	266	36	440	0.19	0.0
2014	9	6	78.8	48.6	66.7	64.1	6.4	20	209	31	466	0.22	0.0
2014	9	7	82.7	52.7	68.9	64.8	9.1	24	160	19	448	0.26	0.0
2014	9	8	82.1	57.5	71.0	66.0	11.1	21	160	52	446	0.26	0.0
2014	9	9	57.5	48.2	61.5	62.2	12.8	24	3	20	63	0.04	0.1
2014	9	10	55.7	46.4	54.9	57.7	13.0	28	3	19	223	0.13	0.0
2014	9	11	55.2	40.2	54.6	56.3	7.3	19	342	21	302	0.12	0.0
2014	9	12	56.3	39.5	54.4	55.5	4.2	15	249	52	300	0.11	0.0
2014	9	13	65.1	37.3	54.0	54.6	10.3	28	179	29	347	0.20	0.0
2014	9	14	59.2	41.7	55.1	55.0	6.8	17	285	38	265	0.11	0.0
2014	9	15	66.7	41.1	59.1	56.4	5.4	17	236	45	431	0.18	0.0
2014	9	16	72.6	45.5	60.9	57.3	7.2	15	171	36	424	0.22	0.0
2014	9	17	72.6	43.1	63.2	58.8	5.5	15	15	49	413	0.17	0.0
2014	9	18	75.9	41.8	62.0	58.7	9.4	24	148	27	340	0.19	0.0
2014	9	19	79.8	61.5	65.4	61.5	11.1	27	179	43	208	0.17	0.0
2014	9	20	71.2	49.6	62.1	60.7	7.4	30	289	45	286	0.13	0.0
2014	9	21	65.8	48.5	59.8	58.9	6.0	15	348	61	284	0.10	0.0
2014	9	22	76.9	45.9	61.7	59.0	7.5	18	168	28	402	0.22	0.0
2014	9	23	76.3	55.1	63.1	59.7	10.9	26	149	15	330	0.21	0.0
2014	9	24	67.9	57.9	62.4	60.7	8.7	17	148	14	124	0.06	0.0
2014	9	25	84.4	57.8	65.8	62.3	7.4	16	139	18	326	0.17	0.0
2014	9	26	84.1	62.2	68.4	64.0	11.4	25	140	15	365	0.26	0.0
2014	9	27	86.3	63.1	69.6	64.3	10.6	21	149	14	356	0.28	0.0
2014	9	28	67.0	51.9	64.6	62.4	11.6	25	357	34	210	0.12	0.1
2014	9	29	65.4	46.9	60.0	59.6	7.9	19	47	47	293	0.11	0.0
2014	9	30	61.9	44.3	55.8	56.9	12.1	33	125	16	189	0.12	0.0
Averages			71.7	49.7	62.8	60.9	8.6	22			330		
Totals												5.12	2.0
Max			86.3	63.1	71.0	67.3	13.0	33			467	0.28	1.5
Min			55.2	37.3	54.0	54.6	4.2	15			63	0.04	0.0
Std. Dev.			9.3	7.1	5.2	3.8	2.4	5			104	0.06	

E = estimated value
M = missing value
The number of missing values is indicated in parentheses.

001589

FARGO NW Daily Observations from October 1, 2014 to October 31, 2014
North Dakota Agricultural Weather Network (NDAWN)

Year	Mo	Da	Max Temp (F)	Min Temp (F)	Avg Soil Temp (F)	Avg Turf Temp (F)	Avg Wind Spd (MPH)	Max Wind Spd (MPH)	Avg Wind Dir (deg)	Avg Wind DirSD (deg)	Total Solar Rad (Lys)	Total PET (inch)	Rain fall (inch
2014	10	1	61.9	44.3	61.5	33.1	11.0	33	125	16	219	0.15	0.0
2014	10	2	68.6	46.0	60.3	58.5	9.0	29	283	21	250	0.16	0.0
2014	10	3	46.7	37.2	51.9	53.8	17.7	37	300	13	234	0.16	0.0
2014	10	4	47.2	32.7	48.1	50.2	9.4	24	293	19	276	0.13	0.0
2014	10	5	54.4	35.8	47.8	49.5	9.8	25	279	16	181	0.13	0.0
2014	10	6	62.9	35.2	48.2	49.1	11.0	30	272	30	268	0.19	0.0
2014	10	7	57.5	42.3	50.6	49.8	10.4	29	289	21	283	0.18	0.0
2014	10	8	51.9	30.6	48.6	48.9	5.1	20	311	33	296	0.10	0.0
2014	10	9	52.4	25.9	46.0	46.5	4.3	17	328	30	315	0.09	0.0
2014	10	10	57.1	23.5	47.0	46.1	3.4	13	190	70	304	0.10	0.0
2014	10	11	63.9	33.4	49.7	47.7	12.6	31	155	13	296	0.24	0.0
2014	10	12	58.5	44.9	51.1	49.5	8.8	24	154	46	146	0.10	0.0
2014	10	13	64.7	39.1	53.8	51.7	5.9	19	327	22	285	0.10	0.0
2014	10	14	66.7	33.0	51.1	49.6	2.7	10	285	77	284	0.09	0.0
2014	10	15	69.9	40.9	52.0	49.9	10.5	24	146	16	285	0.24	0.0
2014	10	16	69.5	49.0	54.9	51.6	14.9	30	235	63	217	0.20	0.0
2014	10	17	49.0	42.8	48.7	50.0	14.7	30	325	13	62	0.05	0.0
2014	10	18	44.7	41.7	46.7	48.2	7.7E	18E	285	54	61	0.03	0.0
2014	10	19	70.1	41.3	50.2	48.7	8.4E	24E	300	43	275	0.16	0.0
2014	10	20	63.4	34.1	50.2	48.4	3.7	15	27	59	272	0.08	0.0
2014	10	21	66.6	42.6	51.4	49.3	15.5	33	134	12	258	0.19	0.0
2014	10	22	66.8	51.4	53.9	51.4	13.3	33	159	28	139	0.14	0.0
2014	10	23	71.4	41.4	52.7	51.2	7.4	21	178	15	254	0.15	0.0
2014	10	24	77.2	44.1	54.3	51.5	8.2	22	225	45	245	0.20	0.0
2014	10	25	60.8	39.2	50.3	49.6	6.6	20	285	37	257	0.14	0.0
2014	10	26	64.8	40.0	48.5	47.4	11.9	29	142	14	182	0.26	0.0
2014	10	27	52.6	41.2	46.8	47.4	5.2	16	242	43	47	0.06	0.0
2014	10	28	43.8	37.4	43.6	45.8	12.5	26	300	18	48	0.07	0.0
2014	10	29	43.0	33.3	43.2	44.5	6.9	17	195	65	130	0.06	0.0
2014	10	30	40.6	22.1	41.3	44.0	10.6	28	349	40	82	0.05	0.0
2014	10	31	41.1	12.6	34.8	39.1	6.3	20	151	49	236	0.07	0.0
Averages			58.4	37.4	49.7	48.5	9.2	24			216		
Totals												4.07	0.2
Max			77.2	51.4	61.5	58.5	17.7	37			315	0.26	0.0
Min			40.6	12.6	34.8	33.1	2.7	10			47	0.03	0.0
Std. Dev.			10.2	8.2	5.1	4.4	3.8	7			84	0.06	

E = estimated value
M = missing value
The number of missing values is indicated in parentheses.

001590

FARGO NW Daily Observations from November 1, 2014 to November 30, 2014
North Dakota Agricultural Weather Network (NDAWN)

Year	Mo	Da	Max Temp (F)	Min Temp (F)	Avg Soil Temp (F)	Avg Turf Temp (F)	Avg Wind Spd (MPH)	Max Wind Spd (MPH)	Avg Wind Dir (deg)	Avg Wind DirSD (deg)	Total Solar Rad (Lys)	Total PET (inch)	Rain fall (inch
2014	11	1	49.1	28.8	38.0	39.1	16.9	34	148	12	222	0.17	
2014	11	2	57.0	38.1	42.7	41.5	12.1	26	144	13	186	0.18	
2014	11	3	51.0	38.8	44.5	43.6	8.4	21	278	35	109	0.09	
2014	11	4	43.7	29.8	40.4	42.6	8.7	27	271	26	58	0.07	
2014	11	5	36.7	31.2	37.4	40.3	6.7	16	17	49	33	0.01	
2014	11	6	44.4	29.0	37.4	39.8	5.6	18	251	62	166	0.03	
2014	11	7	51.3	35.8	39.3	40.6	15.5	34	206	76	43	0.06	
2014	11	8	40.4	32.7	38.5	40.3	9.9	24	281	33	138	0.08	
2014	11	9	36.6	22.9	35.6	38.5	6.9	17	357	40	138	0.05	
2014	11	10	23.0	19.1	32.1	35.5	13.0	27	0	26	67	0.05	
2014	11	11	21.2	13.5	29.8	33.5	11.6	24	324	16	87	0.03	
2014	11	12	25.2	11.1	28.6	32.2	11.8	27	316	15	100	0.03	
2014	11	13	19.4	5.8	27.4	31.7	9.4	20	304	21	178	0.03	
2014	11	14	22.3	4.3	24.9	30.1	5.0	15	202	29	198	0.02	
2014	11	15	21.5	6.4	24.2	28.9	5.7	16	255	53	123	0.02	
2014	11	16	21.5	5.8	21.7	27.0	12.2	29	268	49	93	0.04	
2014	11	17	14.8	8.9	21.4	25.7	13.4	28	311	15	111	0.04	
2014	11	18	22.8	11.0	23.6	25.8	10.4	25	231	47	118	0.04	
2014	11	19	26.3	7.8	24.9	26.7	13.3	29	293	16	115	0.06	
2014	11	20	21.4	0.8	20.4	24.3	4.7	15	232	65	181	0.03	
2014	11	21	33.2	9.8	23.6	24.9	12.4	23	161	14	139	0.06	
2014	11	22	45.0	23.1	28.4	27.8	8.4	25	151	17	129	0.05	
2014	11	23	43.6	16.7	31.2	30.0	9.8	23	277	53	39	0.05	
2014	11	24	19.2	5.9	24.1	29.0	13.5	29	326	17	118	0.03	
2014	11	25	26.4	8.7	24.9	28.2	6.4	23	124	51	77	0.03	
2014	11	26	19.2	-11.1	20.0	27.5	11.4	24	345	20	133	0.04	
2014	11	27	10.0	-13.7	14.2	24.4	6.1	19	145	33	150	0.02	
2014	11	28	19.9	9.8	22.5	25.5	8.3	23	127	23	78	0.02	
2014	11	29	24.4	7.0	25.7	26.8	11.6	26	293	63	78	0.03	
2014	11	30	8.5	-3.9	23.5	24.4	12.1	24	287	27	165	0.03	
Averages			30.0	14.5	29.0	31.9	10.0	24			119		
Totals												1.49	(3
Max			57.0	38.8	44.5	43.6	16.9	34			222	0.18	(3
Min			8.5	-13.7	14.2	24.3	4.7	15			33	0.01	(3
Std. Dev.			13.2	13.9	7.8	6.5	3.2	5			49	0.04	

E = estimated value
M = missing value
The number of missing values is indicated in parentheses.

001591

FARGO NW Daily Observations from December 1, 2014 to December 31, 2014
North Dakota Agricultural Weather Network (NDAWN)

Year	Mo	Da	Max Temp (F)	Min Temp (F)	Avg Soil Temp (F)	Avg Turf Temp (F)	Avg Wind Spd (MPH)	Max Wind Spd (MPH)	Avg Wind Dir (deg)	Avg Wind DirSD (deg)	Total Solar Rad (Lys)	Total PET (inch)	Rain fall (inch
2014	12	1	7.3	-11.7	19.4	20.3	11.3	32	168	43	171	0.03	
2014	12	2	19.3	7.3	21.2	21.1	8.5	30	205	52	127	0.03	
2014	12	3	19.8	6.2	21.5	23.2	6.5	15	230	54	153	0.02	
2014	12	4	33.4	13.1	23.6	24.1	10.2	23	150	14	148	0.05	
2014	12	5	27.4	8.1	24.6	25.6	4.6	12	330	42	146	0.02	
2014	12	6	27.5	3.1	23.1	24.5	7.9	29	145	35	50	0.03	
2014	12	7	36.5	27.2	27.6	27.4	14.2	30	160	32	58	0.03	
2014	12	8	34.1	11.3	27.1	28.3	12.1	25	323	25	34	0.05	
2014	12	9	25.0	6.0	23.8	26.2	8.5	24	152	29	61	0.02	
2014	12	10	32.7	24.9	26.8	27.3	13.0	25	152	12	54	0.02	
2014	12	11	32.8	28.4	29.0	28.8	10.8	24	158	12	28	0.01	
2014	12	12	35.3	31.4	30.6	29.9	12.8	27	156	12	41	0.01	
2014	12	13	44.8	33.0	31.6	30.7	8.5	17	150	11	65	0.00	
2014	12	14	45.3	32.3	33.6	31.3	6.8	18	145	75	14	0.00	
2014	12	15	32.3	12.2	30.7	31.5	18.5	35	336	14	33	0.03	
2014	12	16	15.7	4.9	21.6	28.4	10.8	27	328	13	78	0.02	
2014	12	17	18.7	1.4	17.8	24.6	3.7	10	339	43	127	0.01	
2014	12	18	20.6	8.0	18.6	23.6	7.6	17	144	18	38	0.01	
2014	12	19	31.1	20.6	25.6	26.2	9.4	19	152	13	26	0.01	
2014	12	20	31.9	28.8	28.9	28.4	9.9	24	167	16	23	0.01	
2014	12	21	36.1	30.6	30.2	29.5	10.7	22	147	16	27	0.01	
2014	12	22	40.2	33.7	31.5	30.5	7.2	16	108	32	20	0.00	
2014	12	23	33.9	30.2	31.9	31.2	10.3	24	336	20	20	0.00	
2014	12	24	30.2	25.9	31.9	31.6	8.2	17	213	54	39	0.01	
2014	12	25	30.0	25.8	31.6	31.4	7.8	17	320	47	36	0.01	
2014	12	26	25.9	6.5	28.2	30.3	9.5	18	338	16	38	0.03	
2014	12	27	25.3	1.2	21.5	26.4	5.3	13	221	47	80	0.02	
2014	12	28	22.6	-5.2	17.5	23.4	11.3	23	359	16	148	0.05	
2014	12	29	1.5	-11.0	9.0	17.4	7.4	16	328	27	155	0.01	
2014	12	30	2.9	-10.8	7.1	15.4	7.8	18	265	40	133	0.02	
2014	12	31	23.1	-1.9	12.6	17.2	11.5	27	230	32	113	0.05	
Averages			27.2	13.6	24.5	26.3	9.4	22			74		
Totals												0.62	(3
Max			45.3	33.7	33.6	31.6	18.5	35			171	0.05	(3
Min			1.5	-11.7	7.1	15.4	3.7	10			14	0.00	(3
Std. Dev.			10.6	14.5	6.8	4.5	3.0	6			51	0.01	

E = estimated value
M = missing value
The number of missing values is indicated in parentheses.

001592

FARGO NW Daily Observations from January 1, 2015 to January 31, 2015
North Dakota Agricultural Weather Network (NDAWN)

Year	Mo	Da	Max Temp (F)	Min Temp (F)	Avg Soil Temp (F)	Avg Turf Temp (F)	Avg Wind Spd (MPH)	Max Wind Spd (MPH)	Avg Wind Dir (deg)	Avg Wind DirSD (deg)	Total Solar Rad (Lys)	Total PET (inch)	Rain fall (inch
2015	1	1	27.5	4.9	20.1	22.2	9.6	26	326	56	69	0.05	
2015	1	2	37.7	5.2	22.0	23.1	8.3	23	167	35	63	0.06	
2015	1	3	26.1	-12.0	16.6	23.9	17.3	34	336	40	89	0.06	
2015	1	4	-5.5	-13.5	5.0	19.5	9.0	21	297	23	143	0.01	
2015	1	5	-0.2	-12.3	4.2	17.8	7.0	15	210	31	63	0.01	
2015	1	6	5.2	-7.6	6.3	17.7	11.5	25	296	30	92	0.03	
2015	1	7	5.0	-13.3	5.2	16.9	9.8	19	248	43	165	0.03	
2015	1	8	10.9	-2.2	10.5	18.6	15.0	35	312	58	85	0.03	
2015	1	9	7.1	-5.6	6.6	18.6	10.1	22	272	23	161	0.03	
2015	1	10	8.3	-7.3	7.0	17.9	6.6	16	282	74	166	0.02	
2015	1	11	11.2	-5.5	10.0	18.7	5.1	15	276	60	100	0.02	
2015	1	12	-2.5	-16.7	6.1	17.4	4.8	16	310	64	177	0.01	
2015	1	13	13.3	-11.1	6.7	16.8	9.8	21	163	14	93	0.03	
2015	1	14	25.3	4.0	14.7	19.6	6.7	17	181	21	81	0.02	
2015	1	15	35.6	20.1	21.2	23.0	6.8	16	303	55	133	0.02	
2015	1	16	27.9	16.7	23.3	24.7	9.5	25	123	48	58	0.02	
2015	1	17	38.4	27.2	27.5	26.6	11.4	25	272	47	95	0.04	
2015	1	18	32.8	18.8	25.5	26.9	5.2	14	310	61	160	0.02	
2015	1	19	39.4	24.2	28.1	27.8	6.6	19	146	56	125	0.02	
2015	1	20	32.1	27.3	29.7	29.3	5.2	13	27	36	21	0.01	
2015	1	21	27.3	11.3	25.1	28.3	8.2	19	345	30	79	0.02	
2015	1	22	35.4	9.2	22.8	25.9	11.0	25	177	12	158	0.05	
2015	1	23	44.4	29.1	29.8	29.0	6.7	15	247	40	174	0.03	
2015	1	24	33.7	27.4	30.4	29.6	6.4	18	325	62	72	0.01	
2015	1	25	28.4	17.3	28.4	29.0	7.4	22	332	74	156	0.03	
2015	1	26	42.2	25.2	29.4	29.2	9.0	26	306	57	123	0.04	
2015	1	27	34.2	25.7	30.6	29.6	10.1	28	145	20	55	0.01	
2015	1	28	35.2	28.0	31.4	30.5	12.9	29	168	68	41	0.02	
2015	1	29	28.0	6.2	25.9	28.8	13.3	28	337	21	114	0.05	
2015	1	30	33.1	6.5	22.4	25.4	9.0	26	152	51	169	0.05	
2015	1	31	24.6	-2.8	20.2	24.0	15.4	27	359	19	155	0.06	
Averages			23.9	7.2	19.1	23.8	9.2	22			111		
Totals												0.91	(3
Max			44.4	29.1	31.4	30.5	17.3	35			177	0.06	(3
Min			-5.5	-16.7	4.2	16.8	4.8	13			21	0.01	(3
Std. Dev.			14.3	15.3	9.6	4.8	3.2	6			45	0.02	

E = estimated value
M = missing value
The number of missing values is indicated in parentheses.

FARGO NW Daily Observations from February 1, 2015 to February 28, 2015
North Dakota Agricultural Weather Network (NDAWN)

Year	Mo	Da	Max Temp (F)	Min Temp (F)	Avg Soil Temp (F)	Avg Turf Temp (F)	Avg Wind Spd (MPH)	Max Wind Spd (MPH)	Avg Wind Dir (deg)	Avg Wind DirSD (deg)	Total Solar Rad (Lys)	Total PET (inch)	Rain fall (inch
2015	2	1	4.5	-8.8	11.5	17.7	11.0	23	355	30	207	0.03	
2015	2	2	20.4	-3.0	12.9	17.1	7.4	17	188	58	193	0.04	
2015	2	3	14.1	3.5	15.7	19.3	3.4	10	306	53	87	0.01	
2015	2	4	8.3	-6.3	15.9	19.8	7.5	17	280	43	209	0.02	
2015	2	5	24.4	-3.9	16.4	19.1	8.6	20	177	25	217	0.04	
2015	2	6	33.7	16.1	22.5	22.9	5.6	14	81	40	206	0.04	
2015	2	7	35.8	20.4	25.8	25.3	5.7	17	117	66	165	0.03	
2015	2	8	24.4	13.6	23.5	25.0	10.5	20	346	17	56	0.02	
2015	2	9	24.4	10.6	22.0	23.7	5.7	12	12	44	72	0.01	
2015	2	10	30.8	16.1	25.3	25.7	11.3	30	176	77	63	0.03	
2015	2	11	16.1	-7.4	24.2	25.7	15.1	30	324	16	237	0.04	
2015	2	12	12.5	-16.3	20.7	24.2	7.5	19	162	48	197	0.03	
2015	2	13	18.4	4.7	21.6	24.7	11.2	30	326	46	198	0.03	
2015	2	14	4.7	-12.5	10.7	21.1	11.3	32	354	25	229	0.03	
2015	2	15	12.6	-2.3	14.8	20.9	11.4	24	144	17	129	0.03	
2015	2	16	13.7	-1.6	18.6	22.9	9.3	20	324	28	236	0.03	
2015	2	17	2.5	-10.1	13.2	21.0	10.3	23	304	21	232	0.02	
2015	2	18	-2.1	-15.7	6.5	17.4	6.9	19	317	25	294	0.01	
2015	2	19	13.3	-15.6	7.3	15.6	8.8	24	149	13	258	0.03	
2015	2	20	25.8	9.0	17.9	20.1	11.2	23	346	77	134	0.04	
2015	2	21	9.0	-11.9	13.1	19.5	11.9	23	334	15	289	0.03	
2015	2	22	-5.3	-20.4	4.3	15.2	7.6	19	308	36	321	0.01	
2015	2	23	30.8	-11.3	9.9	15.3	12.8	30	199	30	210	0.10	
2015	2	24	31.4	7.6	21.7	21.4	12.4	30	331	31	286	0.08	
2015	2	25	7.7	-7.2	15.3	19.8	11.8	25	352	20	265	0.03	
2015	2	26	7.6	-12.6	10.2	16.4	7.0	18	315	27	319	0.02	
2015	2	27	17.8	-9.5	12.8	16.3	6.7	16	196	26	329	0.04	
2015	2	28	26.7	4.2	17.2	18.7	11.7	26	175	39	244	0.07	
Averages			16.6	-2.5	16.1	20.4	9.3	22			210		
Totals												0.94	(2
Max			35.8	20.4	25.8	25.7	15.1	32			329	0.10	(2
Min			-5.3	-20.4	4.3	15.2	3.4	10			56	0.01	(2
Std. Dev.			11.1	11.3	5.9	3.4	2.8	6			77	0.02	

E = estimated value
M = missing value
The number of missing values is indicated in parentheses.

001594

FARGO NW Daily Observations from March 1, 2015 to March 31, 2015
North Dakota Agricultural Weather Network (NDAWN)

Year	Mo	Da	Max Temp (F)	Min Temp (F)	Avg Soil Temp (F)	Avg Turf Temp (F)	Avg Wind Spd (MPH)	Max Wind Spd (MPH)	Avg Wind Dir (deg)	Avg Wind DirSD (deg)	Total Solar Rad (Lys)	Total PET (inch)	Rain fall (inch
2015	3	1	23.3	1.4	17.5	19.6	8.0	21	261	38	213	0.04	
2015	3	2	33.1	2.7	20.0	20.4	11.8	31	157	17	315	0.10	
2015	3	3	27.1	-0.2	22.6	22.7	15.5	31	296	39	290	0.07	
2015	3	4	4.7	-6.4	13.7	16.9	8.6	21	296	20	275	0.02	
2015	3	5	25.0	-7.6	15.0	16.4	10.1	25	174	22	350	0.08	
2015	3	6	39.6	10.5	23.9	21.8	7.9	19	231	53	325	0.10	
2015	3	7	42.1	26.7	29.7	27.1	8.2	19	291	49	284	0.09	
2015	3	8	48.8	27.2	31.3	28.8	9.0	23	255	31	350	0.13	
2015	3	9	58.4	31.1	34.2	30.2	8.5	20	198	32	352	0.17	
2015	3	10	55.7	32.1	36.1	30.9	8.3	25	301	56	358	0.15	
2015	3	11	57.8	30.0	36.9	31.3	8.8	24	138	19	320	0.15	
2015	3	12	63.1	40.0	40.0	34.1	8.3	23	155	33	182	0.14	
2015	3	13	51.7	31.7	38.1	34.8	9.5	25	294	25	342	0.12	
2015	3	14	66.7	27.4	40.1	35.5	7.0	22	160	30	363	0.18	
2015	3	15	74.6	46.7	46.9	40.3	11.2	32	237	61	287	0.31	
2015	3	16	55.6	19.6	39.0	38.8	10.6	30	355	27	129	0.17	
2015	3	17	47.2	20.0	34.2	33.6	5.8	17	261	35	378	0.14	
2015	3	18	43.7	29.1	34.9	33.4	6.4	17	177	29	183	0.08	
2015	3	19	46.0	29.8	37.2	34.7	8.6	21	180	55	169	0.09	
2015	3	20	36.2	20.5	33.5	33.4	9.0	25	343	51	116	0.05	
2015	3	21	27.0	13.6	31.1	31.9	7.1	15	17	24	196	0.06	
2015	3	22	39.8	27.0	33.0	31.8	6.9	18	95	45	207	0.12	
2015	3	23	35.9	29.1	33.3	31.9	11.5	28	159	16	94	0.06	
2015	3	24	37.3	30.7	34.0	32.0	17.2	35	147	14	111	0.05	
2015	3	25	41.5	25.9	34.1	32.7	17.2	37	293	30	162	0.10	
2015	3	26	34.3	13.9	32.8	32.2	9.4	27	345	21	353	0.10	
2015	3	27	36.4	10.7	30.4	31.7	6.2	17	167	25	239	0.08	
2015	3	28	52.3	23.9	35.5	31.9	14.4	31	155	17	429	0.20	
2015	3	29	56.6	35.6	41.7	36.3	14.8	40	309	50	367	0.19	
2015	3	30	61.2	34.4	43.9	38.2	5.5	19	125	65	373	0.14	
2015	3	31	65.6	31.4	46.8	40.1	3.1	17	144	57	555	0.17	
Averages			44.8	22.2	32.9	30.8	9.5	24			280		
Totals												3.65	(3
Max			74.6	46.7	46.9	40.3	17.2	40			555	0.31	(3
Min			4.7	-7.6	13.7	16.4	3.1	15			94	0.02	(3
Std. Dev.			15.2	13.5	8.4	6.4	3.4	6			107	0.06	

E = estimated value
M = missing value
The number of missing values is indicated in parentheses.

FARGO NW Daily Observations from April 1, 2015 to April 30, 2015
North Dakota Agricultural Weather Network (NDAWN)

Year	Mo	Da	Max Temp (F)	Min Temp (F)	Avg Soil Temp (F)	Avg Turf Temp (F)	Avg Wind Spd (MPH)	Max Wind Spd (MPH)	Avg Wind Dir (deg)	Avg Wind DirSD (deg)	Total Solar Rad (Lys)	Total PET (inch)	Rain fall (inch
2015	4	1	72.1	41.0	49.8	43.1	13.8	32	212	68	380	0.32	0.0
2015	4	2	52.6	21.5	42.2	40.2	17.3	41	289	41	397	0.21	0.0
2015	4	3	42.4	14.6	37.6	35.7	6.4	21	332	58	446	0.14	0.0
2015	4	4	47.9	17.6	40.5	36.2	4.6	16	30	43	445	0.13	0.0
2015	4	5	45.4	24.5	39.6	36.2	9.7	21	45	16	413	0.20	0.0
2015	4	6	43.7	30.4	38.3	35.6	9.3	18	52	15	229	0.19	0.0
2015	4	7	40.0	34.5	36.1	34.7	6.2	17	106	35	64	0.09	0.0
2015	4	8	46.1	33.8	39.2	36.0	6.0	16	42	35	218	0.07	0.0
2015	4	9	61.3	32.0	44.9	39.2	10.2	28	347	24	494	0.26	0.0
2015	4	10	58.0	30.8	46.3	40.5	8.5	22	329	37	558	0.24	0.0
2015	4	11	78.7	33.7	48.4	41.6	11.3	36	173	21	492	0.43	0.0
2015	4	12	69.1	41.0	51.4	44.9	12.3	29	240	61	320	0.29	0.0
2015	4	13	63.1	33.5	46.5	42.3	11.0	34	292	24	550	0.35	0.0
2015	4	14	79.3	34.8	49.9	42.4	9.9	26	161	17	575	0.45	0.0
2015	4	15	75.6	47.7	54.2	45.9	14.7	34	175	17	573	0.44	0.0
2015	4	16	70.5	38.8	56.8	48.5	6.9	24	307	70	497	0.25	0.0
2015	4	17	75.8	31.7	53.7	46.4	6.2	24	312	53	593	0.33	0.0
2015	4	18	72.6	33.7	54.1	46.8	6.5	24	111	44	400	0.27	0.0
2015	4	19	56.2	37.7	48.0	45.8	10.9	28	327	30	134	0.07	0.3
2015	4	20	38.8	33.5	39.0	40.1	13.8	31	333	15	181	0.07	0.0
2015	4	21	43.0	31.2	36.2	37.0	15.8	34	336	16	211	0.12	0.0
2015	4	22	48.0	24.3	39.2	36.8	10.0	29	338	19	638	0.25	0.0
2015	4	23	52.6	9.5E	43.1	38.2	3.0	12	65	45	567	0.16	0.0
2015	4	24	53.5	40.0E	45.9	41.8	10.2	29	121	18	290	0.14	0.0
2015	4	25	62.0	42.7	48.7	43.5	6.3	18	114	27	327	0.16	0.0
2015	4	26	68.2	38.3	54.2	45.8	4.3	16	143	37	630	0.26	0.0
2015	4	27	73.7	36.0	57.3	48.0	5.9	27	326	61	591	0.30	0.0
2015	4	28	65.5	41.4	57.1	50.0	7.1	18	1	19	595	0.23	0.1
2015	4	29	72.5	36.9	58.4	49.6	3.6	15	175	28	639	0.25	0.0
2015	4	30	80.6	47.4	61.0	50.9	10.2	29	181	30	609	0.45	0.0
Averages			60.3	33.2	47.3	42.1	9.1	25			435		
Totals												7.12	0.6
Max			80.6	47.7	61.0	50.9	17.3	41			639	0.45	0.3
Min			38.8	9.5	36.1	34.7	3.0	12			64	0.07	0.0
Std. Dev.			13.4	8.9	7.4	4.9	3.7	7			167	0.11	

E = estimated value
M = missing value
The number of missing values is indicated in parentheses.

001596

FARGO NW Daily Observations from May 1, 2015 to May 31, 2015
North Dakota Agricultural Weather Network (NDAWN)

Year	Mo	Da	Max Temp (F)	Min Temp (F)	Avg Soil Temp (F)	Avg Turf Temp (F)	Avg Wind Spd (MPH)	Max Wind Spd (MPH)	Avg Wind Dir (deg)	Avg Wind DirSD (deg)	Total Solar Rad (Lys)	Total PET (inch)	Rain fall (inch
2015	5	1	75.0	48.1	65.4	54.7	4.0	16	130	78	589	0.24	0.0
2015	5	2	85.9	49.8	63.0	54.3	10.9	36	176	35	554	0.45	0.0
2015	5	3	70.3	46.2	58.0	52.5	8.7	28	333	34	436	0.29	0.0
2015	5	4	70.0	35.6	58.6	50.8	3.0	12	163	66	532	0.21	0.0
2015	5	5	78.8	52.1	62.7	52.4	10.4	26	149	18	588	0.43	0.0
2015	5	6	65.8	57.7	60.2	54.4	10.6	23	143	22	143	0.08	0.1
2015	5	7	67.9	43.7	58.6	55.4	12.4	26	304	66	262	0.13	0.1
2015	5	8	44.2	32.8	48.2	49.2	12.2	25	354	16	337	0.13	0.0
2015	5	9	52.7	28.4	49.5	46.8	9.6	21	16	21	471	0.19	0.0
2015	5	10	47.2	40.9	46.1	46.5	11.3	28	41	18	138	0.06	0.8
2015	5	11	42.8	37.3	42.7	44.4	14.8	30	3	21	149	0.04	0.9
2015	5	12	56.6	32.5	51.7	46.7	5.9	16	21	43	602	0.17	0.0
2015	5	13	65.8	45.3	49.4	48.2	12.4	37	128	19	133	0.16	0.5
2015	5	14	61.2	52.2	53.0	50.1	9.7	26	151	14	158	0.08	0.2
2015	5	15	60.3	48.3	55.3	51.4	4.0	14	40	55	238	0.07	0.0
2015	5	16	69.1	52.4	58.8	53.7	8.2	21	118	21	276	0.13	0.0
2015	5	17	69.4	37.9	59.8	56.4	10.7	33	352	64	243	0.11	2.3
2015	5	18	39.7	32.9	43.6	48.8	16.4	35	338	15	136	0.05	0.2
2015	5	19	55.8	30.8	51.1	48.7	4.1	14	346	32	721	0.19	0.0
2015	5	20	70.9	37.9	56.9	52.4	3.9	16	258	48	700	0.25	0.0
2015	5	21	69.0	41.5	58.9	55.6	5.2	16	339	22	715	0.26	0.0
2015	5	22	75.7	41.7	61.1	57.5	3.4	15	164	30	699	0.27	0.0
2015	5	23	72.9	52.3	62.0	59.5	7.0	21	179	30	678	0.30	0.0
2015	5	24	71.3	53.3	59.5	58.5	4.9	17	96	33	244	0.14	0.0
2015	5	25	65.7	51.3	59.9	58.4	5.7	21	34	28	243	0.09	0.3
2015	5	26	77.4	49.6	63.2	59.1	4.9	15	198	24	565	0.23	0.0
2015	5	27	82.0	52.4	67.2	62.8	3.7	18	3	48	634	0.26	0.0
2015	5	28	84.8	60.3	65.9	64.2	8.1	51	189	48	390	0.22	1.4
2015	5	29	62.4	42.2	58.5	59.9	15.3	31	4	21	400	0.18	0.3
2015	5	30	58.9	34.1	54.4	56.8	7.8	21	20	23	735	0.26	0.0
2015	5	31	62.6	46.3	54.6	57.4	7.5	22	141	23	399	0.20	0.0
Averages			65.6	44.1	56.7	53.8	8.3	24			423		
Totals												5.87	7.8
Max			85.9	60.3	67.2	64.2	16.4	51			735	0.45	2.3
Min			39.7	28.4	42.7	44.4	3.0	12			133	0.04	0.0
Std. Dev.			11.8	8.5	6.4	5.0	3.8	9			211	0.10	

E = estimated value
M = missing value
The number of missing values is indicated in parentheses.

001597

FARGO NW Daily Observations from June 1, 2015 to June 30, 2015
North Dakota Agricultural Weather Network (NDAWN)

Year	Mo	Da	Max Temp (F)	Min Temp (F)	Avg Soil Temp (F)	Avg Turf Temp (F)	Avg Wind Spd (MPH)	Max Wind Spd (MPH)	Avg Wind Dir (deg)	Avg Wind DirSD (deg)	Total Solar Rad (Lys)	Total PET (inch)	Rain fall (inch
2015	6	1	74.0	53.5	57.5	57.5	13.5	29	151	15	478	0.33	0.0
2015	6	2	80.3	60.4	61.9	59.3	12.6	41	162	16	320	0.26	0.0
2015	6	3	70.8	55.1	60.3	60.3	8.5	19	316	43	127	0.07	0.0
2015	6	4	73.6	55.0	63.9	61.4	6.5	18	9	29	461	0.20	0.0
2015	6	5	76.2	57.9	65.8	63.7	5.8	17	113	29	463	0.21	0.0
2015	6	6	73.4	58.1	64.6	63.8	8.8	26	153	47	255	0.14	0.4
2015	6	7	83.6	56.3	67.8	65.2	6.4	21	306	43	659	0.29	0.0
2015	6	8	85.6	56.1	69.8	67.6	3.6	17	306	33	620	0.27	0.0
2015	6	9	90.3	59.7	67.4	67.6	7.9	30	292	71	564	0.33	0.0
2015	6	10	73.4	55.1	65.7	66.5	4.6	13	12	30	469	0.20	0.0
2015	6	11	80.4	59.1	69.9	68.7	3.7	16	80	51	688	0.28	0.0
2015	6	12	82.8	57.6	71.4	68.9	7.8	21	172	19	712	0.38	0.0
2015	6	13	82.3	60.6	72.8	68.9	9.3	23	163	17	680	0.35	0.0
2015	6	14	71.4	57.3	68.7	67.9	6.4	23	4	47	436	0.16	0.9
2015	6	15	69.4	54.8	66.7	66.7	6.2	19	345	28	636	0.24	0.0
2015	6	16	61.1	46.3	59.8	62.4	4.4	14	141	41	194	0.08	0.2
2015	6	17	70.4	52.9	62.5	62.6	3.5	13	310	73	400	0.13	0.0
2015	6	18	68.9	52.4	66.1	65.0	6.7	22	12	33	607	0.23	0.0
2015	6	19	83.0	57.4	67.6	65.4	10.2	27	178	28	554	0.33	0.0
2015	6	20	78.4	59.3	69.3	67.0	6.0	19	347	54	429	0.17	0.0
2015	6	21	86.0	52.8	72.1	68.1	4.8	21	185	59	682	0.31	0.1
2015	6	22	72.3	58.5	70.5	68.5	7.6	28	327	36	495	0.19	0.2
2015	6	23	81.8	56.5	71.8	67.8	5.2	19	245	31	694	0.30	0.0
2015	6	24	81.6	59.5	73.3	69.0	5.4	28	198	53	483	0.22	0.2
2015	6	25	80.2	54.5	73.0	69.7	2.3	11	356	40	658	0.22	0.0
2015	6	26	83.8	60.0	76.0	71.6	3.9	15	12	64	696	0.28	0.0
2015	6	27	84.2	62.1	74.1	70.2	7.1	21	177	33	453	0.24	0.0
2015	6	28	82.5	57.0	73.0	69.5	5.7	20	343	21	629	0.26	0.0
2015	6	29	77.7	61.4	70.7	68.4	4.6	14	323	30	305	0.13	0.0
2015	6	30	74.9	56.1	68.9	67.3	2.4	10	68	48	306	0.12	0.0
Averages			77.8	56.8	68.1	66.2	6.4	21			505		
Totals												6.92	2.5
Max			90.3	62.1	76.0	71.6	13.5	41			712	0.38	0.9
Min			61.1	46.3	57.5	57.5	2.3	10			127	0.07	0.0
Std. Dev.			6.5	3.3	4.6	3.5	2.7	7			163	0.08	

E = estimated value
M = missing value
The number of missing values is indicated in parentheses.

001598

FARGO NW Daily Observations from July 1, 2015 to July 31, 2015
North Dakota Agricultural Weather Network (NDAWN)

Year	Mo	Da	Max Temp (F)	Min Temp (F)	Avg Soil Temp (F)	Avg Turf Temp (F)	Avg Wind Spd (MPH)	Max Wind Spd (MPH)	Avg Wind Dir (deg)	Avg Wind DirSD (deg)	Total Solar Rad (Lys)	Total PET (inch)	Rain fall (inch
2015	7	1	76.0	61.3	72.2	68.0	5.2	14	174	23	501	0.20	0.0
2015	7	2	78.4	57.9	72.5	67.2	7.1	20	178	19	561	0.27	0.0
2015	7	3	83.1	63.3	74.5	69.0	3.4	10	33	69	517	0.21	0.0
2015	7	4	84.9	65.0	75.5	69.7	8.1	21	166	17	524	0.27	0.0
2015	7	5	84.0	66.5	76.1	70.4	8.3	23	221	78	397	0.21	0.0
2015	7	6	67.0	48.5	71.5	68.0	10.7	27	2	17	544	0.24	0.0
2015	7	7	73.2	43.6	70.5	65.9	3.8	16	184	33	703	0.25	0.0
2015	7	8	71.8	56.2	66.8	64.7	6.0	17	169	25	266	0.13	0.1
2015	7	9	83.0	53.7	70.9	67.1	3.6	13	229	47	662	0.26	0.0
2015	7	10	87.3	59.1	74.8	69.3	7.5	17	161	17	653	0.34	0.0
2015	7	11	84.5	68.3	75.5	70.5	9.5	22	150	16	491	0.25	0.0
2015	7	12	88.5	69.9	77.0	72.4	7.9	25	149	34	435	0.22	0.0
2015	7	13	83.9	66.6	76.6	72.2	5.6	18	285	53	554	0.23	0.0
2015	7	14	88.8	64.5	79.1	73.6	3.9	15	22	70	611	0.25	0.0
2015	7	15	88.8	67.2	77.7	73.3	5.7	29	173	31	398	0.19	0.0
2015	7	16	81.0	67.3	74.4	72.0	4.9	22	176	50	333	0.13	1.1
2015	7	17	84.4	63.7	77.2	73.6	4.2	24	7	49	595	0.22	0.4
2015	7	18	74.8	63.5	74.2	71.8	8.6	25	267	27	555	0.24	0.0
2015	7	19	85.7	60.1	75.3	70.0	9.0	23	252	25	682	0.37	0.0
2015	7	20	74.9	58.7	75.1	69.8	6.6	19	328	28	605	0.25	0.0
2015	7	21	81.8	57.6	76.4	70.1	3.5	12	307	73	598	0.24	0.0
2015	7	22	84.4	65.5	77.7	71.9	8.6	19	163	23	585	0.28	0.2
2015	7	23	86.7	65.8	78.9	72.6	11.0	28	158	21	638	0.32	0.0
2015	7	24	83.6	65.8	77.3	72.5	5.6	21	308	57	466	0.20	0.0
2015	7	25	85.4	62.2	75.7	71.1	6.4	19	179	20	409	0.20	0.0
2015	7	26	87.9	65.8	78.7	72.4	5.3	18	168	22	653	0.28	0.0
2015	7	27	89.1	69.8	79.4	73.2	9.0	22	148	17	534	0.28	0.0
2015	7	28	78.9	65.6	77.6	72.9	12.9	33	222	40	584	0.32	0.7
2015	7	29	81.6	66.4	73.8E	69.3E	14.6E	30	282	19	596E	0.37	0.0
2015	7	30	83.4	55.0E	75.0	69.3	7.9	24	293	16	621	0.32	0.0
2015	7	31	82.8	56.7	75.3	68.9	6.1	19	301	24	647	0.30	0.0
Averages			82.2	62.0	75.3	70.4	7.1	21			546		
Totals												7.84	2.8
Max			89.1	69.9	79.4	73.6	14.6	33			703	0.37	1.1
Min			67.0	43.6	66.8	64.7	3.4	10			266	0.13	0.0
Std. Dev.			5.5	6.1	2.8	2.3	2.8	5			106	0.06	

E = estimated value
M = missing value
The number of missing values is indicated in parentheses.

001599

FARGO NW Daily Observations from August 1, 2015 to August 31, 2015
North Dakota Agricultural Weather Network (NDAWN)

Year	Mo	Da	Max Temp (F)	Min Temp (F)	Avg Soil Temp (F)	Avg Turf Temp (F)	Avg Wind Spd (MPH)	Max Wind Spd (MPH)	Avg Wind Dir (deg)	Avg Wind DirSD (deg)	Total Solar Rad (Lys)	Total PET (inch)	Rain fall (inch
2015	8	1	86.4	57.7	76.9	69.4	3.9	16	160	23	615	0.26	0.0
2015	8	2	78.2	57.5	77.1	70.1	7.9	22	334	32	601	0.28	0.0
2015	8	3	78.5	50.3	73.9	67.5	4.6	20	322	21	657	0.26	0.0
2015	8	4	79.2	47.0E	74.4	67.5	3.5	15	33	37	641	0.24	0.0
2015	8	5	81.2	61.1	74.8	68.1	7.3	17	154	22	463	0.26	0.0
2015	8	6	77.2	64.9	73.6	68.7	5.5	20	172	36	216	0.10	0.8
2015	8	7	85.4	59.5	74.9	70.7	3.2	16	215	54	577	0.21	0.2
2015	8	8	83.9	65.8	76.5	72.9	4.1	12	335	72	563	0.22	0.3
2015	8	9	79.4	61.0	74.2	71.8	3.7	13	4	27	431	0.17	0.0
2015	8	10	82.3	57.3	74.8	70.8	3.1	14	342	28	537	0.20	0.0
2015	8	11	85.7	54.4	76.8	71.2	3.0	13	181	45	592	0.23	0.0
2015	8	12	91.7	63.0	78.6	71.7	9.5	23	185	21	554	0.34	0.0
2015	8	13	88.7	69.7	78.3	72.6	4.6	20	192	42	327	0.17	0.0
2015	8	14	93.4	67.5	81.1	73.9	5.7	14	179	23	548	0.26	0.0
2015	8	15	92.0	72.5	81.9	74.6	11.4	30	173	18	548	0.32	0.0
2015	8	16	76.0	57.4	72.8	71.1	5.7	22	282	43	184	0.09	0.0
2015	8	17	74.4	50.2	70.0	68.1	1.7	8	48	66	442	0.14	0.0
2015	8	18	64.9	55.8	65.6	66.0	6.4	24	5	31	103	0.06	0.2
2015	8	19	69.6	48.2	63.3	63.8	9.0	23	352	21	393	0.18	0.0
2015	8	20	75.8	44.7	66.3	63.8	4.3	17	171	26	582	0.22	0.0
2015	8	21	82.6	58.6	69.3	65.8	10.7	22	163	15	435	0.24	0.0
2015	8	22	75.7	55.8	67.8	67.0	11.9	32	188	45	119	0.11	0.3
2015	8	23	68.1	52.5	62.6	63.1	15.1	36	300	21	456	0.22	0.0
2015	8	24	70.8	47.0	63.3	61.7	8.7	23	320	19	571	0.25	0.0
2015	8	25	72.4	40.4	64.5	61.2	3.1	16	354	23	565	0.19	0.0
2015	8	26	76.6	48.0	65.6	61.6	5.6	17	150	17	489	0.22	0.0
2015	8	27	78.1	59.1	68.9	64.1	5.2	13	158	26	366	0.15	0.0
2015	8	28	80.7	63.5	72.0	66.7	8.7	20	182	15	455	0.19	0.0
2015	8	29	81.7	61.1	72.0	67.2	8.6	18	168	13	373	0.18	0.0
2015	8	30	86.3	63.3	72.6	67.8	10.8	24	163	13	436	0.24	0.0
2015	8	31	80.5	63.6	72.8	68.1	6.7	22	176	48	328	0.16	0.0
Averages			79.9	57.4	72.2	68.0	6.6	19			457		
Totals												6.36	2.1
Max			93.4	72.5	81.9	74.6	15.1	36			657	0.34	0.8
Min			64.9	40.4	62.6	61.2	1.7	8			103	0.06	0.0
Std. Dev.			6.9	7.7	5.3	3.7	3.2	6			149	0.06	

E = estimated value
M = missing value
The number of missing values is indicated in parentheses.

001600

FARGO NW Daily Observations from September 1, 2015 to September 30, 2015
North Dakota Agricultural Weather Network (NDAWN)

Year	Mo	Da	Max Temp (F)	Min Temp (F)	Avg Soil Temp (F)	Avg Turf Temp (F)	Avg Wind Spd (MPH)	Max Wind Spd (MPH)	Avg Wind Dir (deg)	Avg Wind DirSD (deg)	Total Solar Rad (Lys)	Total PET (inch)	Rain fall (inch
2015	9	1	89.0	58.8	73.4	67.5	4.8	16	147	23	501	0.24	0.0
2015	9	2	89.2	67.3	76.2	69.4	9.0	21	146	16	492	0.26	0.0
2015	9	3	91.3	71.3	77.6	70.9	12.0	26	145	14	443	0.26	0.0
2015	9	4	82.2	73.4	75.6	71.4	7.6	23	149	33	194	0.11	0.0
2015	9	5	83.0	67.6	74.0	70.9	3.9	14	118	61	185	0.08	0.1
2015	9	6	77.9	54.9	72.0	70.7	4.4	17	345	42	224	0.09	0.2
2015	9	7	73.9	50.0	64.2	66.0	3.1	13	189	62	267	0.11	0.0
2015	9	8	73.9	48.4	65.1	64.1	5.1	22	282	30	501	0.20	0.0
2015	9	9	75.7	48.9	65.3	63.1	3.1	13	19	56	347	0.14	0.0
2015	9	10	64.5	41.2	62.8	61.3	6.4	24	2	19	393	0.15	0.0
2015	9	11	66.8	40.9	62.7	60.1	3.1	14	326	49	411	0.14	0.0
2015	9	12	76.0	44.2	62.6	59.6	7.9	22	188	18	450	0.25	0.0
2015	9	13	85.7	50.9	66.2	61.2	10.1	25	177	16	463	0.32	0.0
2015	9	14	78.9	49.9E	68.5	63.3	6.7	15	75	36	390	0.18	0.0
2015	9	15	84.0	67.7	70.4	65.3	12.0	29	159	15	352	0.26	0.0
2015	9	16	77.3	61.5	70.3	65.6	5.8	19	356	58	291	0.15	0.0
2015	9	17	70.3	47.5	66.9	63.9	7.7	23	311	35	244	0.13	0.0
2015	9	18	61.0	41.3	59.3	59.6	4.0	15	242	28	158	0.06	0.0
2015	9	19	75.7	44.4	60.2	58.7	8.1	22	208	25	413	0.23	0.0
2015	9	20	78.4	50.5	63.1	59.6	8.4	19	170	18	425	0.24	0.0
2015	9	21	91.1	56.7	66.4	61.3	9.4	24	190	58	423	0.34	0.0
2015	9	22	67.1	46.1	63.7	60.2	6.3	18	29	26	300	0.17	0.0
2015	9	23	60.8	50.0	59.1	57.4	5.1	15	72	26	72	0.04	1.2
2015	9	24	73.0	58.7	62.6	60.3	2.7	9	73	49	185	0.05	0.0
2015	9	25	80.2	58.4	65.8	62.9	5.6	16	150	23	365	0.15	0.0
2015	9	26	82.5	59.7	66.6	63.6	11.4	26	169	15	389	0.29	0.0
2015	9	27	80.3	58.4	67.8	63.8	6.5	22	168	65	320	0.18	0.0
2015	9	28	69.1	43.9	64.0	62.0	4.9	20	354	27	336	0.15	0.0
2015	9	29	68.7	35.0	59.3	58.4	3.6	17	152	45	396	0.15	0.0
2015	9	30	70.2	49.3	59.1	57.5	11.2	25	155	16	322	0.28	0.0
Averages			76.6	53.2	66.4	63.3	6.7	19			342		
Totals												5.40	1.6
Max			91.3	73.4	77.6	71.4	12.0	29			501	0.34	1.2
Min			60.8	35.0	59.1	57.4	2.7	9			72	0.04	0.0
Std. Dev.			8.5	9.8	5.3	4.2	2.8	5			111	0.08	

E = estimated value
M = missing value
The number of missing values is indicated in parentheses.

001601

FARGO NW Daily Observations from October 1, 2015 to October 31, 2015
North Dakota Agricultural Weather Network (NDAWN)

Year	Mo	Da	Max Temp (F)	Min Temp (F)	Avg Soil Temp (F)	Avg Turf Temp (F)	Avg Wind Spd (MPH)	Max Wind Spd (MPH)	Avg Wind Dir (deg)	Avg Wind DirSD (deg)	Total Solar Rad (Lys)	Total PET (inch)	Rain fall (inch
2015	10	1	65.4	51.2	58.7	56.7	9.9	28	141	17	280	0.22	0.0
2015	10	2	62.3	44.0	56.9	55.6	7.5	21	125	19	356	0.17	0.0
2015	10	3	61.6	42.7	55.8	54.7	7.3	20	126	20	328	0.15	0.0
2015	10	4	60.9	48.4	56.2	54.9	8.4	20	154	18	169	0.13	0.0
2015	10	5	61.4	52.7	56.8	55.4	4.9	14	195	34	101	0.07	0.0
2015	10	6	61.9	41.6	57.2	55.4	4.8	18	338	32	360	0.12	0.0
2015	10	7	65.4	31.9	53.3	52.9	6.9	23	151	22	262	0.15	0.0
2015	10	8	54.4	47.8	53.1	53.4	7.3	20	330	35	81	0.05	0.0
2015	10	9	61.4	38.2	53.8	53.4	5.2	19	178	33	291	0.10	0.0
2015	10	10	81.5	48.6	56.8	54.4	8.4	21	189	23	279	0.22	0.0
2015	10	11	95.1	52.2	60.2	56.0	9.2	45	236	53	317	0.35	0.0
2015	10	12	61.6	35.4	55.3	54.4	16.3	42	299	26	68	0.12	0.0
2015	10	13	61.7	32.4	51.9	51.8	2.5	12	295	42	330	0.08	0.0
2015	10	14	70.4	38.4	51.7	51.0	7.2	24	277	26	304	0.19	0.0
2015	10	15	56.5	29.6	50.4	49.8	10.1	26	319	26	273	0.17	0.0
2015	10	16	50.2	24.5	44.9	46.9	2.6	8	214	34	155	0.05	0.0
2015	10	17	57.8	24.9	45.7	46.1	2.6	14	114	53	312	0.09	0.0
2015	10	18	68.6	43.2	49.9	47.9	12.7	32	161	17	295	0.25	0.0
2015	10	19	71.0	46.9	53.4	50.3	6.2	18	26	53	237	0.15	0.0
2015	10	20	68.9	46.2	54.3	51.0	6.4	16	110	44	257	0.14	0.0
2015	10	21	60.0	41.1	53.8	51.3	9.4	28	301	38	254	0.15	0.0
2015	10	22	64.8	34.3	50.3	48.7	5.0	17	156	25	282	0.14	0.0
2015	10	23	54.3	46.7	50.8	49.9	9.7	24	147	63	33	0.02	0.9
2015	10	24	56.6	35.0	48.6	49.3	4.9	18	301	23	278	0.07	0.0
2015	10	25	52.4	34.7	46.1	48.1	3.8	9	59	30	132	0.03	0.0
2015	10	26	53.0	34.9	46.2	47.7	6.3	16	78	30	215	0.06	0.0
2015	10	27	58.9	46.0	49.3	49.0	10.6	27	152	25	225	0.11	0.0
2015	10	28	48.7	34.1	44.8	47.2	14.5	33	313	13	70	0.05	0.1
2015	10	29	41.3	37.9	42.6	44.9	8.4	27	326	29	46	0.02	0.0
2015	10	30	50.4	35.3	43.3	45.1	9.0	21	174	17	201	0.06	0.0
2015	10	31	54.0	38.5	44.1	45.3	13.7	31	240	56	89	0.07	0.0
Averages			61.0	40.0	51.5	50.9	7.8	22			222		
Totals												3.75	1.2
Max			95.1	52.7	60.2	56.7	16.3	45			360	0.35	0.9
Min			41.3	24.5	42.6	44.9	2.5	8			33	0.02	0.0
Std. Dev.			10.1	7.6	4.9	3.6	3.4	8			99	0.07	

E = estimated value
M = missing value
The number of missing values is indicated in parentheses.

001602

FARGO NW Daily Observations from November 1, 2015 to November 30, 2015
North Dakota Agricultural Weather Network (NDAWN)

Year	Mo	Da	Max Temp (F)	Min Temp (F)	Avg Soil Temp (F)	Avg Turf Temp (F)	Avg Wind Spd (MPH)	Max Wind Spd (MPH)	Avg Wind Dir (deg)	Avg Wind DirSD (deg)	Total Solar Rad (Lys)	Total PET (inch)	Rain fall (inch
2015	11	1	55.7	32.5	44.6	45.7	6.1	23	190	48	139	0.06	
2015	11	2	61.7	32.2	44.7	45.5	2.0	14	294	63	175	0.04	
2015	11	3	66.4	38.1	47.4	46.4	5.1	19	66	35	227	0.08	
2015	11	4	51.3	38.6	47.0	47.0	2.6	17	310	41	46	0.00	
2015	11	5	43.9	35.7	44.9	46.5	8.5	20	308	22	59	0.01	
2015	11	6	43.3	30.9	41.8	44.6	7.3	24	285	20	96	0.03	
2015	11	7	49.8	28.9	40.3	43.0	7.1	15	208	26	216	0.06	
2015	11	8	58.3	33.4	41.6	43.0	7.8	23	178	15	225	0.09	
2015	11	9	58.0	34.5	43.1	43.5	6.6	19	163	23	216	0.07	
2015	11	10	58.4	37.6	45.7	45.0	8.9	17	171	66	195	0.08	
2015	11	11	37.8	32.4	42.1	43.7	9.7	21	350	20	33	0.01	
2015	11	12	38.8	29.4	39.0	41.7	9.2	25	309	22	35	0.02	
2015	11	13	46.3	22.6	36.8	39.8	6.5	18	192	44	205	0.07	
2015	11	14	56.9	34.0	39.2	40.3	5.2	17	172	29	138	0.06	
2015	11	15	61.3	34.7	41.9	41.5	6.7	23	143	17	197	0.09	
2015	11	16	54.2	48.6	46.3	44.8	12.3	27	150	14	27	0.04	
2015	11	17	50.5	38.6	45.8	45.9	7.6	19	346	54	21	0.00	
2015	11	18	43.4	26.7	41.9	43.9	11.7	43	299	32	65	0.03	
2015	11	19	30.7	21.0	35.8	39.4	17.8	41	291	11	137	0.05	
2015	11	20	27.9	11.6	32.7	36.5	3.5	12	315	37	186	0.02	
2015	11	21	28.6	7.2	30.2	34.6	3.4	14	196	29	162	0.02	
2015	11	22	39.2	12.6	29.3	33.7	6.4	22	190	39	121	0.04	
2015	11	23	42.2	26.3	31.0	33.7	5.5	17	296	56	166	0.03	
2015	11	24	43.1	28.7	31.5	33.8	7.6	22	129	21	150	0.04	
2015	11	25	35.7	20.2	31.8	34.4	9.2	22	341	50	21	0.02	
2015	11	26	20.8	9.6	31.6	33.7	8.2	19	350	18	76	0.02	
2015	11	27	26.6	4.5	28.4	32.6	5.4	15	212	32	174	0.03	
2015	11	28	36.6	13.7	28.0	32.0	5.0	16	207	26	174	0.04	
2015	11	29	39.6	14.7	28.6	31.6	3.5	9	168	18	98	0.03	
2015	11	30	36.6	29.4	31.0	31.9	5.3	22	80	36	59	0.03	
Averages			44.8	27.0	38.1	40.0	7.1	21			128		
Totals												1.21	(3
Max			66.4	48.6	47.4	47.0	17.8	43			227	0.09	(3
Min			20.8	4.5	28.0	31.6	2.0	9			21	0.00	(3
Std. Dev.			11.8	10.9	6.6	5.4	3.2	7			69	0.03	

E = estimated value
M = missing value
The number of missing values is indicated in parentheses.

001603

FARGO NW Daily Observations from December 1, 2015 to December 31, 2015
North Dakota Agricultural Weather Network (NDAWN)

Year	Mo	Da	Max Temp (F)	Min Temp (F)	Avg Soil Temp (F)	Avg Turf Temp (F)	Avg Wind Spd (MPH)	Max Wind Spd (MPH)	Avg Wind Dir (deg)	Avg Wind DirSD (deg)	Total Solar Rad (Lys)	Total PET (inch)	Rain fall (inch
2015	12	1	32.8	27.4	31.4	32.1	7.7	16	15	26	70	0.00	
2015	12	2	28.2	12.1	31.5	32.3	3.8	13	273	63	168	0.01	
2015	12	3	33.6	11.3	31.3	32.5	5.4	12	187	23	149	0.02	
2015	12	4	39.0	17.1	31.3	32.5	12.0	30	164	11	162	0.05	
2015	12	5	39.3	24.7	31.5	32.7	5.3	17	176	22	75	0.01	
2015	12	6	37.1	22.4	31.5	32.8	5.6	20	169	22	164	0.01	
2015	12	7	37.5	29.6	31.6	32.9	8.9	25	169	14	122	0.03	
2015	12	8	37.5	26.5	31.6	32.9	4.4	15	187	35	68	0.01	
2015	12	9	42.7	26.5	31.6	33.0	6.2	19	165	15	107	0.02	
2015	12	10	44.9	32.3	31.9	33.3	7.2	24	296	38	112	0.02	
2015	12	11	34.3	31.0	32.4	33.9	4.6	14	16	26	34	0.00	
2015	12	12	32.6	28.7	32.9	34.5	3.8	11	344	34	44	0.00	
2015	12	13	33.8	28.8	33.5	34.8	6.2	15	9	27	45	0.00	
2015	12	14	33.3	28.1	33.7	34.9	11.2	23	17	15	38	0.01	
2015	12	15	29.8	25.9	33.1	34.0	6.4	15	43	19	49	0.01	
2015	12	16	26.6	19.7	32.9	33.8	10.4	23	327	35	62	0.01	
2015	12	17	25.4	10.7	32.9	33.5	13.1	28	284	11	99	0.03	
2015	12	18	15.8	2.7	32.6	33.0	8.6	19	297	31	128	0.02	
2015	12	19	23.6	1.9	31.9	32.2	7.8	21	162	37	93	0.03	
2015	12	20	25.3	18.1	31.3	31.9	6.5	17	350	36	78	0.01	
2015	12	21	21.5	18.1	30.9	31.7	6.2	19	179	59	42	0.00	
2015	12	22	35.0	20.0	30.8	31.7	11.8	29	158	27	42	0.03	
2015	12	23	29.9	19.2	30.8	31.7	8.6	22	295	44	43	0.02	
2015	12	24	19.2	10.3	29.5	31.3	7.1	23	296	39	138	0.02	
2015	12	25	27.2	14.2	29.4	31.0	5.7	20	73	56	53	0.01	
2015	12	26	14.6	-3.2	27.6	30.4	9.4	22	359	23	84	0.02	
2015	12	27	6.7	-5.1	23.8	28.3	3.5	12	338	51	155	0.01	
2015	12	28	18.1	-0.4	23.2	27.3	4.7	21	82	52	112	0.01	
2015	12	29	19.1	14.2	25.9	28.3	5.6	13	5	24	67	0.01	
2015	12	30	17.9	3.1	26.4	28.4	2.6	9	291	20	138	0.01	
2015	12	31	18.8	1.3	25.7	27.7	7.2	17	271	28	118	0.02	
Averages			28.4	16.7	30.5	32.0	7.0	19			92		
Totals												0.46	(3
Max			44.9	32.3	33.7	34.9	13.1	30			168	0.05	(3
Min			6.7	-5.1	23.2	27.3	2.6	9			34	0.00	(3
Std. Dev.			9.2	11.1	2.8	2.1	2.7	5			43	0.01	

E = estimated value
M = missing value
The number of missing values is indicated in parentheses.

001604

FARGO NW Daily Observations from January 1, 2016 to January 31, 2016
North Dakota Agricultural Weather Network (NDAWN)

Year	Mo	Da	Max Temp (F)	Min Temp (F)	Avg Soil Temp (F)	Avg Turf Temp (F)	Avg Wind Spd (MPH)	Max Wind Spd (MPH)	Avg Wind Dir (deg)	Avg Wind DirSD (deg)	Total Solar Rad (Lys)	Total PET (inch)	Rain fall (inch
2016	1	1	25.9	13.3	26.6	28.1	8.0	18	271	39	160	0.02	
2016	1	2	29.3	16.3	26.5	28.0	8.2	18	291	45	160	0.03	
2016	1	3	26.7	12.5	27.5	28.6	4.5	19	296	50	163	0.01	
2016	1	4	26.1	8.3	25.3	27.4	11.8	30	166	12	145	0.03	
2016	1	5	27.3	15.5	26.0	27.6	9.3	29	161	19	119	0.02	
2016	1	6	28.7	25.5	28.2	28.9	5.3	12	69	15	39	0.00	
2016	1	7	28.1	18.6	29.2	29.5	4.7	12	356	30	79	0.00	
2016	1	8	19.0	1.3	29.1	29.6	9.1	21	346	17	101	0.02	
2016	1	9	2.2	-15.8	25.2	27.7	7.6	23	330	26	171	0.02	
2016	1	10	-2.2	-20.1	21.2	24.9	2.0	9	192	27	143	0.01	
2016	1	11	7.8	-11.7	19.9	24.0	6.9	22	297	62	103	0.02	
2016	1	12	1.1	-14.9	17.7	22.4	5.2	13	236	48	173	0.01	
2016	1	13	19.2	0.7	21.2	23.7	4.8	12	199	69	142	0.01	
2016	1	14	23.3	-2.3	24.8	25.8	6.7	21	13	30	69	0.02	
2016	1	15	2.2	-7.3	23.5	24.5	7.3	16	344	15	133	0.01	
2016	1	16	-5.8	-19.5	20.8	22.1	6.5	16	314	25	181	0.01	
2016	1	17	-3.6	-23.6	17.9	19.7	2.1	8	271	30	182	0.01	
2016	1	18	6.9	-3.6	19.7	20.9	2.6	10	123	53	135	0.01	
2016	1	19	11.9	-3.5	19.6	20.8	9.3	22	157	15	97	0.02	
2016	1	20	23.9	11.9	22.5	23.3	5.6	17	125	61	67	0.01	
2016	1	21	19.4	5.2	24.1	24.7	4.7	13	355	20	134	0.01	
2016	1	22	14.4	-3.5	21.8	23.6	6.5	27	174	29	177	0.02	
2016	1	23	31.3	12.0	22.6	24.3	12.6	27	175	14	136	0.04	
2016	1	24	33.6	20.0	25.9	26.0	6.1	17	357	21	82	0.01	
2016	1	25	25.3	19.3	26.3	26.5	8.0	18	340	15	125	0.01	
2016	1	26	25.9	17.7	26.8	26.9	5.7	14	307	55	131	0.02	
2016	1	27	38.9	17.1	28.4	28.1	14.9	33	257	48	156	0.05	
2016	1	28	35.8	18.5	30.9	29.7	8.0	24	348	56	106	0.03	
2016	1	29	38.2	24.6	28.9	28.9	10.7	27	183	36	104	0.03	
2016	1	30	38.0	25.6	30.7	29.9	5.8	16	245	17	106	0.02	
2016	1	31	35.2	18.5	29.1	28.7	2.4	9	282	44	205	0.01	
Averages			20.5	5.7	24.8	26.0	6.9	18			130		
Totals												0.54	(3
Max			38.9	25.6	30.9	29.9	14.9	33			205	0.05	(3
Min			-5.8	-23.6	17.7	19.7	2.0	8			39	0.00	(3
Std. Dev.			13.4	14.8	3.8	2.9	3.0	7			39	0.01	

E = estimated value
M = missing value
The number of missing values is indicated in parentheses.

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FARGO NW Daily Observations from February 1, 2016 to February 29, 2016
North Dakota Agricultural Weather Network (NDAWN)

Year	Mo	Da	Max Temp (F)	Min Temp (F)	Avg Soil Temp (F)	Avg Turf Temp (F)	Avg Wind Spd (MPH)	Max Wind Spd (MPH)	Avg Wind Dir (deg)	Avg Wind DirSD (deg)	Total Solar Rad (Lys)	Total PET (inch)	Rain fall (inch
2016	2	1	36.5	19.5	29.5	28.6	2.4	9	152	69	190	0.02	
2016	2	2	29.9	17.1	29.1	28.8	6.9	21	10	34	36	0.02	
2016	2	3	24.4	9.3	25.4	27.2	6.0	18	316	62	210	0.03	
2016	2	4	23.7	14.3	26.7	27.5	4.9	13	300	65	170	0.02	
2016	2	5	30.0	14.3	26.3	27.1	6.4	17	181	38	204	0.03	
2016	2	6	39.8	19.1	27.2	27.4	9.1	24	194	29	136	0.05	
2016	2	7	38.4	13.0	29.8	29.6	16.9	36	315	31	47	0.06	
2016	2	8	15.2	7.0	22.9	26.9	14.5	32	350	19	193	0.03	
2016	2	9	13.2	2.6	18.6	24.5	6.9	16	357	25	118	0.02	
2016	2	10	14.4	2.6	19.2	23.9	4.6	13	50	40	187	0.02	
2016	2	11	15.2	-0.5	20.1	23.9	2.8	12	317	53	142	0.02	
2016	2	12	11.3	-8.5	16.7	22.2	7.6	20	345	22	274	0.03	
2016	2	13	13.7	-9.2	13.3	19.6	9.9	27	151	19	204	0.04	
2016	2	14	23.3	11.9	18.6	21.7	11.4	28	167	15	73	0.03	
2016	2	15	36.4	20.1	23.1	24.5	4.9	14	188	56	258	0.03	
2016	2	16	30.0	16.9	25.6	26.5	6.8	17	22	18	133	0.03	
2016	2	17	29.0	17.2	25.5	26.3	9.2	25	153	23	137	0.05	
2016	2	18	38.2	28.7	29.1	28.4	15.3	32	149	13	156	0.05	
2016	2	19	47.3	33.6	31.3	30.2	9.3	27	275	49	180	0.05	
2016	2	20	37.9	24.9	31.7	30.8	7.7	21	344	43	116	0.03	
2016	2	21	25.0	18.8	31.7	30.6	6.4	17	358	29	144	0.03	
2016	2	22	35.1	21.0	31.7	29.3	7.9	19	183	15	160	0.04	
2016	2	23	34.3	27.5	31.7	30.4	6.1	18	328	58	80	0.02	
2016	2	24	35.4	20.5	31.6	30.1	4.7	18	344	71	225	0.03	
2016	2	25	28.5	25.2	31.6	30.5	7.0	19	342	38	108	0.03	
2016	2	26	47.2	23.3	31.3	29.8	8.1	19	222	30	305	0.09	
2016	2	27	55.1	32.0	31.6	30.9	5.5	15	248	64	313	0.09	
2016	2	28	36.7	22.1	31.8	31.2	10.4	23	314	51	150	0.04	
2016	2	29	38.1	2.2	30.9	29.5	12.3	35	8	19	297	0.11	
Averages			30.5	15.4	26.7	27.5	8.0	21			171		
Totals												1.14	(2
Max			55.1	33.6	31.8	31.2	16.9	36			313	0.11	(2
Min			11.3	-9.2	13.3	19.6	2.4	9			36	0.02	(2
Std. Dev.			11.2	11.0	5.4	3.1	3.5	7			73	0.02	

E = estimated value
M = missing value
The number of missing values is indicated in parentheses.

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TECHNICAL PAPER

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Emissions of Ammonia, Hydrogen Sulfide, and Odor before, during, and after Slurry Removal from a Deep-Pit Swine Finisher

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ABSTRACT

It is a common practice in the midwestern United States to raise swine in buildings with under-floor slurry storage systems designed to store manure for up to one year. These so-called "deep-pit" systems are a concentrated source for the emissions of ammonia (NH_3), hydrogen sulfide (H_2S), and odors. As part of a larger six-state research effort (U.S. Department of Agriculture-Initiative for Future Agriculture and Food Systems Project, "Aerial Pollutant Emissions from Confined Animal Buildings"), real-time NH_3 and H_2S with incremental odor emission data were collected for two annual slurry removal events. For this study, two 1000-head deep-pit swine finishing facilities in central Iowa were monitored with one-year storage of slurry maintained in a 2.4 m-deep concrete pit (or holding tank) below the animal-occupied zone. Results show that the H_2S emission, measured during four independent slurry removal events over two years, increased by an average of 61.9 times relative to the before-removal H_2S emission levels. This increase persisted during the agitation process of the slurry that on average occurred over an 8-hr time period. At the conclusion of slurry agitation, the H_2S emission decreased by an average of 10.4 times the before-removal emission level. NH_3 emission during agitation increased by an average of 4.6 times the before-removal emission level and increased by an average of 1.5 times the before-removal emission level after slurry removal was completed. Odor emission increased by a factor of 3.4 times the before-removal odor emission level and decreased after the slurry-removal event by a factor of 5.6 times the before-removal emission level. The results indicate that maintaining an adequate barn ventilation rate regardless of animal comfort demand is essential to keeping gas levels inside the barn below hazardous levels.

IMPLICATIONS

Deep-pit slurry removal events lead to elevated H_2S, odor, and NH_3 concentrations inside the pig building and emissions from this facility. H_2S is the gas of most concern and can reach levels dangerous to animals and workers. These results highlight the need for a preplanned protocol that must be established for barn ventilation rate maintenance to ensure that H_2S concentrations do not reach lethal levels.

INTRODUCTION

Many swine raised (reared from 7 or 18 kg to 120 kg) in the midwestern U.S. are grown in structures where year-long storage of manure is present below the occupied zone of the animals. These so-called "deep-pit" systems represent a concentrated source of nutrients that once applied judiciously to the soil provide an excellent source of fertilizer. The standard method for manure removal from buildings using deep-pit manure storage is to provide significant mixing of the slurry before and during slurry removal to suspend solids and to provide a consistent liquid manure fertilizer. This process commonly takes place in the fall after crops have been removed or in early spring before planting begins and generally takes

from one to three 8-hr work days per 1000-pig building depending upon off-site hauling capacities. This process of slurry removal can represent an acute concentrated emission source for gases and odors. Removal of slurry involves the in situ mixing and agitation of the manure and subsequent application to the field. Significant problems can arise during this process if proper ventilation procedures are not followed. Turbulent activity of the slurry surface can result in very rapid release of odors, ammonia (NH_3), and hydrogen sulfide (H_2S), the latter of which has been linked to several animal and human casualties. Nuisance complaints related to swine production are generally highest during slurry removal and subsequent land application. The objective of this paper is to report on the emission of NH_3, H_2S, and odors before, during, and after slurry removal from two identical deep-pit swine finishing facilities located in the midwestern part of the United States over two annual slurry removal events.

Swine Housing NH_3 Emissions

Several U.S. and northern European studies have investigated the emission of gases from livestock and poultry production systems. Typically, the gases investigated include NH_3, H_2S, and the general class of volatile organic compounds associated with livestock odors.[1] Recently, the need to study the concentrations of these gases in the community surrounding livestock and poultry operations has surfaced because of increasing pressure from regulatory agencies. The following literature review focuses on the emissions from swine housing. A more complete review of the literature on emissions can be found in Hoff et al.[2]

Aarnink et al.[3] studied the NH_3 emission patterns of nursery and finishing pigs raised on partially slatted flooring. They found that for nursery pigs, an average increase of 16 mg NH_3 pig^{-1} day^{-1} was measured, and this increased to 85 mg NH_3 pig^{-1} day^{-1} (4.8 mg NH_3 m^{-2} hr^{-1}) for finishing pigs. The overall average NH_3 emission measured was between 0.70 and 1.20 g NH_3 pig^{-1} day^{-1} for nursery pigs (19–33 g NH_3 animal unit $[AU]^{-1}$ day^{-1}; 1 AU = 500 kg) and between 5.7 and 5.9 g NH_3 pig^{-1} day^{-1} (331 mg NH_3 m^{-2} hr^{-1}) for finishing pigs (42–43 g NH_3 AU^{-1} day^{-1}). They found an increase in NH_3 emission during the summer months for nursery pigs attributed to higher ventilation rates but this same trend was not found for finishing pigs. They also found that removing the under-floor stored slurry reduced the NH_3 emission by ~20% for a period of 10 hr, after which time the NH_3 emission regained the pre-removal emission level.

Demmers et al.[4] investigated the exhausted concentrations and emission rates of NH_3 from mechanically ventilated swine buildings. They reported NH_3 concentrations in a swine finishing house between 12 and 30 mg NH_3 m^{-3} with an average NH_3 emission rate of 46.9 kg NH_3 AU^{-1} yr^{-1} (160 g NH_3 AU^{-1} day^{-1} or 1008 mg NH_3 m^{-2} hr^{-1}).

Burton and Beauchamp[5] studied the relationship between outside temperature, ventilation system response, in-house NH_3 concentration, and the resulting emission of NH_3 from the swine housing unit. They clearly showed the inverse relationship of in-house NH_3 concentration with outside temperature and the direct relationship of NH_3 emission from the swine housing unit with outside temperature. This trend was attributed to the increased ventilation rates required during the summer to control inside climate temperatures for the housed animals. They summarized results over a 1-yr period and reported the monthly averages. February had the highest in-house concentration at 15 mg NH_3-N L^{-1} corresponding to the lowest emission rate at 0.9 kg NH_3-N day^{-1}. August had the lowest in-house concentration of 4 mg NH_3-N L^{-1} and, correspondingly, the highest emission rate of 3.2 kg NH_3-N day^{-1}, on average.

Ni et al.[6] investigated the exhausted concentrations and emission rates of NH_3 in and from a deep-pit swine finishing building with and without the presence of animals and with pits that were roughly half full (1.3 m manure depth; 2.4 m depth capacity). They investigated the gas release rates with and without the effect of heating the building through unit space heaters. Without the presence of animals, they measured NH_3 concentrations between 6 and 15 ppm with emission rates between 40 and 58 mg NH_3 m^{-2} hr^{-1} (5–8 g NH_3 AU^{-1} day^{-1}). When the buildings were restocked with pigs, exhaust air concentrations of NH_3 were, on average, 15.2 ppm with corresponding emission rates of 233 mg NH_3 m^{-2} hr^{-1} (40–50 g NH_3 AU^{-1} day^{-1}).

Groot Koerkamp et al.[7] conducted an extensive study of NH_3 emissions from swine housing facilities. They investigated both indoor NH_3 levels and simultaneous measurements of building ventilation rates and reported the resulting emission rates. In general, NH_3 concentrations varied between 5 and 18 ppm, with average emission rates between 649 and 3751 mg NH_3 AU^{-1} hr^{-1} (16–90 g NH_3 AU^{-1} day^{-1} or between 122–706 mg NH_3 m^{-2} hr^{-1}).

Hinz and Linke[8] investigated the indoor concentrations and emissions of NH_3 from a mechanically ventilated swine finishing facility during a grow-out period where pigs ranged between 25 and 100 kg. Interior NH_3 concentrations during the grow-out varied from 10 to 35 ppm, and these were inversely proportional to outside temperature. Emission rate of NH_3 varied from 70 g NH_3 pig^{-1} hr^{-1} (38 kg average pig wt) to 210 g NH_3 pig^{-1} hr^{-1} (83 kg average pig wt) resulting in an average NH_3 emission rate of 66 g NH_3 AU^{-1} day^{-1} (518 mg NH_3 m^{-2} hr^{-1}).

Zahn et al.[9] studied the NH_3 emission rate from both deep-pit and pull-plug swine finishing facilities during summer periods. They found that the NH_3 emission rates were very similar for these two facility types and grouped the emission data into an overall average of 66 ng NH_3 cm^{-2} sec^{-1} (311 g NH_3 AU^{-1} day^{-1} or 2376 mg NH_3 m^{-2} hr^{-1}).

Zhu et al.[10] studied the daily variations in NH_3 emissions from various mechanically and naturally ventilated swine housing systems. For a mechanically ventilated swine gestation facility, they measured internal NH_3 concentrations between 9 and 15 ppm, with emission rates consistent at ~5 μg NH_3 m^{-2} sec^{-1} (2.2 g NH_3 AU^{-1} day^{-1}). For a mechanically ventilated farrowing facility, they measured internal NH_3 concentrations between 3 and 5 ppm, with emission rates ranging between 20 and 55 μg NH_3 m^{-2} sec^{-1} (15–42 g NH_3 AU^{-1} day^{-1}). For a mechanically ventilated nursery facility, they measured internal NH_3 concentrations between 2 and 5 ppm, with emission rates ranging between 20 and 140 μg NH_3 m^{-2}

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sec^{-1} (23–160 g NH_3 AU^{-1} day^{-1}). For a mechanically ventilated finishing facility, they measured internal NH_3 concentrations between 4 and 8 ppm, with emission rates ranging between 20 and 55 μg NH_3 m^{-2} sec^{-1} (10–26 g NH_3 AU^{-1} day^{-1} or between 72–198 mg NH_3 m^{-2} hr^{-1}). For a naturally ventilated finishing facility with pit exhaust fans, they measured internal NH_3 concentrations between 7 and 15 ppm, with emission rates ranging between 60 and 170 μg NH_3 m^{-2} sec^{-1} (28–80 g NH_3 AU^{-1} day^{-1} or between 216–612 mg NH_3 m^{-2} hr^{-1}).

Osada et al.[11] investigated the NH_3 emission from a swine finisher over an 8-week period comparing under-floor stored manure (control) and under-floor manure removed weekly (treatment). They reported only slight differences in NH_3 emission rates with the control at 11.8 kg NH_3 AU^{-1} yr^{-1} (32 g NH_3 AU^{-1} day^{-1} or 255 mg NH_3 m^{-2} hr^{-1}) and the treatment at 11 kg NH_3 AU^{-1} yr^{-1} (30 g NH_3 AU^{-1} day^{-1}).

Swine Housing H_2S Emissions

Ni et al.[6] investigated the exhausted concentrations and emission rates of H_2S in a deep-pit swine finishing building with and without the presence of animals and with pits that were roughly half full (1.3-m depth, 2.4-m depth capacity). They investigated the gas release rates with and without the effect of heating the building through unit space heaters. They measured H_2S concentrations ranging from 221 to 1492 ppb with corresponding emission rates between 1.6 and 3.8 mg H_2S m^{-2} hr^{-1} (0.22–0.49 g H_2S AU^{-1} day^{-1}). When the buildings were restocked with pigs, exhaust air concentration of H_2S averaged 423 ppb with a corresponding emission rate of 9.4 mg H_2S m^{-2} hr^{-1} (1.25 g H_2S AU^{-1} day^{-1}).

Zahn et al.[9] studied the H_2S emission rate from both deep-pit and pull-plug swine finishing facilities during summer periods. They found that the H_2S emission rates were very similar for these two facility types and grouped the emission data into an overall average of 0.37 ng H_2S cm^{-2} sec^{-1} (1.7 g H_2S AU^{-1} day^{-1} or 13.3 mg H_2S m^{-2} hr^{-1}).

Zhu et al.[10] studied the daily variations in H_2S emissions from various mechanically and naturally ventilated swine housing systems. For a mechanically ventilated swine gestation facility, they measured internal H_2S concentrations between 500 and 1200 ppb, with emission rates consistent at ~2 μg H_2S m^{-2} sec^{-1} (1 g H_2S AU^{-1} day^{-1}). For a mechanically ventilated farrowing facility, they measured internal H_2S concentrations between 200 and 500 ppb, with emission rates consistent at ~5 μg H_2S m^{-2} sec^{-1} (4 g H_2S AU^{-1} day^{-1}). For a mechanically ventilated nursery facility, they measured internal H_2S concentrations between 700 and 3400 ppb, with emission rates ranging between 20 and 140 μg H_2S m^{-2} sec^{-1} (23–160 g H_2S AU^{-1} day^{-1}). For a mechanically ventilated finishing facility, they measured internal H_2S concentrations between 300 and 600 ppb, with emission rates consistent at ~10 μg H_2S m^{-2} sec^{-1} (5 g H_2S AU^{-1} day^{-1} or 36 mg H_2S m^{-2} hr^{-1}). For a naturally ventilated finishing facility with pit exhaust fans, they measured internal H_2S concentrations between 200 and 400 ppb, with emission rates ranging between 5 and 15 μg H_2S m^{-2} sec^{-1} (2 and 7 g H_2S AU^{-1} day^{-1} or between 18 and 54 mg H_2S m^{-2} hr^{-1}).

Summary

A large variation in both NH_3 and H_2S emission rates from various swine production buildings has been reported. Considering the literature cited, the range of H_2S emissions expected for finishing pigs is between 1.6 and 54 mg H_2S m^{-2} hr^{-1} from the exhaust ventilation air for swine finishing pigs. The range of NH_3 emissions expected is between 4.8 and 2376 mg NH_3 m^{-2} hr^{-1} from the ventilation air for swine finishing pigs, with the dominating average emission rates in the 300 to 500 mg NH_3 m^{-2} hr^{-1} range. The study by Hinz and Linke[8] also pointed out the changes in emission rates expected as finishing pigs mature, with a reported three-fold increase between 38- and 83-kg average body weight.

FACILITY DESCRIPTION

Two identical deep-pit swine finishing facilities in central Iowa were monitored for this research project; this arrangement represents one of six U.S. sites monitored for a larger six-state emissions study funded by the U.S. Department of Agriculture under the Initiative for Future Agriculture and Food Systems program.[12,13] Each facility monitored, as shown in Figure 1, was designed to house 1000 pigs ranging in weight between ~18 and 120 kg. Slurry was stored in a 2.4-m-deep holding concrete basin below a fully slatted concrete floor and was designed to store manure for one calendar year. Slurry removal and land application was conducted once per year in the fall (October).

Each barn was fan-ventilated for all seasons using a combination of methods. The cold-to-mild weather ventilation was handled with a series of pit (Fans 1, 2), side (Fan 3), and end wall (or tunnel) fans (Fans 4, 5; Figure 1) in combination with a series of 10 rectangular center-ceiling inlets to distribute fresh air within the building. Figure 1 shows the center-ceiling inlet placement and the approximate airflow patterns desired from these inlets. The warm-to-hot weather ventilation was handled with tunnel ventilation, where all fans except Fan 3 were used in combination with an adjustable curtain at the opposing end wall. During this tunnel mode of ventilation, the 10 center-ceiling inlets inside the barn were closed. The barn was controlled for temperature by operation of the end wall exhaust fans and the inlet distribution system controlled via static pressure. As barn temperature demanded airflow rate changes, the inlet distribution system would adjust accordingly to maintain a desired operating static pressure of 20 Pa.

The layout given in Figure 1 includes a mobile emission laboratory (MEL) that housed all instrumentation required to measure gas concentrations and pertinent environmental data and to monitor the barn ventilation rate. NH_3 (Model 17C chemiluminescence; TEI, Inc.), H_2S (Model 45C pulsed fluorescence; TEI, Inc.), and CO_2 (Model 3600 IR, MSA, Inc.) were measured at 12 locations: six from Barn 1 and six from Barn 2. A solenoid switching system enabled gas samples to be delivered to each analyzer simultaneously in 10-min switching increments. Therefore, each location was measured for 10 min every 120 min. The gas concentration measurement at the conclusion of each 10-min sampling interval was used to represent the concentration at that sampling location for

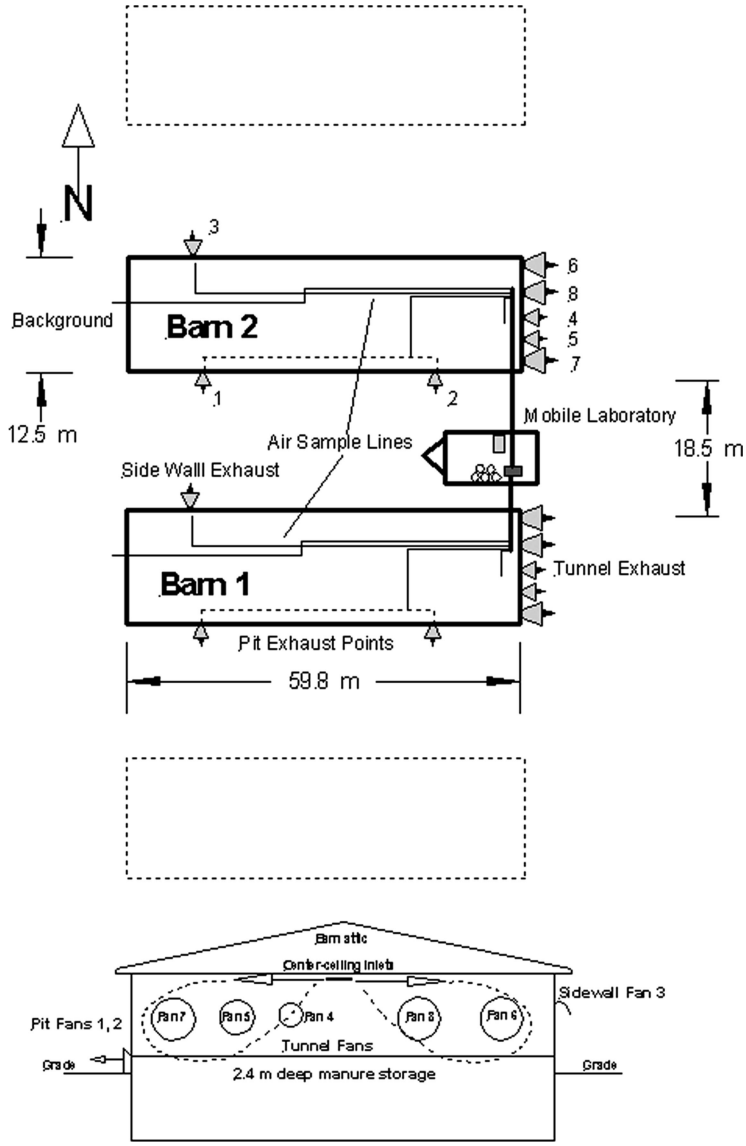

Figure 1. Layout of buildings monitored for this study. Entire site consists of four identical buildings. The monitored buildings shown represent the two center barns of the site. Two pit fans (1,2), one sidewall fan (3), and five end wall tunnel fans (4,5,6,7,8) were present, representing four possible emission zones.

the prior 120 min. This enabled a continuous concentration profile at each sampling location that was used along with continuous airflow data to generate a continuous emissions profile. The analyzers were calibrated before each pump-out event with U.S. Environmental Protection Agency (EPA)-protocol calibration gases. Environmental variables such as temperature, relative humidity, static pressure, and end wall curtain opening level were also measured. Ventilation rate was measured by recording the on/off status of all single-speed fans (Fans 5, 6, 7, 8; Figure 1) and the on/off status along with fan rpm levels for all variable speed fans (Fans 1, 2, 3, 4). Individual fan airflow rates were measured in situ using a FANS unit described in Casey et al.[14] The FANS unit was a device that fit on the intake side of all fans and integrated air velocity across the intake area of the fan with five calibrated anemometers. Airflow rates were measured for a range of expected operating static pressures and fan rpm levels from which a fan calibration equation was developed. By knowing fan status and/or fan rpm level and the current operating static pressure, fan airflow rate could be determined. Specific details related to the MEL setup and quality assurance/quality control procedures can be found in Heber et al.[13] and Jacobson et al.[15]

For emission calculations, the exhausted airflow rate along with the corresponding gas concentration at each emission point was measured. For the barns shown in Figure 1, three emission locations were monitored: the blended pit ventilation air from Fans 1 and 2, the emission at the sidewall Fan 3, and the emission from the combination of Fans 4 to 8 (tunnel end). Concentrations from the other three sampling points were also monitored, but these were not included in the emission calculations. Emission rates were calculated as

$$E = \Sigma(Q_o C_o - Q_i C_i) = \Sigma(Q'_o C'_o - Q'_i C'_i) \qquad (1)$$

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Table 1. Slurry removal scheduling.

Year	Barn	Date Started	Date Ended	Time Start	Time End
2002	1	October 16	October 16	11:45	18:00
	2	October 18	October 18	10:00	17:00
2003	1[a]	October 21	October 21	18:00	22:00
		October 22	October 22	09:30	14:00
	2	October 20	October 20	10:00	18:30

[a]Barn 1 in 2003 emptied in two separate events over a two-day period.

where C_i is mass concentration at the barn air inlet, mg m^{-3} or $\mu g\ m^{-3}$; E is barn emission rate, mg sec^{-1} or $\mu g\ sec^{-1}$; C_o is mass concentration at the barn air exhaust, mg m^{-3} or $\mu g\ m^{-3}$; C_i' is standardized mass concentration at the barn air inlet (based on standard conditions of temperature and pressure [STP]), mg $(sm)^{-3}$ or $\mu g\ (sm)^{-3}$; C_o' is standardized mass concentration at the barn exhaust (based on STP), mg $(sm)^{-3}$ or $\mu g\ (sm)^{-3}$; Q_o is barn outlet moist airflow rate at T_o, $m^3\ sec^{-1}$; Q_i is barn inlet moist airflow rate at T_i, $m^3\ sec^{-1}$; Q_i' is moist standard ventilation rate at the barn inlet (based on STP), $sm^3\ sec^{-1}$; and Q_o' is moist standard ventilation rate at barn exhaust (based on STP), $sm^3\ sec^{-1}$.

The background concentrations were measured also with one of the sampling locations from a total of six for each monitored barn. The background sampling location was measured within 0.5 m of the end of each barn as shown in Figure 1. The STPs used were 20 °C and 101,325 Pa.

Odor data were also collected for this research project on 2-week intervals. However, during slurry agitation and manure removal, frequent gas samples were collected before, during, and after slurry removal to assess odor concentration and odor emission rate. Odor samples were collected in 10-L Tedlar bags using a vacuum chamber (Model Vac-U-Camber; SKC, Inc.) with a vacuum pump (Model 224–44XR; SKC, Inc.) at a sample flow rate of 3 L min^{-1}. Odor samples were analyzed within 18 hr using a dynamic dilution forced-choice olfactometer (Model AC'SCENT; St. Croix Sensory, Inc.) at the Iowa State University Olfactometry Laboratory.

Table 1 outlines the scheduled slurry removal events for the years 2002 and 2003. The results given in this paper involve the emissions measured for the 24 hr surrounding these slurry removal events. The producer followed a strict protocol before starting each slurry removal event. Before the slurry was agitated, the producer would manually override the ventilation control system by establishing an airflow rate close to 30 fresh-air changes per hour, open all 10 center-ceiling inlet diffusers, and make sure that the end wall curtain used for tunnel ventilation was closed. After these adjustments were made, usually more than 1 hr before agitation, the barn was deemed ready for agitation and slurry removal. The ventilation system was then left alone in manual mode throughout the entire slurry removal event, and no one was allowed in the barn during the slurry removal event. Each slurry removal event for a barn took 6.25–8.5 hr as shown in Table 1.

Table 2. H_2S concentration (ppb) before, during, and after slurry removal.

Year	Barn	Before	Max During	After	Date	Location
2002	1	272	9990[a]	79	October 16, 2002	pit
		592	9833	197	October 16, 2002	sidewall
		473	9990[a]	186	October 16, 2002	tunnel
	2	1084	5455	31	October 18, 2002	pit
		1775	11,990	43	October 18, 2002	sidewall
		857	15,918	30	October 18, 2002	tunnel
2003	1[b]	397	850	467	October 21, 2003	pit
		467	22,245	69	October 22, 2003	pit
		336	3128	678	October 21, 2003	sidewall
		678	12,011	71	October 22, 2003	sidewall
		337	11,957	148	October 21, 2003	tunnel
		148	16,378	71	October 22, 2003	tunnel
	2	2067	35,825	93	October 20, 2003	pit
		460	7840	55	October 20, 2003	sidewall
		1360	8075	69	October 20, 2003	tunnel

[a]Exceeded maximum set range of analyzer, which was 10,000 ppb. Analyzer subsequently changed to a range of 50,000 ppb; [b]Barn slurry emptied over two days; after on October 21, 2003, the same as before on October 23, 2003.

RESULTS AND DISCUSSION

The results presented summarize the H_2S, NH_3, and odor emissions before, during, and after slurry was removed from Barns 1 and 2. The results are intended to characterize the emission changes that occur during and after slurry removal and the potential concentrations reached in the barn during slurry removal.

Table 2 shows the average H_2S concentration (ppb) before the slurry was agitated, the maximum H_2S concentration during slurry removal, and the average concentration after the slurry was removed from each barn for the 2 yr reported. Table 2 summarizes the concentrations associated with each of the three possible emission points (pit, sidewall, and tunnel fans). The averages recorded in Table 2 were for the 6 hr either before or after slurry was removed from the barn.

The overall maximum H_2S concentration reached 35,825 ppb for Barn 2, at the pit exhaust fan location during the 2003 removal event. On average, the H_2S concentration measured at the pit fan exhaust location reached a level that was 18 times higher during agitation as compared with the before-removal level. For the sidewall and tunnel fan exhaust locations, the average H_2S concentration was 27.7 times higher during slurry removal compared with the before-removal concentration.

The characteristics of an emission event experienced during slurry removal are shown in Figure 2. Figure 2a shows the barn temperature, outside temperature, and total barn airflow rate, and Figure 2b shows the total barn H_2S emission rate (mg $H_2S\ m^{-2}\ hr^{-1}$) and the associated total barn airflow rate ($m^3\ hr^{-1}$) for Barn 1 during the 2003 removal event. As shown in Table 1, this barn was emptied over a two-day period and the multiple elevated emission events are clearly evident. The ambient temperature ranged from a high/low of 23 and 8 °C for October 21, 2003, and a high/low of 24 and 3 °C for October 22, 2003, respectively. The producer routinely bypassed the barn's automatic control system during a slurry removal event to ensure an adequate ventilation rate for the barn

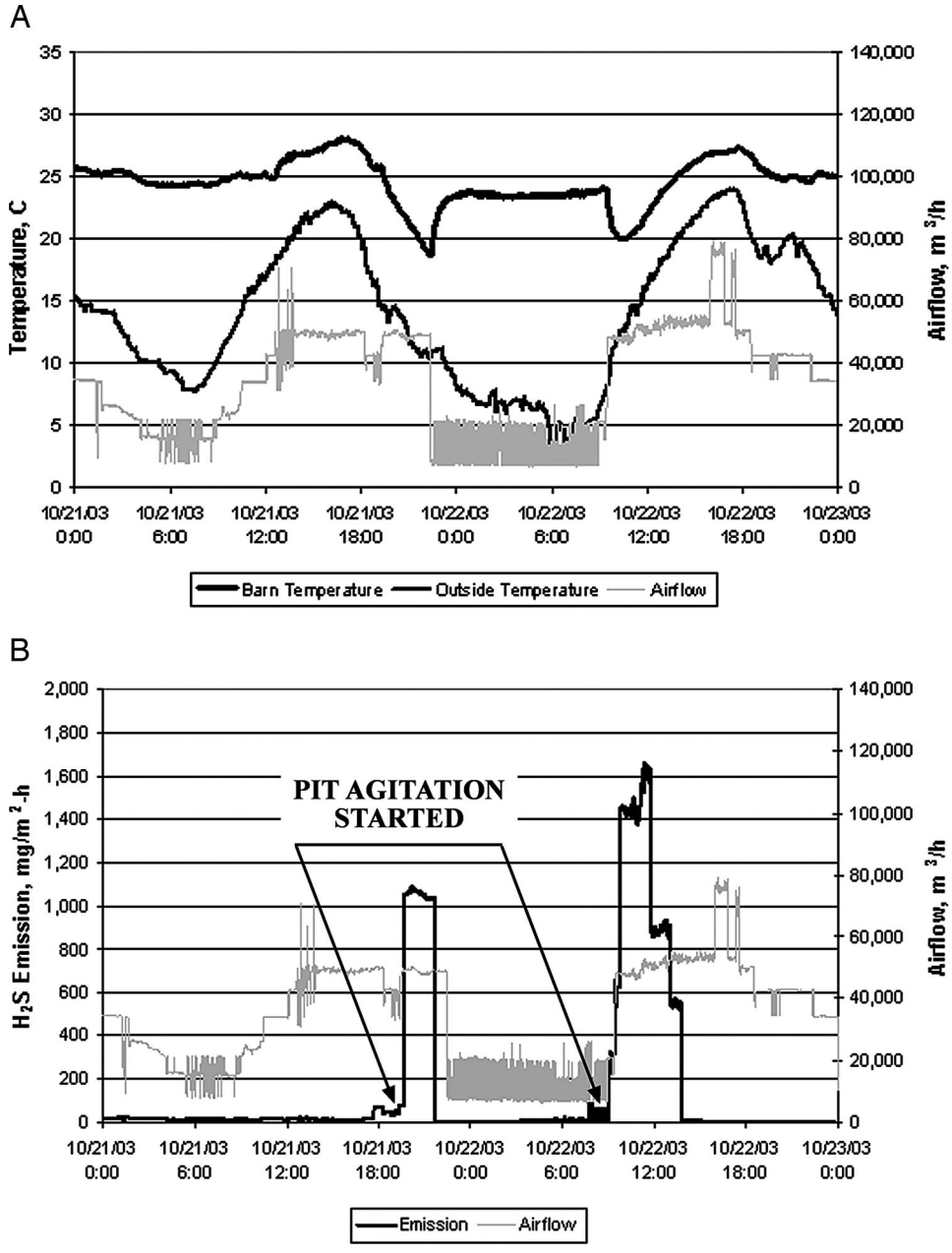

Figure 2. (a) Barn temperature, outside temperature, airflow rate, and (b) H_2S emission before, during, and after a slurry removal event (Barn 1, October 2003, removal event).

by manually turning on selected tunnel fans. The elevated ventilation rate initiated by the producer surrounding both slurry removal events is clearly evident in Figure 2. The elevated H_2S emission rate is clearly evident and dramatic. The emission shown was in direct correlation with slurry agitation, resulting in an elevated H_2S emission rate after the slurry was agitated and fell quickly once slurry agitation stopped. Observing the H_2S analyzer once agitation began showed a definite elevated concentration within minutes after the agitator was started. Figure 3 shows the characteristic H_2S emission for a slurry removal event that occurred over one continuous agitation and removal period. The manual override on the ventilation system resulted in a barn ventilation rate that increased from 13,200 $m^3\ hr^{-1}$ to an average of 56,000 $m^3\ hr^{-1}$. The barn, running in automatic control, would have ventilated the space at ~13,200 $m^3\ hr^{-1}$ or 6.5 fresh-air changes per hr. With the producer's manual override of the ventilation system, the barn was allowed to ventilate at 56,000 $m^3\ hr^{-1}$ or 27.9 fresh-air changes per hr. This characteristic points out the need for the establishment of a ventilation protocol before considering the agitation of slurry, regardless of the depth of slurry in the holding pit. The producer's protocol resulted in no loss of pig life for any of the pit agitation procedures studied with this research project.

The H_2S and NH_3 emissions for the four slurry removal events are summarized in Table 3. The before and after averages were determined by the 24-hr period before the barn was agitated and the 24-hr period after the slurry

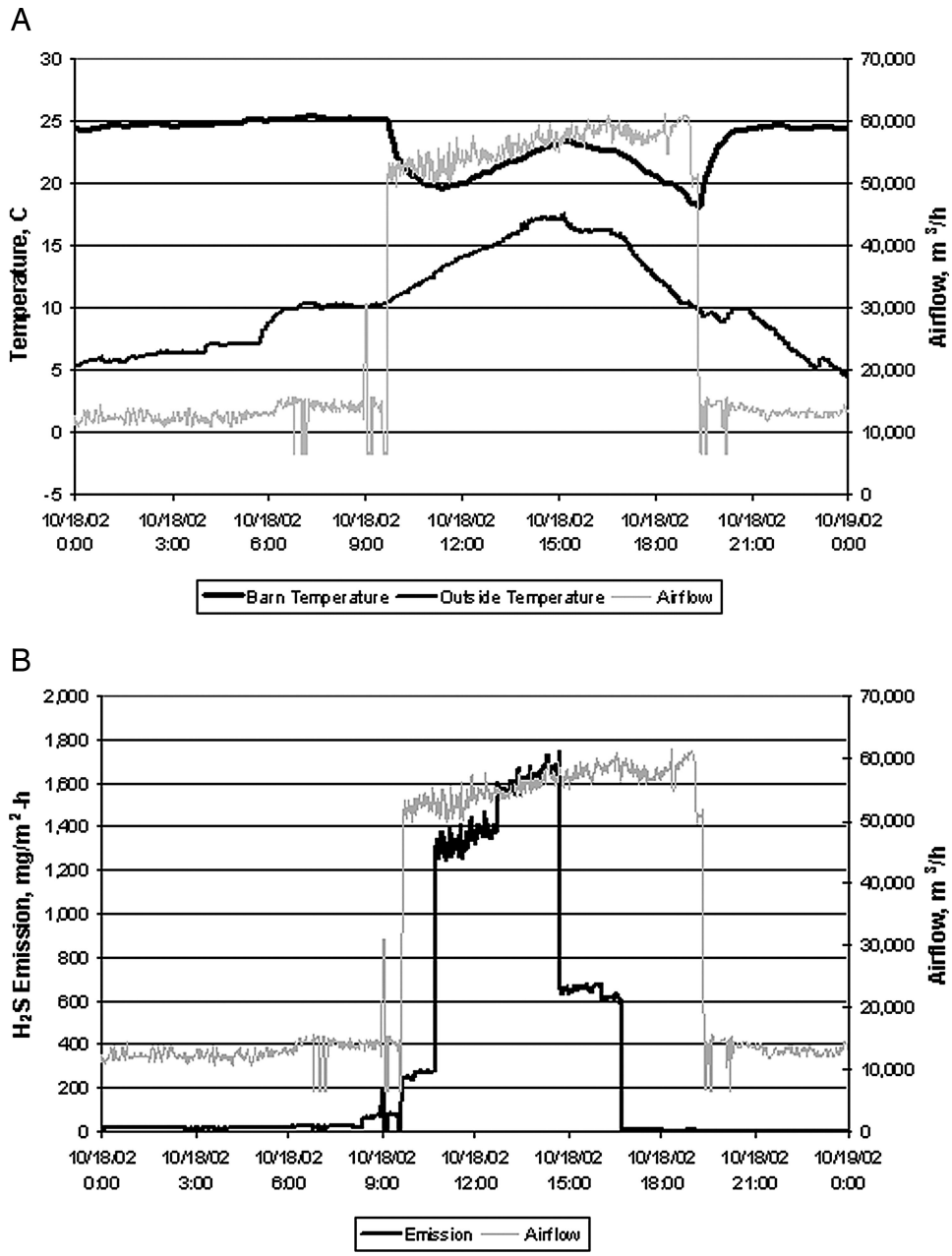

Figure 3. (a) Barn temperature, outside temperature, airflow rate, and (b) H_2S emission before, during, and after a slurry removal event (Barn 2, October 2002, removal event).

was removed from the barn. As shown in Table 3, a very large variation in H_2S emission rates existed before, during, and after slurry removal. The absolute maximum H_2S emission rate measured for the four events was 1,739 mg H_2S m^{-2} hr^{-1}. The average H_2S emission rate for the four slurry removal events was 1,528 ± 201 mg H_2S m^{-2} hr^{-1}. The average before and after H_2S emission rate for the four slurry removal events was 35.1 ± 26 mg H_2S m^{-2} hr^{-1} and 3.8 ± 1.9 mg H_2S m^{-2} hr^{-1}, respectively. If one considers the period of time from just before slurry agitation to the time just after all of the manure was removed from the barn, the cumulative H_2S emission measured for the case shown in Figure 2b was 5.5-kg H_2S and that shown in Figure 3b was 5.7-kg H_2S. The average NH_3 emission rate for the four slurry removal events was 1,836 ± 708 mg NH_3 m^{-2} hr^{-1}. The average before and after NH_3 emission rate for the four slurry removal events was 441 ± 251 mg NH_3 m^{-2} hr^{-1} and 639 ± 369 mg NH_3 m^{-2} hr^{-1}, respectively. Consistently, the after-removal NH_3 emission rate was higher than the before-removal level. A typical NH_3 emission event is shown in Figure 4 for the single continuous slurry removal event shown in Figure 3.

Odor data were collected for this research project at 2-week intervals. However, during the slurry removal event for Barn 2 in 2003, a more detailed odor evaluation procedure was conducted to capture the odor emitted during slurry agitation and manure removal. Odor data for Barn 1 during slurry removal were not collected. Table 4 and Figure 5 summarize the measured

Table 3. Measured emission levels for H_2S and NH_3 in mg m^{-2} hr^{-1}.[a]

H_2S Emissions, mg H_2S m^{-2} hr^{-1}					Literature ranges (see text) mg m^{-2} hr^{-1} 1.6–54
Year	Barn	Before	Max During	After	
2002	1	13.5 (10.5)	1389.4	3.6 (6.4)	
	2	25.6 (15.1)	1739.1	1.3 (0.8)	
2003	1	28.3 (32.5)	1655.9	4.3 (2.1)	
	2	72.9 (35.5)	1326.2	6.0 (3.1)	
NH_3 Emissions, mg NH_3 m^{-2} hr^{-1}					Literature ranges (see text) mg m^{-2} hr^{-1} 4.8–2376
Year	Barn	Before	Max During	After	
2002	1	264.4 (105.0)	1173.5	324.7 (185.3)	
	2	219.3 (62.5)	1329.3	390.8 (189.5)	
2003	1	516.9 (145.3)	2225.0	708.8 (368.6)	Most commonly reported ranges (mg m^{-2} hr^{-1}) 300–500
	2	761.0 (384.6)	2614.7	1129.8 (468.7)	

Notes: [a]Both barns had a floor area of 747 m^2. Barn 1 had 58,900 kg of pigs, and Barn 2 had 52,500 kg for year 2002 during slurry removal. Barn 1 had 103,530 kg of pigs, and Barn 2 had 83,250 kg for year 2003 during slurry removal. Standard deviation shown in parenthesis.

results. The increase in odor concentration, mgasurgd in odor units (OU) defined as the fesh-air dilution-to-detection (OU m^{-3}) during slurry removal was 4.3 and 2.1 times higher for the pit and tunnel fan exhaust locations, respectively, compared with the before-removal levels. The after-removal odor concentration was 1.3 and 3 times lower than the before-removal levels. The maximum odor strength during slurry removal reached 9,625 OU m^{-3} and 8,228 OU m^{-3} for the pit and tunnel exhaust locations, respectively. During slurry agitation, the odor emission rate (OU m^{-2} sec^{-1}) had maximum levels of 22.2 and 130.6 OU m^{-2} sec^{-1} for the pit and tunnel exhaust fan locations, respectively. The odor concentration measurements indicated that the pit and tunnel exhaust points were relatively similar before, during, and after slurry removal. However, the odor emission was 5.3 times higher from the tunnel exhaust point than the pit exhaust point because of the higher airflow rate from the tunnel exhaust fans during slurry removal.

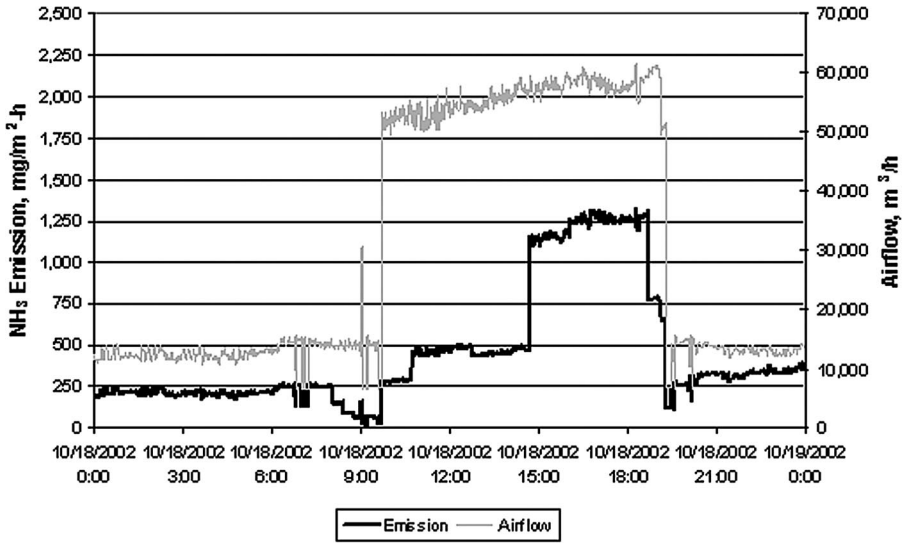

Figure 4. Barn airflow rate and NH_3 emission before, during, and after a slurry removal event (Barn 2, October 2002, removal event).

Table 4. Odor strength (OU m^{-3}) and odor emission rate (OU m^{-2} s) measured for the pit and tunnel exhaust locations before, during, and after slurry removal. Barn 2 for the 2003 slurry removal event shown.

	Odor Strength (OU m^{-3})			Odor Emission Rate (OU m^{-2} s)		
Location	**Before**	**During**	**After**	**Before**	**During**	**After**
Pit	1632 (590)	7022 (1215) [9625]	1258 (513)	3.8 (1.4)	16.2 (2.8) [22.2]	2.9 (1.2)
—	{1.7 m^3 sec^{-1}}	{1.7 m^3 sec^{-1}}	{1.7 m^3 sec^{-1}}			
Tunnel	2611 (468)	5430 (1237) [8228]	868 (622)	26.7 (7.3)	86.2 (19.6) [130.6]	2.5 (1.6)
—	{7.6 m^3 sec^{-1}}	{11.9 m^3 sec^{-1}}	{2.3 m^3 sec^{-1}}			

Notes: The average and standard deviation (in parentheses) shown along with the maximum (in brackets) during slurry removal. The average airflow rate (in {}) is also shown for the measurements before, during, and after slurry removal. These are shown below each odor strength measurement.

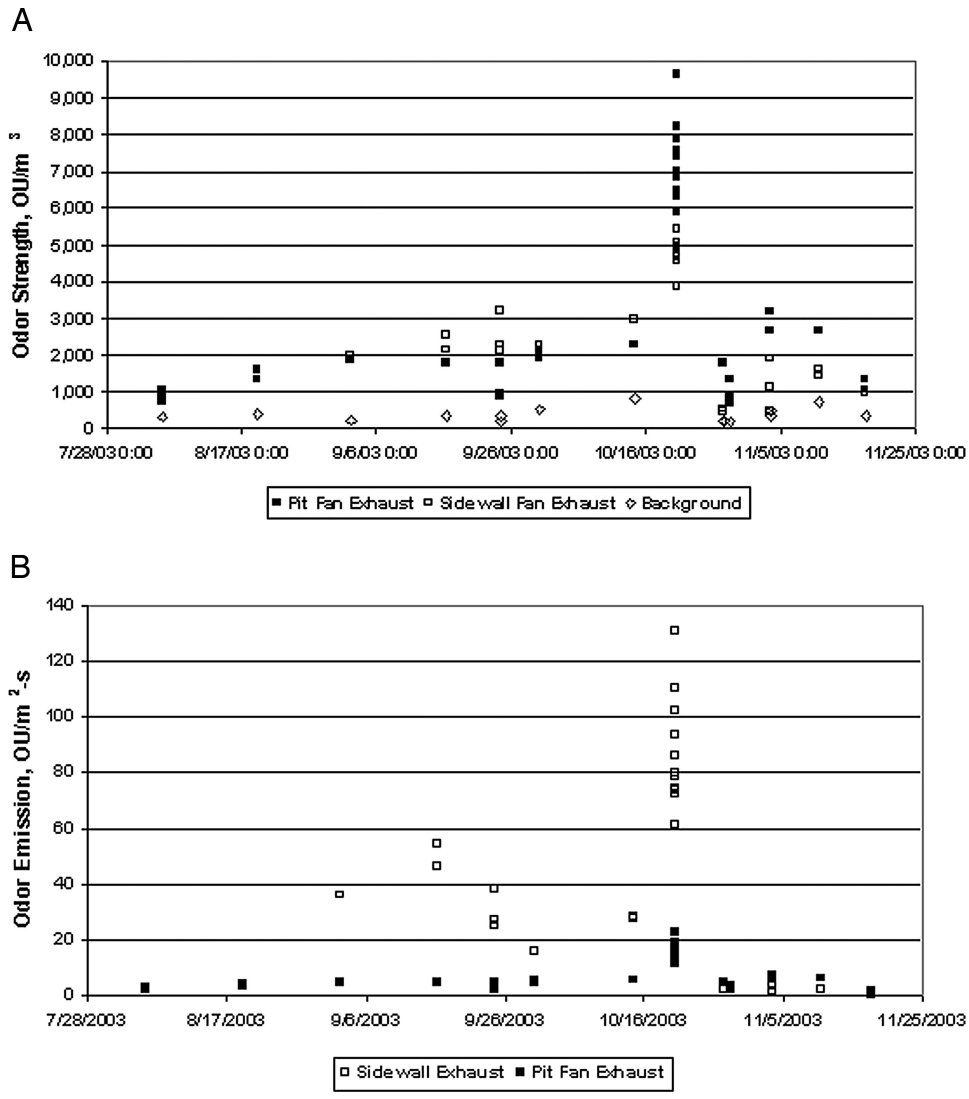

Figure 5. (a) Odor strength and (b) odor emission rate from Barn 2 during the 2003 slurry removal event. Before data measured on October 14, 2003, and after data measured on October 27, 2003.

CONCLUSIONS

The emission of H_2S, NH_3, and odor before, during, and after slurry removal events from two deep-pit swine finishing facilities indicated large increases in concentrations and emission rates during slurry removal, with odor and H_2S emissions lowering to levels well below the pre-removal rates. Although at times the pit exhaust concentrations can be much higher than from non-pit fans, the emission of H_2S, NH_3, and odor from the pit fans is substantially lower than the predominant tunnel fans because of the large differences in ventilation rate capacities when tunnel fans are active. A slurry removal event will result in an acute exposure event for the animals and workers. A protocol establishing a minimum ventilation rate should be established before agitation begins, and all workers should remain outside the facility during agitation. For this research project, the operator established a fixed and minimum ventilation rate of ~27 fresh-air changes per hour with the resulting inside H_2S concentration levels well below lethal levels.

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NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD
AIR FILTRATION AND SCRUBBING
(No.)

Code 371

I. DEFINITION

A device or system for reducing emissions of air contaminants from a structure via interception and/or collection.

II. PURPOSE

To control gaseous and particulate air emissions from ventilated structures by inertial collection, filtration, electrostatic collection, adsorption, scrubbing, and/or bioremoval. Specifically, this practice standard can be used to reduce emissions of the following air contaminants that contribute to air quality resource concerns:

- Direct emissions of particulate matter
- Volatile organic compounds (VOCs)
- Ammonia
- Odorous sulfur compounds
- Methane

III. CONDITIONS WHERE PRACTICE APPLIES

This practice applies to any agricultural operation that includes a naturally or mechanically ventilated structure from which the air contaminants identified in the Purpose section above may be emitted:

IV. CRITERIA

A. GENERAL CRITERIA APPLICABLE TO ALL PURPOSES

1. Design the device or system to remove air contaminants from a structure via inertial impaction, direct interception, electrostatic attraction, absorption, or adsorption and meet the minimum design and operational requirements for the type of device or system specified.

2. Base the design of devices or systems on demonstrated performance for agricultural production or similar applications. Sources of independent verifiable data for demonstrating device or system performance may include universities; local, state, or federal agencies; other independent research organizations; a manufacturer's guarantee based on manufacturer literature and research results; generally-accepted good engineering practices; and/or actual operating experience.

3. Follow the requirements of the National Electrical Code based on the location and type of installation for all electrical components, including wiring, boxes, connectors, etc. Local electrical requirements may exceed those set by NEC.

4. Ventilation

   a. For mechanically ventilated structures, all concentrated airflows will not necessarily need to be treated. Apply the device or system only to those concentrated airflow(s) that are identified for treatment in order to accomplish the intended goal(s) of the device or system.

   b. Size the device or system to treat the maximum ventilation rate of the concentrated airflow(s) to be treated.

   c. Base ventilation rates on industry standards for ventilated structure design or good engineering design principles. Maintain the minimum

required ventilation rates after the addition of the device or system.

5. Fans

   a. Base fan evaluation and/or selection on the ability to provide the required ventilation rate for the sum of the maximum expected pressure drop through the ventilated structure and the control device and on the ability to meet the range of ventilation rates needed. The ability to provide the required ventilation rate can be based on performance characteristics developed by a recognized independent testing laboratory or a manufacturer's guarantee

   b. Base fan selection also on the anticipated characteristics and composition of the concentrated airflow. Preferentially select fans made of materials that will resist corrosion.

   c. Utilize shutters on all fans in multiple fan systems to minimize the potential for backflow.

6. Ductwork. Design and size ductwork to achieve the maximum ventilation rate and minimize pressure drop.

7. Byproducts. Handle, store, and dispose of any byproducts of the device or system in accordance with all legal requirements and to prevent nuisances to the public.

B. SPECIFIC CRITERIA- INERTIAL COLLECTORS

Utilize inertial collectors for removing particulate matter from a concentrated airflow exhausted from a mechanically ventilated structure. Inertial collection is not effective for removing gaseous compounds from a concentrated airflow.

Base inertial collector design on the following:

- Characteristics of the concentrated airflow, such as velocity, temperature, moisture content, and chemical composition
- Concentration of particulate matter in the concentrated airflow
- Particle size distribution of particulate matter in the concentrated airflow
- Particle size range to be collected
- Collection and disposal system for particulate matter removed by the inertial collector

C. SPECIFIC CRITERIA- FABRIC FILTERS

Utilize fabric filters for removing particulate matter from a concentrated airflow exhausted from a mechanically ventilated structure. Fabric filters are not effective for removing gaseous compounds from a concentrated airflow.

Base fabric filter design on the following:

- Characteristics of the concentrated airflow, such as velocity, temperature, moisture content, and chemical composition
- Concentration of particulate matter in the concentrated airflow
- Particle size distribution of particulate matter in the concentrated airflow
- Particle size range to be collected
- Airflow-to-cloth ratio of the filter material
- Collection and disposal system for particulate matter removed by the fabric filter
- Methodology for cleaning the fabric material

D. SPECIFIC CRITERIA- ELECTROSTATIC COLLECTORS

Utilize electrostatic collectors for removing particulate matter from either the inside of a structure or a concentrated airflow exhausted from a mechanically ventilated structure. Electrostatic collection is not effective for removing gaseous compounds.

Base electrostatic collector design on the following:

- Characteristics of the concentrated airflow or air inside the structure, such as velocity, temperature, and moisture content
- Concentration of particulate matter in the concentrated airflow or air inside the structure
- Particle size distribution of particulate matter in the concentrated airflow or air inside the structure
- Particle size range to be collected
- Collection and disposal system for particulate matter removed by the electrostatic collector
- Methodology for cleaning the collector plates

E. SPECIFIC CRITERIA- WET SCRUBBERS/BIOSCRUBBERS

Utilize wet scrubbers/bioscrubbers for removing particulate matter or gaseous compounds from either the inside of a structure or a concentrated airflow exhausted from a mechanically ventilated structure.

Base wet scrubber/bioscrubber design on the following:

- Characteristics of the concentrated airflow or air inside the structure, such as velocity, temperature, and moisture content
- Type of air contaminant(s) to be removed from the concentrated airflow or air inside the structure
- Concentration of the targeted air contaminant(s) in the concentrated airflow or air inside the structure
- Particle size distribution of particulate matter in the concentrated airflow or air inside the structure, if particulate matter is the targeted air contaminant
- Particle size range to be collected, if particulate matter is the targeted air contaminant
- Collection and disposal/recovery system for the scrubbing liquid and any removed air contaminants and other byproducts

F. SPECIFIC CRITERIA-ADSORBERS

Utilize adsorbers for removing gaseous compounds from a concentrated airflow exhausted from a mechanically ventilated structure. Adsorption may also remove particulate matter, although there is a greater potential for fouling of the adsorption media if higher particulate matter concentrations are present in the concentrated airflow.

Base adsorber design on the following:

- Characteristics of the concentrated airflow, such as velocity, temperature, and moisture content
- Type of air contaminant(s) to be removed from the concentrated airflow
- Concentration of the targeted air contaminant(s) in the concentrated airflow
- Potential for fouling of the adsorption media by particulate matter
- Recovery/regeneration system for the adsorption media
- Collection and disposal/recovery system for any removed air contaminants and other byproducts

Pre-clean a concentrated airflow containing high particulate loading to minimize the potential for fouling of the adsorption media.

G. SPECIFIC CRITERIA- BIOFILTERS

1. Utilize biofilters for removing gaseous compounds from a concentrated airflow exhausted from a mechanically ventilated structure. Biofilters may also remove particulate matter, although there is a greater potential for fouling biofilter media if higher particulate matter concentrations are present in the concentrated airflow.
2. **Airflow containing high particulate loading shall be pre-cleaned to remove a significant fraction of particulate in order to prevent plugging of the biofilter.**

3. **Biofilters may be designed utilizing design factors found in "Biofilter Design Information," BAEU-18, Revised March 2004, (or later) published by the University of Minnesota in combination with recent research.**
4. Design documentation shall include the following:
   a. Characteristics of the concentrated airflow, such as velocity, temperature, and moisture content
   b. Type of air contaminant(s) to be removed from the concentrated airflow
   c. Concentration of the targeted air contaminant(s) in the concentrated airflow
   d. Potential for fouling of the biofilter media by particulate matter
   e. Type of biofilter media to be used and anticipated lifespan of the media
   f. Collection and disposal/recovery system for the biofilter media and any removed air contaminants and other byproducts
5. **Wood chips shall be seasoned at least one year. If used, compost should be well composted organic material.**
6. **Organic media beds shall be designed for a minimum effective life of three years.**
7. **Fans shall have readily available published performance characteristics.**
8. **Shutters are required on all fans, on multiple fan systems, which supply gas to a biofilter to prevent backflow.**
9. **Inlets, ductwork and plenum used to distribute mechanically ventilated air through the biofilter should be sized to maintain airflow velocities between 600 - 1000 fpm.**
10. Divert excess moisture (such as from precipitation) away from the biofilter.
11. Include an additional moisture delivery system in the biofilter design, if needed.
12. Implement a facility rodent control program that includes the biofilter.
13. Remove vegetation from the biofilter media periodically to maintain proper airflow.

V. CONSIDERATIONS

1. Include the total cost (installation plus operation) of the device or system in comparison with the intended performance of the device or system. There is considerable variability in the installation cost of the options in this standard. Additionally, there is also considerable variability in the operating cost (including labor, maintenance, energy, etc.) of the various options.
2. Minimization of the overall system pressure drop to less than 0.3 inches of water column may allow for the use of standard agricultural production fans.
3. For particulate-laden concentration airflows, consider keeping the fan outside of the airflow stream or installing a device or system to remove the particulate matter from the airflow stream prior to contacting the fan to reduce the need or frequency for cleaning accumulated particulate matter from the fan blades.
4. If possible, recycle byproducts and/or filtration/scrubbing media and liquids instead of disposal.
5. **Roof runoff can add excessive moisture to the biofilter and displace the material due to physical impact. It is recommended to utilize gutters to divert the water where roof runoff will discharge onto the biofilter.**

VI. PLANS AND SPECIFICATIONS

Prepare plans and specifications for application of this practice for each site or planning unit according to the criteria of this standard. Specifications shall be recorded using specification sheets, job sheets, practice

requirement sheets, narrative statements in conservation plans, or other acceptable documents.

Prepare a design documentation that includes a process diagram and specifies the following minimum information:

1. Type of device or system to be used
2. Identification of the air to be treated (i.e., concentrated airflow(s) from a mechanically ventilated structure or air inside a structure). Also identify any concentrated airflow(s) or air inside a structure that will not be treated by the device or system. Include a justification for treatment or non-treatment of the identified concentrated airflow(s) and/or air inside a structure.
3. Type and concentration/amount of air contaminant(s) to be targeted for removal
4. Characteristics of the concentrated airflow or air inside the structure, such as velocity, temperature, and moisture content
5. Design parameters for the device or system related to air contaminant removal
6. Process controls and monitoring
7. Expected performance (control efficiency) of the device or system
8. Collection and disposal/recovery system for any removed air contaminants and other byproducts

VII. OPERATION AND MAINTENANCE

1. Develop and implement an operation and maintenance plan that is consistent with the purposes of this practice, its intended life, safety requirements, and the criteria used for its design.
2. Operate and maintain the device or system in accordance with the manufacturer's recommendations, if applicable.
3. For fans used in particulate-laden airflows, develop and implement a fan inspection and maintenance plan to prevent and/or remove dust accumulation.
4. Design and construct ductwork to enable all sections to be safely isolated and cleaned as part of routine maintenance.

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Odor, Ammonia, and Hydrogen Sulfide Concentration and Emissions from Two Farrowing-Gestation Swine Operations in North Dakota

S. Rahman, D. Newman

Abstract. *Odor and air emissions from swine facilities are a growing public nuisance faced by animal industries across the country. Quantification of odor, ammonia (NH_3) and hydrogen sulfide (H_2S) emissions from swine facilities is essential to develop and implement odor abatement techniques. In this study, odor, NH_3 and H_2S emissions were measured bi-weekly/monthly from two sow farms (Farm-A with outdoor lagoon systems; Farm-B deep pit system) in North Dakota. Air samples were collected from exhaust fans using a vacuum chamber and Tedlar bags. Odor detection threshold values were determined using a dynamic dilution olfactometer. Ammonia and H_2S concentration were measured using Dräger™ chip measurement systems (CMS) and a Jerome™ meter. Air flow rates from exhaust fans were measured using a portable thermo-anemometer and ventilation rate was determined as the summation of air flow rates of all fans.*

Average odor concentration for the gestation and farrowing barn for Farm-A were 926±439 and 695±428 OU m^{-3}, respectively, whereas these values were 964±371 and 629±341 OU m^{-3}, respectively in Farm-B. Farm-A, NH_3 emissions from the farrowing barn varied between 2.66 and 9.36 g d^{-1} AU^{-1}, but in the gestation barn it varied from 4.19 to 30.73 g d^{-1} AU^{-1}. Similarly, farrowing barn ammonia emission from Farm-B varied between 1.92 and 5.30 g d^{-1} AU^{-1}, but gestation barn ammonia emissions varied between 17.68 and 58.56 g d^{-1} AU^{-1}. Overall, deep pit housing systems resulted in significantly higher NH_3 concentrations and odor emissions. Similarly, Farm-A H_2S emission varied between 0.42 to 1.45 g d^{-1} AU^{-1} in the farrowing barn, whereas it varied from 0.87 and 8.22 g d^{-1} AU^{-1} in the gestation barn. Similarly, farrowing barn H_2S emissions from Farm-B varied from 0.27 to 0.55 g d^{-1} AU^{-1}, but for the gestation barn ammonia emission varied between 2.17 and 8.37 g d^{-1} AU^{-1}. The gestation barn had much higher H_2S emissions than that of the farrowing barn. In general, the deep pit housing systems (Farm-B) resulted in higher pollutant gases concentration and emissions.

Keywords. *Odor, Ammonia, Hydrogen sulfide, Concentration, Emissions, Farrowing, Gestation, Swine operation.*

Animal agriculture is playing an important role in the United States as well as the North Dakota economy and its contribution is increasing. Livestock industries, as a whole, contributed 11.4% of the total cash agricultural receipts in 2009 in North Dakota (NASS-USDA, 2011). In August 2010, there were 160,000 head of hogs in North Dakota raised on 178 farms. Often these farms are close to communities and highways. Swine production plays an important economic role in key hog producing states in the United States (Huang et al., 2004). The growth of swine production in the United States, as well as in North Dakota, is expected to continue. This could possibly aggravate environmental problems, such as pollution, climate change, and loss of biodiversity (van der Meer, 2008). The main environmental concerns with animal production facilities are soil, water, and air pollution (i.e., odor, ammonia, hydrogen sulfide, and greenhouse gases) (Thompson et al., 2004; Kerr et al., 2006).

People who live near livestock farms have often voiced their concerns about odors and these sometime results in lawsuits. Odor emissions are a nuisance and a contentious issue in communities near livestock facilities and they also pose potential health risks (Lu et al., 2008). Odor emissions are an increasingly difficult and pressing problem for the swine industry (Archibeque et al., 2006) when it wants to either expand an existing livestock facility or to establish a new facility. This problem will likely continue as livestock facilities expand and large numbers of animals are raised on smaller areas.

Over the years, the agricultural community and large-scale livestock operations have changed significantly. The trend include an overall reduction in the number of farms, but an increase in intensive livestock production facilities; a major source of odor. Odor nuisance and pollutant gas emissions continues to be a major issue for livestock industries because of their potential environmental and health effects on animals, workers, and neighbors of confined animal feeding operations (Sun et al., 2010). Several large swine (e.g., 27) facilities are in operation in North Dakota, but no air emissions data are available from any of these operations. Under the Emergency Planning and Community Right to Know Act (EPCRA) for confined animal feeding operations (CAFOs) (effective 20 January 2009), large CAFO (i.e., over 700 dairy cows, 2500 swine over 55 lb) need

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to report air emissions such as ammonia (NH_3), and hydrogen sulfide (H_2S). To improve agricultural air quality research, the National Research Council (NRC, 2003) highlighted the need for emission studies focusing on individual farm operations or sources within the farm.Therefore, it is important to monitor odor and air emissions from livestock and poultry production facilities from North Dakota livestock operations and management practices.

Odors from CAFOs or animal feeding operation (AFOs) are produced primarily via incomplete fermentation of livestock manure by bacteria and volatile fatty acid (VFA) is the predominant malodorous compounds produced during fecal starch fermentation. Odor emissions from AFOs are complex mixtures of NH_3, H_2S, and a large number of volatile organic compounds (VOCs) (Laor et al., 2007). However, the odor emissions composition can vary with the types of animal raised, seasonal variations, the stages of animal growth, the types of feed, sampling locations, etc. Offensive odors are the problem that can lead to public opposition to establishing a new livestock facility or expanding an existing facility. Odor emissions from livestock operations constitute a major issue. One approach to deal with odor complaints involves collecting on-farm odor and air emissions data from different livestock production facilities for an extended period of time to establish guidelines for minimum setback distances between livestock operations and surrounding neighbors (McGinn et al., 2003). At the same time, making more information available to the public might also help to reduce pollution through changes in their management practices (Centner and Patel, 2010).

Although more than 130 gases are derived from animal manure decomposition, NH_3 and H_2S gases pose the greatest environmental concern (Ni et al., 2009). Ammonia is considered a precursor of ozone, so it is regulated by the Clean Air Act (US CRS 2010; Centner and Patel, 2010). Ammonia is an environmental pollutant and livestock operations release substantial amounts of NH_3 to the atmosphere from livestock buildings, manure handling and storage systems, and during and following land application of manure (Arogo et al., 2001; Sommer and Hutching, 2001; Aneja et al., 2001). Land application reduces the nitrogen (N) content of manure and can affect groundwater, surface water, and air (Hao et al., 2006; Ivanova-Peneva et al., 2008; VanderZaag et al., 2008). Ammonia emissions have become one of the major worldwide air pollution problems in recent years (Ni et al., 2000). Ammonia from animal wastes and fertilizer is believed to constitute about 90% or more of anthropogenic NH_3 emissions (Buijsman et al., 1987).

Like NH_3, H_2S is produced as a result of bacterial reduction of sulphate and decomposition of sulphur-containing organic constituents of manure under anaerobic conditions (Arogo et al., 2000; Koelsch et al., 2004; Predicala et al., 2008). Hydrogen sulfide (H_2S) is colorless, heavier than air, highly soluble in water and has the characteristic odor of rotten eggs at low concentrations. The presence of H_2S in swine confinement buildings is important from both health and odor perspective (Arogo et al., 2000). It is toxic to humans and animals at high concentrations (Koelsch et al., 2004) and high concentrations of these pollutants may cause irritation to eyes, nose, throat, or have other toxic effects to workers (Wing et al., 2008). Pollutants, such as NH_3, H_2S, and others (particulate matter, odor, and pathogens) emitted by animal production units represent risks to the health and well-being of animals, workers, and neighboring inhabitants, and to the global environment (NRC, 2003; Elenbaas-Thomas et al., 2005) and the effects of these pollutants have been studied extensively (Zhu et al., 2000; Gay et al., 2003). Ammonia emissions from livestock facilities must be reduced to minimize environmental damage. However, before adapting best management practices to reduce these pollutants, one should know the emissions concentration levels of these pollutants. Extensive studies on H_2S emission from swine facilities has been conducted (Zhu et al., 2000; Ni et al., 2002) in other states, but no data is available on H_2S emissions in North Dakota.

The climate of North Dakota is very unique and it is characterized by its unpredictability. It is characterized by semi-arid conditions with low annual rainfall (<250 mm) in the western half of the state, whereas the eastern portion experiences more precipitation with an average of 560 mm. Most of the precipitation occurs during May through August. Before and after this period, precipitation is low to moderate. The average annual rainfall in the study area is 420 mm and the average relative humidity (RH) ranges from 53% to 82% (NPWRC, 2011a). Summer months are hot and winter months are very cold. The average annual temperature for the state of North Dakota ranges from 2.78°C (37°F) in the northern part to 6.1°C (43°F) in the south (NPWRC, 2011b). Due to unique climatic conditions, emissions data from other states are not directly applicable to North Dakota climatic conditions. Therefore, the objective of this research was to quantify odor, NH_3 and H_2S concentration and emission rates from two swine farms under North Dakota farming practices and climatic conditions.

Materials and Methods

Description of Facilities and Management Practices

Two commercial swine farms (hereafter Farm-A and Farm-B) were monitored (fig. 1). They were located 50 km apart. Farm-A consists of two gestation-barns (hereafter g-barn) and two farrowing barns (hereafter f-barn). Farm-A has a shallow pit system and manure is typically removed from the shallow pits every three weeks and stored in an outdoor anaerobic storage. Each g-barn has a capacity of 2200 head. In each f-barn, there are eight rooms with 52 farrowing crates per room. Thus, there are a total of 832 (8×52×2) farrowing stalls on this farm. The farrowing rooms on this farm are identical to each other and each farrowing room has the same number of sows except at cleaning and maintenance times. There were five exhaust fans in each farrowing room (23 × 12 m) for a total of 40 (5×8) exhaust fans in each f-barn. There were 12 wall mounted exhaust fans and 20 tunnel fans in each g-barn (171 × 24 m) for a total 34 fans in each g-barn on this farm. The total capacity of this facility is 5000 head.

Similarly, Farm-B consists of two g-barns and two f-barns. Each g-barn (165 × 24 m) has 2100 gestation-stalls with deep pits and the f-barn (24 × 12.5 m) has 15 farrowing rooms (7 rooms on one side and 8 rooms on the other side) with 60 crates per room (15×60 = 900 farrowing stalls). Each farrowing room in the g-barn is identical to each other. This facility is cross ventilated via pit fans in the winter, whereas summer ventilation is tunnel vented with cooling pad at the end walls and fans in the center of the side walls. The f-barn

Figure 1. Study sites and description of facilities: (a) Showing two gestation barns, two farrowing barns, and an outdoor lagoon system at Farm-A; (b) Showing two gestation (deep pit manure storage underneath) and two farrowing barns in Farm-B; (c) Showing exhaust fans (five fans/room) and sampling location of a farrowing room in Farm-B; and (d) One of the sampling location of pit fan in Farm-B.

has shallow pull plug-type pits that drain manure into the corresponding g-barn pits every three weeks when the farrowing room is emptied at piglet weaning. It is also power washed. Farm-B has two deep pit systems and they were completely separated from each other. In each g-barn, there are 16 pit ventilation fans and eight wall ventilation fans. Thus a total of 32 pit fans and 16 wall ventilation fans are in this g-barn. The total capacity of this facility is 5000 animals. The major differences between the two farms are that Farm-A has an outdoor manure collection system, whereas, Farm-B has a deep pit manure collection system. Both farms are owned and operated by the same producer. The swine had similar food rations.

Odorous Air Sample Collection

Because of limited resources and sample handling capacity and the large number of exhaust fans, a limited (12 samples) number of samples were collected during each sampling event. Samples were collected from the same exhaust fans and at the same time of day (10 am -12 noon) each time. During each sampling event at Farm-A, duplicate air samples were collected from the same minimum ventilation fan of a farrowing room, whereas in the g-barn, duplicate air samples were collected from every alternate fan on the same side of the barn. In this way, a total of 12 samples were collected for odor analysis. For Farm-B, air sampling protocol was the same as for Farm-A, but the g-barn air samples were collected from the pit fans. All air samples were collected from the exhaust side of the fan due to bio-security reasons and to gain producer cooperation. All air samples were collected in 10-L Tedlar bags using a vacuum chamber (SKC Inc., Eighty Four, Pa.) and samples were shipped overnight to an olfactometry lab at Iowa State University within 24 h of collection for odor dilution to threshold (DT) values.

Concentration and Ventilation Measurement

Odor DT values were analyzed using a forced-choice dynamic olfactometer (AC'Scent International Olfactometer, St. Croix Sensory, Inc., Stillwater, Minn.) at Olfactory Lab at Iowa State University with eight trained panelists. During each air sampling event, duplicate NH_3, and triplicate H_2S concentrations were measured using the Dräger^{TM} Chip Measurement Systems (CMS) (SKC Inc., Eighty Four, Pa.) and a Jerome meter 631X (Arizona Instrument, Phoenix, Ariz.), respectively. The ammonia chips (2-50 ppm) used were factory calibrated and the Jerome meter (0.003-50 ppm) used in this study was new and factory calibrated. All measurements were taken at the exhaust side of the fan. In addition, indoor temperature and relative humidity (RH) were recorded using HOBO Pro T/RH loggers (Onset Computer Corporation, Bourne, Mass.) with a 0.2°C

accuracy for temperature and 2.5% for RH. For the farrowing room, one HOBO logger was installed in the middle of the room. For the g-barn, two HOBO loggers were installed and data were recorded hourly.

The average air velocity rates (m s^{-1}) of all running fans were measured using a portable thermo-anemometer (Extech Instruments Corporation, Waltham, Mass.; range 0.4-30 m s^{-1} and accuracy ±3%+0.20 m s^{-1}) using at least 10 to 20 locations across the radius of an exhaust fan (fig. 2) were used as per Zhang et al. (2007). The air flow rate (m^3 s^{-1}) of each fan was calculated from the measured average air velocity and fan cross-sectional area. The measured fan airflow rate was compared with the published data from the BioEnvironmental and Structural Systems (BESS) lab fan testing data for the corresponding fans model. The total ventilation rate from each room was determined as the summation of the air flow rates of all fans.

Odor, NH_3 and H_2S Emission Rates Calculation

Odor emission rate was calculated from the measured odor concentration and air flow rate as follows:

$$ER_{odor} = C_{odor} \times V_{rate} \quad (1)$$

where

ER_{odor} = odor emission rate (OU m^{-3})
C_{odor} = odor concentration (OU m^{-3})
V_{rate} = ventilation rate through exhaust fan (m^3 s^{-1}).

Ammonia (NH_3) and H_2S emission rate was calculated using following equations:

$$ER_{p\_gas} = \frac{\left\{\left(C_{p\_gas} \times \frac{P}{RT} \times MW_{p\_gas} \times V_{rate}\right)\left(\frac{24\times3600}{10^3}\right)\right\}}{AU} \quad (2)$$

where

ER_{P_gas} = pollutant gas (i.e., NH_3 or H_2S) emission rate (g day^{-1} AU^{-1})
C_{P_gas} = pollutant gas (i.e., NH_3 or H_2S) concentration (ppm)
P = absolute pressure [atm (i.e., 1.0 atm)]
R = ideal gas constant (0.08206 1-atm/gmol-K)
T = absolute temperature [K (°C + 273), (i.e., 25°C)]
MW_{P_gas} = molecular weight of the pollutant gas (i.e., 17.03 for NH_3 and 34.07 for H_2S)
AU = animal unit = (N_{animal} × M_{animal})/500 (1 AU =500 kg of animal weight)
N_{animal} = number of animal
M_{animal} = average mass of an animal (kg)

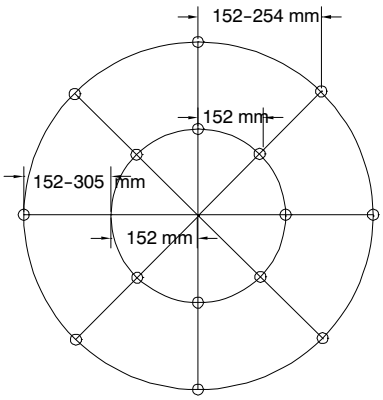

Figure 2. Schematic of air velocity measurement points (smaller circles) across the radius of an exhaust fan.

Data Analysis

Analyses of variance (ANOVA) were performed using the SAS program and data were polled and analyzed using the GLM statistical model. Both concentration and emissions were analyzed at α = 0.05 significance level and were compared between farrowing and gestation barns of the same farm and between the two farms. The significance of the differences in concentration and emissions were examined according to Duncan's multiple range tests (Steel et al., 1997).

Results and Discussion

Odor Concentrations and Emissions

The average odor concentrations for Farm-A and Farm-B are shown in figures. 3 and 4, respectively. Average odor concentration for the g- and f-barn at the Farm-A were 926±440 and 695±428 OU m^{-3}, respectively (table 1). These values were 964±371 and 629±341 OU m^{-3}, respectively, for Farm-B (table 1). On average, the g-barn had a higher odor threshold than the f-barn. The average g-barn odor concentration at Farm-A was slightly higher than that of the f-barn (fig. 3a), but differences were not statistically significant. A similar trend was also observed for Farm-B.

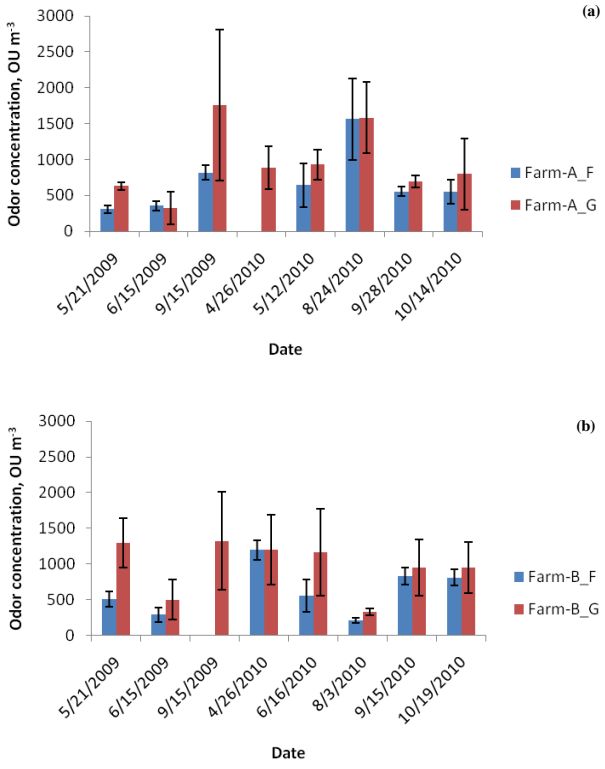

Figure 3. Variation of odor concentrations between gestation (g-barn) and farrowing (f-barn) barns at (a) Farm-A and (b) Farm-B.

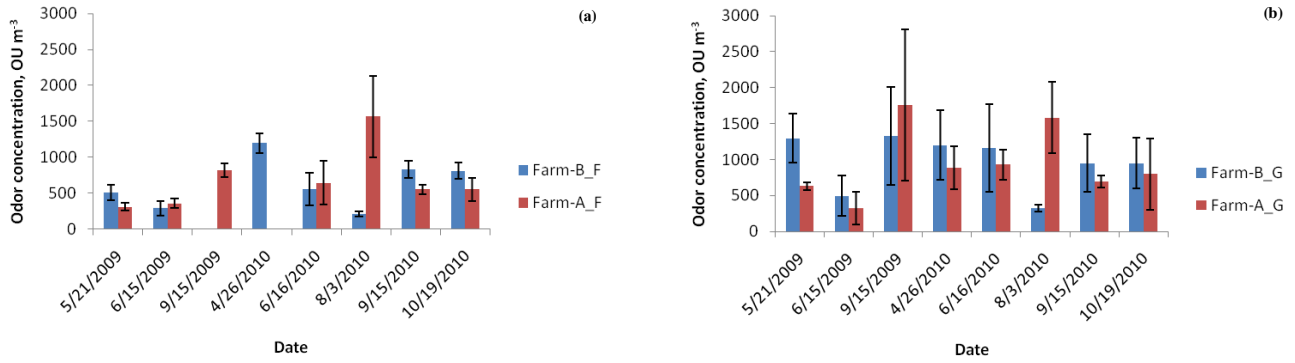

Figure 4. Odor concentrations comparison between Farm-A and Farm-B: (a) farrowing barn (f-barn) and (b) gestation barn (g-barn).

The g-barn had higher odor concentration than the f-barn. These trends and values were comparable to those reported by Zhou and Zhang (2003) and Zhu et al. (2000), in contrast with the trend reported by Guo et al. (2006).

The odor concentration varied significantly among sampling events. Low odor concentrations were observed during the warm season from May-September, while during the cold season, October-April, the odor concentration was high (fig. 3). During the colder months, the ventilation rate was low, thus the odor concentration was greater. However, high odor concentration does not necessarily mean a high odor emissions rate unless the ventilation rate is also high.

When odor concentrations were compared between Farm-A and Farm-B, Farm-B had a higher average odor concentration than Farm-A (fig. 4). This was likely due to differences in housing and manure management systems. Farm-B had a deep pit manure collection system. Farm-A had an outdoor manure storage system. Other researchers have also noticed that manure characteristics and manure depth influence odor concentration level (Miller et al., 2004; Pelletier et al., 2005). Measured average odor emission varied from 2.11 to 53.51 $OUs^{-1}m^{-2}$ for Farm-B. It varied from 2.31 to 31.2 $OUs^{-1}m^{-2}$ for the Farm-A. The average odor emission rates for the f-barn and g-barn at Farm-A varied from 3.2 to 25.34 $OUs^{-1}m^{-2}$ and 2.31 to 31.2 $OUs^{-1}m^{-2}$, respectively. Whereas, these values varied from 2.11 to 6.40 $OUs^{-1}m^{-2}$ and 6.74 to 53.51 $OUs^{-1}m^{-2}$, respectively, for Farm-B. Average odor emission rate for the g- and f-barn at the Farm-A were 16.34±15.0 and 10.89±10.0 $OUs^{-1}m^{-2}$, respectively (table 1). These values were 19.44±19.2 and 4.56±1.5 $OUs^{-1}m^{-2}$, respectively, for Farm-B (table 1). This result is consistent with that observed by Zhang et al. (2007) under climatic conditions in Manitoba, Canada. This variation in odor emission was likely due to variation in ventilation rates. When more fans were running, odor emissions increased due to the higher ventilation rate. The g-barn had greater odor emissions than the f-barn, however the differences were not significant. The higher odor emissions from g-barn at Farm-B are attributed to the fact that manure was removed from the farrowing barn every three weeks, whereas manure was stored in the deep pit 6 to 9 months underneath the gestation barn. The longer manure removal time leads to more odor emissions (Zhang et al., 2007). Results obtained in this study are within the range of 1.18-192 OU s^{-1} m^{-2} and 7.6-23.0 OU s^{-1} m^{-2} as reported by (Gay et al., 2003; Zhang et al., 2007), respectively. Odor emissions were higher at Farm-B than at Farm-A, which was due to deep pit system. Odor emissions increased as manure depth in the deep pit system increased as also reported by others (Miller et al., 2004).

Ammonia Concentrations and Emissions

Variation of NH_3 concentrations from Farm-A and Farm-B are presented in figure 5. Farm-B had higher NH_3 concentrations than Farm-A (table 1). This was likely due to differences in manure management systems, i.e., Farm-B had a deep pit system whereas Farm-A had a shallow pit and outdoor storage system. Because of the deep pit system, manure is typically held for 6 to 9 months and anaerobic decomposition of manure produce higher ammonia concentration. Irrespective of farm management practices, the gestation barns had higher NH_3 concentration (5.37 and 11.15 ppm in Farm-A and Farm-B, respectively) than the farrowing barns (4.85 ppm for Farm-A and 7.11 ppm for Farm-B, respectively). The differences were not statistically significant, except g-barn of Farm-B.

Table 1. Averages and standard deviations of different measured parameters from farrowing and gestation barn at Farm-A and Farm-B over the entire sampling period.

		Farrowing		Gestation	
Parameters	N	Farm-A	Farm-B	Farm-A	Farm-B
Ventilation rate (m^3 s^{-1})	288	4.25b[a]±3.37	3.45b±3.15	82.54a±62.51	97.56a±68.03
Odor concentration (OU m^{-3})	146	695a±428	629a±341	926a±440	964a±371
Odor emission (OU s^{-1} m^{-2})	146	10.89a±10.0	4.56a±1.5	16.34a±15.0	19.44a±19.2
Ammonia concentration (ppm)	144	4.86b±2.8	7.11b±3.82	5.37b±2.25	11.15a±5.43
Ammonia emission (g d^{-1} AU^{-1})	144	5.37c±2.85	3.27d±1.54	11.46b±9.69	32.40a±17.86
Hydrogen sulfide concentration (ppm)	432	0.369b±0.18	0.417b±0.20	0.587b±0.46	0.758a±0.45
Hydrogen sulfide emission (g d^{-1} AU^{-1})	432	0.743c±0.39	0.409d±0.20	2.372b±2.74	4.714a±3.00

[a] Averages within a row followed by different letters are significantly different at $P \leq 0.05$ according to Duncan multiple range tests.

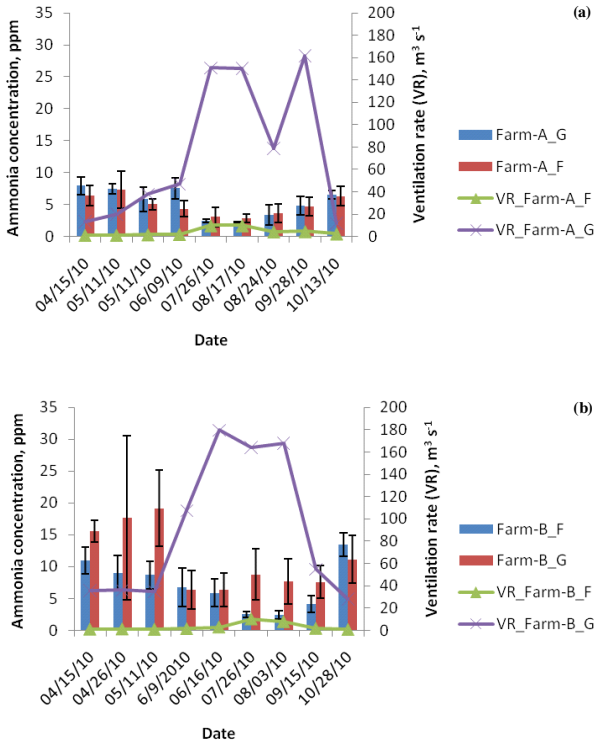

Figure 5. Variation of ammonia concentrations (NH_3) between farrowing (f-) and gestation (g-) barn between two farms: a) Farm-A and b) Farm-B.

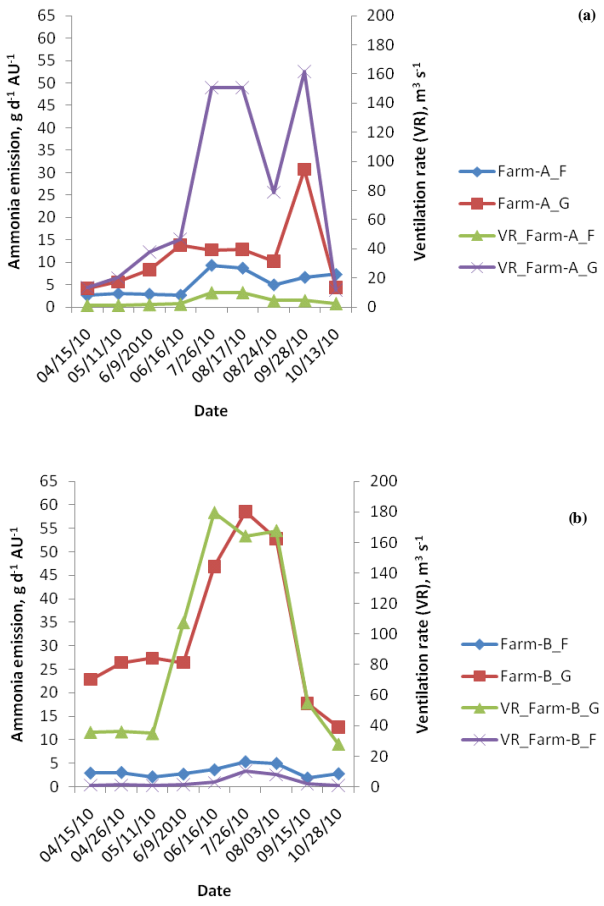

Figure 6. Variation of ammonia emissions from gestation (g-) and farrowing (f-) barn at (a) Farm-A and (b) Farm-B.

For Farm-A, the NH_3 concentration ranged from 2.23 to 7.95 ppm for the gestation barn, whereas it ranged from 6.37 to 19.13 ppm for Farm-B. Similarly, the NH_3 concentration in the farrowing barn ranged from 2.87 to 7.33 ppm at Farm-A. These values ranged from 2.43 to 10.99 ppm for Farm-B. In general, the lowest NH_3 concentration was recorded during June-August and the highest concentration was found during April-May. This can be explained that during April-May, only minimum ventilation fans were running and ambient temperatures were low. This resulted in high NH_3 concentrations. During July-August, the ventilation rates were the highest. This resulted in lower NH_3 concentrations. A similar trend has been observed by other researchers (Guo et al., 2006; Sun et al., 2010). The results obtained in this study were compared with other studies (Zhu et al., 2000; Blunden et al., 2008). Ammonia concentrations were within the same ranges as found in other studies (Zhu et al., 2000; Blunden et al., 2008; Sun et al., 2010).

At Farm-A, NH_3 emissions from the f-barn varied between 2.66 to 9.36 g d^{-1} AU^{-1}, but in the g-barn it varied from 4.19 to 30.73 g d^{-1} AU^{-1} (fig. 6). Although manure from both barns was removed every three weeks, the g-barn showed higher ammonia emissions, which was due to the variation in ventilation rates. As shown in figure 6, the f-barn ammonia emissions at Farm-B varied between 1.92 and 5.30 g d^{-1} AU^{-1}, but the g-barn ammonia emissions varied between 17.68 to 58.56 g d^{-1} AU^{-1} for the same farm. The higher ammonia emissions from the g-barn are attributed to the fact that g-barn had a deep pit manure storage system and stored manure for 6 to 9 months.

At Farm-A, the f-barn ammonia emissions followed a trend similar to the f-barn emissions at Farm-B, but the g-barn emissions were much lower than at Farm-B. This is attributed to the fact that Farm-A had an outdoor manure storage system where manure was removed from both the f- and g-barns every three weeks, whereas Farm-B had deep pit system in the g-barn. In general, when the NH_3 concentrations were low, the emissions rates were high due to the high ventilation rates.

Hydrogen Sulfide Concentrations and Emissions

Figures 7 and 8 represent the variation of H_2S concentrations from Farm-A and Farm-B. The average H_2S concentration of the g- and f-barns at Farm-A were 0.59 ± 0.46 ppm and 0.37 ± 0.18 ppm, respectively. Similarly, the H_2S concentrations of these units for Farm-B were 0.76 ± 0.45 ppm and 0.42 ± 0.20 ppm, respectively. When the results obtained in this study are compared with other studies (Zhu et al., 2000; Blunden et al., 2008), the H_2S concentrations are within the ranges (0.148 to 0.927 ppm) as reported by Zhou and Zhang (2003) for a swine barn in Manitoba, Canada. When the H_2S concentrations were compared between f- and g-barns for the same farm, the g-barn showed higher concentrations than the f-barn. Similar to the NH_3 concentration variation, the lowest H_2S concentration was noticed during the months of July-August and the higher concentration was noticed during the months of April-May (fig. 7).

When the H_2S concentrations were compared between the two farms (fig. 8), Farm-B showed slightly higher H_2S concentration than the Farm-A. This was likely due to differences in manure management systems as described in

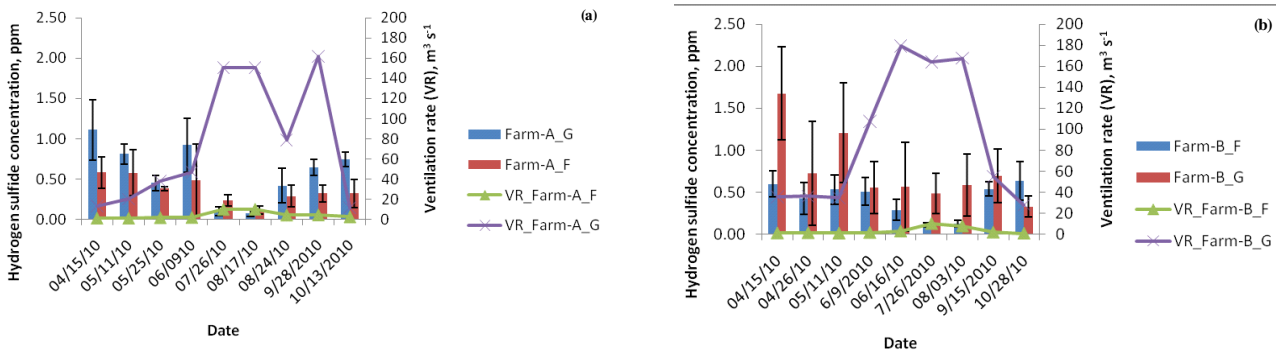

Figure 7. Variation of hydrogen sulfide (H_2S) concentrations of farrowing and gestation barns: (a) Farm-A and (b) Farm-B.

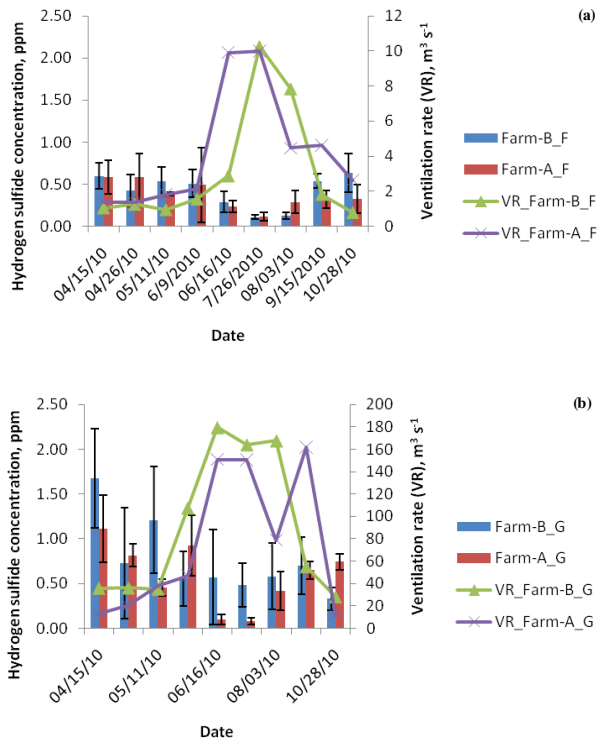

Figure 8. Variation of hydrogen sulfide concentrations of: (a) farrowing and (b) gestation barn between farms Farm-A and Farm-B.

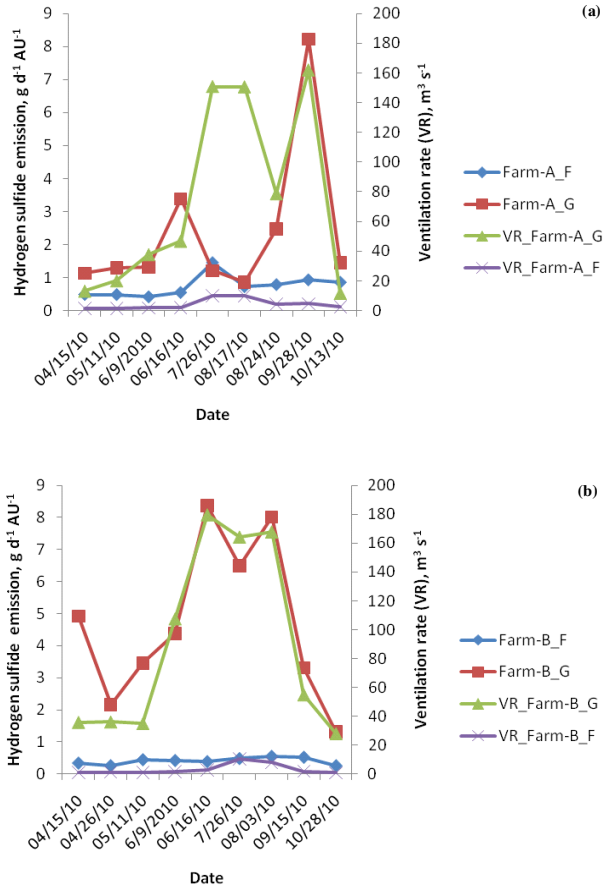

Figure 9. Variation in hydrogen sulfide emissions of (a) Farm-A and (b) Farm-B.

the previous section, but the differences were not statistically significant except g-barn of Farm-B. In a deep pit manure storage system, it is common that bubbles rise from the liquid manure. This carries higher hydrogen sulfide concentrations (Ni et al., 2009). The H_2S concentration is likely to increase suddenly when the bubbles burst and release H_2S. Irrespective of farm management practices, the gestation unit had greater H_2S concentrations than the farrowing unit. This is likely due to a longer manure storage period and manure storage depth.

Farm-A H_2S emissions varied between 0.42 to 1.45 g d^{-1} AU^{-1} for the f-barn, whereas it varied from 0.87 to 8.22 g d^{-1} AU^{-1} in the g-barn. In September 2010, an anomaly in the ventilation rate was observed (fig. 9a). The ventilation rate increased sharply (by 69%) as compared to the previous months as a result of high ambient temperatures. A similar pattern was observed at Farm-B. Hydrogen sulfide emissions followed the same pattern as the ammonia emissions. As shown in figure 9b, the f-barn H_2S emissions at Farm-B varied from 0.27 to 0.55 g d^{-1} AU^{-1}, but for the g-barn ammonia emissions varied between 2.17 and 8.37 g d^{-1} AU^{-1}. The g-barn had much higher H_2S emissions than that of the f-barn for the same reason as for the ammonia emissions. In terms of H_2S emission between two farms, Farm-A had higher H_2S emissions for the f-barn. But, Farm-B had higher emissions for the g-barn.

CONCLUSIONS

- There was no significant difference in odor concentrations and emission rates between gestation and farrowing barns.

- In general, deep pit housing systems (Farm-B) had higher pollutant gases concentrations and emissions than a lagoon manure management (Farm-A).
- No significant differences in odor concentrations were noticed between deep pit (Farm-B) and lagoon manure management (Farm-A) systems.
- Irrespective of farm management practices, gestation units had higher ammonia concentrations and emissions, but the differences were not significant statistically.
- Gestation barns had much higher hydrogen sulfide emissions than the farrowing barns and the differences were not statistically significant.

ACKNOWLEDGEMENT

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RESEARCH REPORT
ENVIRONMENT

Title: Quantification of Greenhouse Gas Emissions from a Production Scale Midwestern Breeding/Gestation/Farrowing Facility – **NPB #10-066**

Investigator: Dr. Hongwei Xin, Professor and Associate Chair of Research

Institution: Iowa State University

Co-Investigator: John P. Stinn, Graduate Research Assistant, Dept. of Agl and Biosystems Engineering

Date Submitted: 9/1/2012

Industry Summary

Gaseous emissions from livestock production continue to receive increasing attention due to concerns over their environmental and health impacts. Local concerns over gaseous emissions are usually focused on odor and environmental impacts. For example, ammonia (NH_3) is usually of concern for its potential negative impacts on local environments or ecological systems due to deposition, whereas greenhouse gases (GHGs) emissions are of concern for their potential impacts on global climate change. However, it is important to understand the quantity and composition of gasses being emitted to the atmosphere. The primary GHGs associated with livestock production are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Information on GHG emissions from U.S. swine production facilities is meager, especially under commercial production conditions.

Therefore, the objective of this study was to quantify the emissions of GHGs and ammonia from a Midwestern production-scale breeding/gestation/farrowing facility over a one-year period. This study will begin to establish the baseline GHG emissions and contribute to national emissions inventory on ammonia emissions for swine production in the United States, particularly under Midwestern production conditions.

A 4300 sow capacity breeding/gestation/farrowing facility in central Iowa was used in this one-year intensive monitoring study. The facility consisted of one breeding/early gestation barn, one late gestation barn, and two farrowing buildings with 9 farrowing rooms each (40 farrowing crates per room). The farrowing rooms held manure in a shallow pit that was drained into an external storage at the end of each farrowing cycle (~21days). The breeding/early gestation barn and late gestation barn held manure in a deep pit of each barn. Manure from the barns and the external storage was pumped out twice a year.

A Mobile Air Emissions Monitoring Unit (MAEMU) was used to continuously measure variables needed to determine the gaseous emissions from the breeding/gestation barns and two farrowing rooms. For each monitored barn/room the following data were collected on a 30 second basis: fan running status, building static pressure, indoor air temperature and relative humidity (RH), outdoor air temperature and RH, and barometric pressure. Gaseous concentrations of the exhaust air were measured with a gas sampling system that stepped sequentially through two composite sample locations in each barn or room (8 total), with 6 minutes of sampling and analysis per location to ensure stabilized readings. In addition, gaseous concentrations of the ambient air

These research results were submitted in fulfillment of checkoff-funded research projects. This report is published directly as submitted by the project's principal investigator. This report has not been peer-reviewed.

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or background were measured every two hours. The static pressures and fan status were used with fan-specific performance curves developed from *in-situ* measurements to determine each fan's airflow rate, hence the building ventilation rate.

The average daily emissions from each source – breeding/early gestation (B/EG) barn, late gestation (LG) barn, farrowing barns, external manure storage, and farm-level overall, in pounds per 100 sows per day, is summarized in Table 1. The results show that methane emissions from the shallow-pit farrowing barns are 18% of those from the external manure storage and 0.11-0.12% of those from the deep-pit breeding/gestation barns. The farm-level daily CH_4 (0.28 lb/sow-d) and N_2O (5.2×10^{-4} lb/sow-d) emissions were equivalent to 7.3 lb CO_{2eq}/sow-d. Majority (~94%) of the farm-level CO_2 emission (8.2 lb/sow-d) is from animal respiration. Daily ammonia emissions averaged 0.03 lb/sow in the B/EG phase, 0.03 lb/sow-d in the LG phase, 0.074 lb/(sow+litter)-d in the farrowing phase, and 0.007 lb/(sow+litter)-d for the external manure storage, with an overall farm total of 0.033 lb/sow-d. Based on the daily farm-level ammonia emissions obtained from this study, the number of animals needed to trigger the EPA CERCLA reporting threshold of 100 lb NH_3/d ranges from 3523 gestation sows to 1233 farrowing sows and litters for the manure handling systems involved in the study.

The measured emission rates from the LG and B/EG barns are higher than measured values from other breeding/gestation systems. This is due to previous measurements being taken on shallow pit buildings. The deep-pit manure storage results in more methane and nitrous production as manure is the main source of these two gasses in swine production systems. This is further evidenced by the drastically higher methane emissions from the external manure storage compared to the farrowing barns.

Table 1. Average daily emissions of ammonia (NH_3), carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) and their CO_2 equivalent (CO_{2eq}) from breeding/early gestation (B/EG) barn, late gestation (LG) barn, farrowing barns, and external manure storage on a per 100 sows or per 100 (sows+litters) basis

Source of Emissions	Unit	Daily Emissions			
		NH_3	CO_2	N_2O	CH_4
B/EG Barn	lb/100 sows	2.72	635	0.085	22.5
	CO_{2eq}	-	635	25.4	562
LG Barn	lb/100 sows	2.95	700	0.017	22.6
	CO_{2eq}	-	700	4.99	565
Farrowing Barns	lb/100 (sows+litters)	7.44	2133	0.077	13.0
	CO_{2eq}	-	2133	23.0	326
External Manure Storage	lb/100 (sows+litters)	0.67	135	0.001	72.1
	CO_{2eq}	-	135	0.182	1803
Farm Overall	lb/100 sows	3.34	820	0.052	28.5
	CO_{2eq}	-	820	15.5	711

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Keywords

Aerial emissions, ammonia, greenhouse gases (GHG), gestation, farrowing

Scientific Abstract

Interest in ammonia and greenhouse gas (GHG) emissions from animal feeding operations is increasing. However, information is meager concerning ammonia and GHG emissions from swine operations, particularly from breeding, gestation, and farrowing facilities. The purpose of this study is to quantify GHG emissions from a breeding/gestation and farrowing facility located in Central Iowa. The monitored portion of the facility consists of a deep-pit breeding and early gestation (~40 days) barn (1800 head), a deep-pit late gestation (>40 days) barn (1800 head), and two shallow-pit farrowing rooms (40 farrowing crates per room). Monitoring began in January 2011 and will continue for two years to cover the seasonal effects on the emissions. This paper reports on data collected from January 12, 2011 to June 30, 2012. A mobile air emissions monitoring unit is dedicated to the extensive monitoring. At the time of this writing, results from the study show the following average daily emissions per animal unit (AU = 500 kg body mass): 33.1 g NH_3, 7.72 kg CO_2, 1.0 g N_2O, and 273.6 g CH_4 for sows in the breeding/early gestation barn; and 34.2 g NH_3, 8.08 kg CO_2, 0.2 g N_2O, and 259.9 g CH_4 for sows in the late gestation barn. The average daily emissions per crate (sow and piglets) of the farrowing rooms are: 33.8 g NH_3, 9.69 kg CO_2, 0.4 g N_2O, and 59.3 g CH_4. A dynamic flux chamber was deployed on the external manure storage several times over the monitoring period to capture the seasonal variation of emissions. For the monitored period, the storage had the following average daily emission per square meter of surface area: 0.41 g NH_3, 81.5 g CO_2, 0.07 g N_2O, and 51.6 g CH_4, which was equivalent to daily emissions on a farrowing sow basis of 3.1 g NH_3, 613 g CO_2, 0.002 g N_2O, and 326 g CH_4. These results will be enhanced by the data from the second year monitoring of the same facility.

Introduction

Gaseous emissions from livestock production have received increasing attention as concern has grown over their environmental and health impacts. Local concerns over gaseous emissions are usually focused on the odor and environmental impacts. For example, ammonia (NH_3) is usually of concern for its potential negative impacts on local environments due to deposition. However, it is important to study these emissions to understand the quantity and composition of gasses being emitted to the atmosphere. The three biggest gasses of concern in terms of having potential to affect climate change are the greenhouse gasses (GHG): carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4). In order to understand the magnitude of GHG emissions from livestock production, reliable emission factors for different livestock production systems in different geographic/climatic areas must be determined. Currently, there is a gap in the swine data for the breeding/gestation and farrowing stages of production.

The US breeding pig inventory was 5.97 million head as of March 1, 2011 and Iowa leads the US with over 17% of the breeding inventory (USDA NASS, 2011). The US EPA estimates that agriculture is responsible for 6.3% of the total GHG emissions in the US (2011 US Greenhouse Gas Inventory Report). As mitigation technologies are developed to reduce emissions, it is important to have accurate baseline emission rates for design and implementation of mitigation technologies, to evaluate the effectiveness of the technologies, and to direct technology development toward the areas of animal production that have the largest emissions footprint.

There is limited literature on GHG emissions from swine gestation and farrowing facilities. The gestation side is particularly sparse as many of the studies done are for shallow-pit or flush systems, not the deep-pit system common in the Midwest. Accumulation and storage of the manure in a deep-pit system increases the potential for NH_3, N_2O, and CH_4 emissions by providing a relatively stable environment for the chemical and biological processes that produce these gasses to occur. The literature for farrowing facility emissions is more comparable due to the common manure management practice of shallow-pit systems but is still meager. Additionally, many of these studies involved intermittent air sampling, which can struggle to capture the diurnal fluctuations of gaseous emissions and can be significantly impacted by short-term weather conditions.

Therefore, the objective of this study was to quantify emissions of GHG and ammonia from a Midwestern production scale breeding/gestation/farrowing facility over a one-year period. This study, when coupled with the results from a recent study by Pepple et al. (2011), will begin to establish the baseline GHG and NH_3 emissions data for the entire swine production cycle under Midwestern production conditions.

Objectives

The goal of this project is to quantify greenhouse gas (GHG) emissions from a production scale swine breeding/gestation/farrowing facility located in Central Iowa. To achieve this goal, the following project objectives were developed:

- Quantify CH_4, N_2O, and CO_2 emissions from the swine facility over a one- year period:
  - -Quantify GHG emissions from a deep-pit breeding/gestation barn (1,800 sows in barn)
  - -Quantify GHG emissions from a deep-pit late gestation barn (1,800 sows in barn)
  - -Quantify GHG emissions from a shallow-pit farrowing barn (360 sows)
  - -Quantify GHG emissions from external manure storage (160 ft. diameter slurry store)
- Measure stored manure characteristics during the one-year emissions monitoring period

Materials & Methods

A 4300 sow capacity breeding/gestation/farrowing facility in central Iowa was used in this field monitoring study. The facility consisted of one breeding/early gestation barn, one late gestation barn, and two farrowing buildings with 9 farrowing rooms each (40 farrowing crates per room). Two farrowing rooms, designated F1 and F2, were selected to be monitored. The farrowing rooms were each 15.5m x 13.9m (51ft x 45.5ft) with a shallow-pit system (0.61m deep) that was flushed out after every turn (approx. every 21 days). Each room utilized two 0.3m (12 in.) fans, two 0.6m (24 in.) variable speed fans, one 0.91m (36 in.) fan, and one 1.2m (48 in.) fan for ventilation with the inlet air drawn from a common hallway. Each room had 40 farrowing crates and one 66kW (225,000 BTU/h) space heater. Figure 1 shows the monitoring system layout for the farrowing rooms. Each room's exhaust air was sampled in the same manner, i.e., one composite sample being from the shallow-pit fans and one composite sample from the lowest stage wall fans.

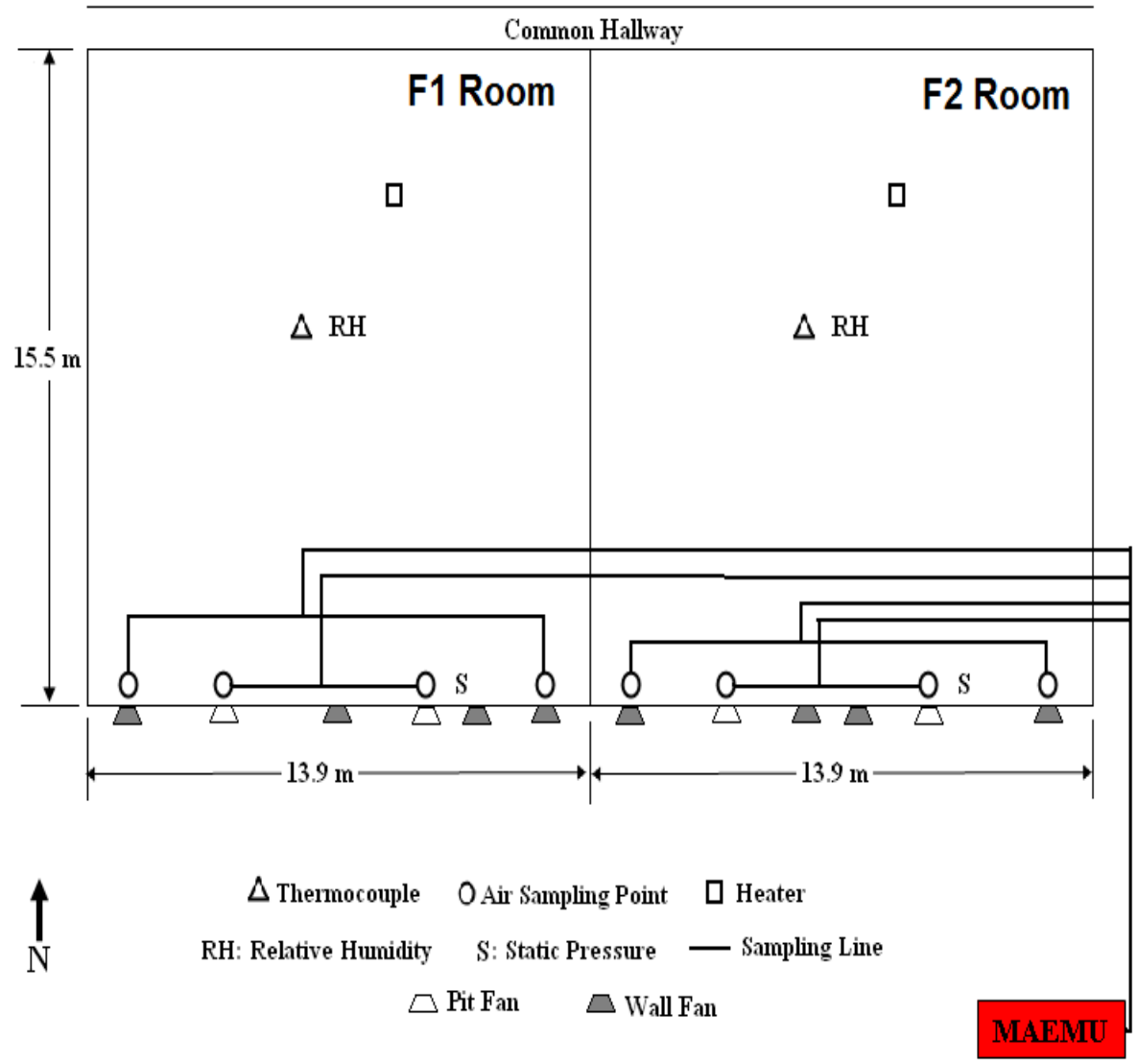


Figure 1. Diagram of Farrowing Rooms F1 and F2 showing air sampling, temperature, static pressure, and relative humidity measurement locations.

The breeding/early gestation barn and the late gestation barn, designated as the B/EG and LG Barns, respectively, had the same dimensions, ventilation design, and 1800 head capacity. The barns had dimensions of 121.9m x 30.5m (400ft x 100ft) and used mechanical ventilation year-round. Each barn had twelve 0.6m (24 in.) pit fans, fifteen 1.32m (52 in.) endwall fans, 55 bi-directional ceiling inlets, and ten 66 kW (225,000 BTU/hr) space heaters. When necessary, curtains on evaporative cooling pads located on the north, south, and east walls were dropped to allow for tunnel ventilation with the cooling effect of the pads. Each barn had a deep-pit (3.05 m) and the manure was pumped out semi-annually, in the fall and spring. Figure 2 shows the monitoring system layout for the B/EG and LG Barns. Exhaust air samples from each barn were drawn as a composite from four of the lowest ventilation stage pit fans, and a second sample from the lowest stage endwall fans. The B/EG Barn contained both sows waiting to be bred and gestating sows up to day 40 of the gestation cycle. After day 40 the sows were moved to the LG Barn where they were held until ready to give birth at which time they were moved into a farrowing room. The B/EG Barn also received new breeding stock and held culled stock until they were hauled off. As a result, B/EG's population fluctuated somewhat while the LG Barn was maintained at capacity.

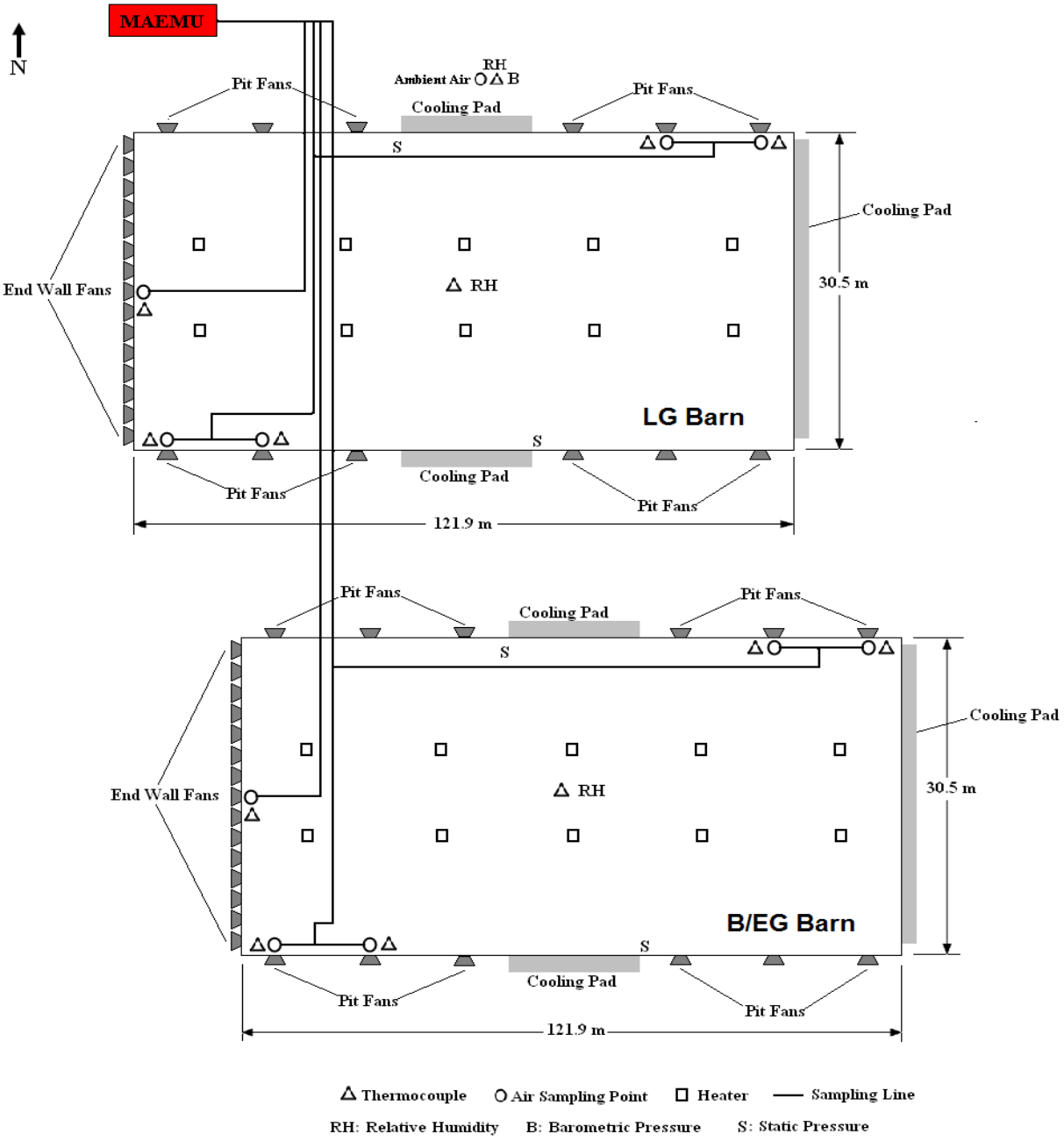


Figure 2. Diagram of B/EG and LG Barns showing air sampling, temperature, static pressure, relative humidity, and barometric pressure measurement locations.

A Mobile Air Emissions Monitoring Unit (MAEMU, fig. 3) was used to continuously collect data needed to determine emissions from the previously described barns and farrowing rooms. A detailed description of the MAEMU and its operation can be found in Moody et al. (2008). The MAEMU housed, among other measurement and data acquisition equipment, a photoacoustic multi-gas analyzer (INNOVA Model 1412, INNOVA AirTech Instruments A/S, Ballerup Denmark) to measure NH_3, CO_2, N_2O, and CH_4 concentrations. The analyzer was challenged weekly with calibration gasses and recalibrated as needed.

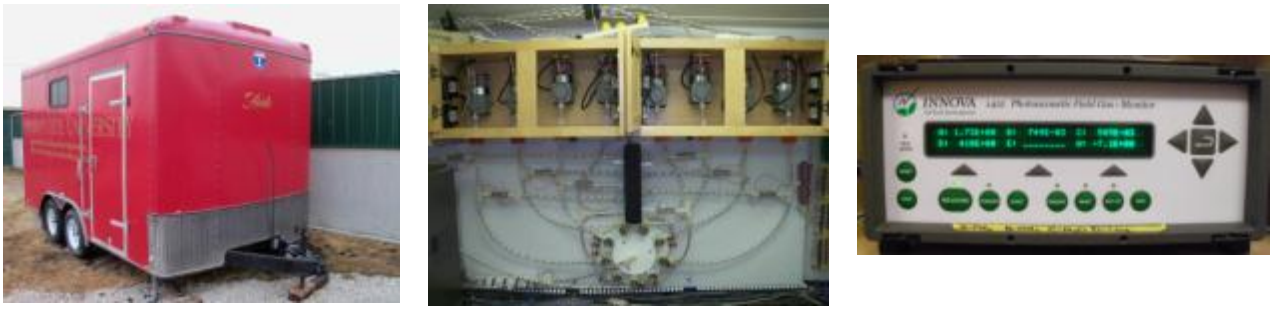


Figure 3. The Mobile Air Emissions Monitoring Unit (MAEMU) installed on the monitored B/G/F farm (left), gas sampling system (middle), and the Innova 1412 multi-gas analyzer (right).

Air samples were drawn for 120 s from each location. This corresponded to four 30-s measurement cycles of the analyzer. The fourth measurement value was taken as the exhaust air pollutant concentration. The 120 s sampling period corresponded to the T98 response time of 120 s for the analyzer. Samples were drawn from the 8 in-house locations and 1 outside location to provide ambient background data. Samples were drawn from each in-house location every 16 min (2 min per location) with the outside air being sampled every two hours for 6 min. The outside location can be seen in Figure 2 on the north side of LG Barn. Pit fan sampling ports were located below the slats/floor directly under each fan. Wall fan sampling ports were located approximately 1.0 m (3.28 ft) in front of each wall fan (fig. 4). The sample port locations were chosen to best represent the exhaust air leaving each barn/room. Each sample line contained three consecutive in-line filters (60, 20, 5 µm) to prevent particulate matter from entering and plugging/damaging sample lines, pumps, valves, and the gas analyzer. The MAEMU utilized a positive-pressure gas sampling system to minimize potential infusion of unwanted air to the sample line. All pumps and sample lines were checked weekly for leaks and blockages. All sample lines were protected from moisture condensation by using temperature-controlled resistive heat tape or trace.

All fans at the facility had single speed except for the 0.6m (24 in) wall fans in the farrowing rooms, which had variable speed. The fans were calibrated *in situ* at multiple operating points (i.e., static pressure) to develop a performance curve for each fan at the start of the project. This calibration was performed with a Fan Assessment Numeration System (FANS) (Gates et al. 2004) and every 6 months approximately 20% of the fans are measured again to check for performance drift (fig. 4). For the variable speed fans (0.6m wall fans in F1 and F2), the performance curve was derived as a function of static pressure and fan speed (revolutions per minute, RPM). For the single speed fans (all other fans) the performance curve was derived as a function of static pressure. The on/off status of each fan was monitored continuously by an inductive current switch on the each fan motor's power cord (Muhlbauer et al. 2011) with its analog output connected to the data acquisition system. The speed of the variable speed fans was measured by Hall Effect speed sensors (GS100701, Cherry Corp, Pleasant Prairie, WI). Static pressure sensors were located near the south wall of each farrowing room and near the middle of the north and south walls in B/EG and LG Barns.

Figure 4. Examples of exhaust air sampling ports (left & middle) and the in-situ ventilation fan calibration device used to determine air flow rate of the exhaust fans (right).

The external manure storage vat had a diameter of 48.8m (160 ft) and a depth of 4.57m (15 ft), but management did not allow manure depth to exceed 3.05m (10 ft). Manure originated in the farrowing rooms and was added every day from the farrowing rooms that were being weaned. The vat was pumped twice a year, in the fall and spring. A dynamic flux chamber system was developed similar to the one used by Acevedo et al. (2009). The chamber was floated on the vat manure surface for a range of ambient conditions and gas concentrations were measured with an Innova 1412 photoacoustic analyzer. Figure 5 shows the monitoring system with the floating dynamic flux chamber.

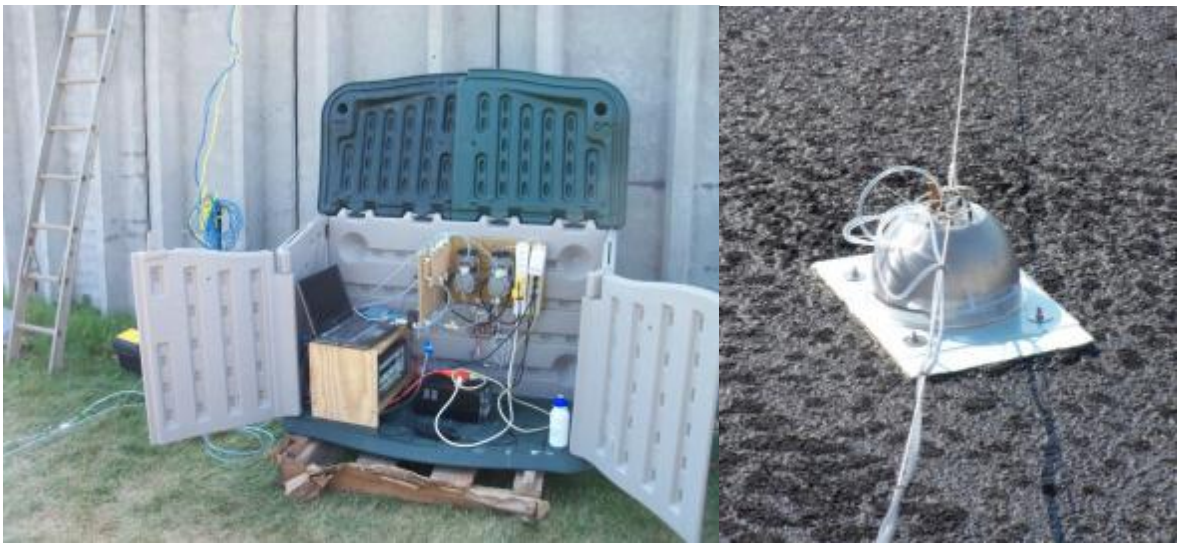


Figure 5. External manure storage monitoring system (left) and floating dynamic flux chamber on the manure storage surface (right)

Results

Ammonia (NH_3) and GHG (CO_2, CH_4, N_2O) Emissions from the Barns and Rooms

The daily emission rates of ammonia and the greenhouse gasses for the B/EG and LG Barns are shown in Figure 6 in kg per barn per day. The daily emission rates for F1 and F2 Rooms are shown in Figure 7 in kg per room per day.

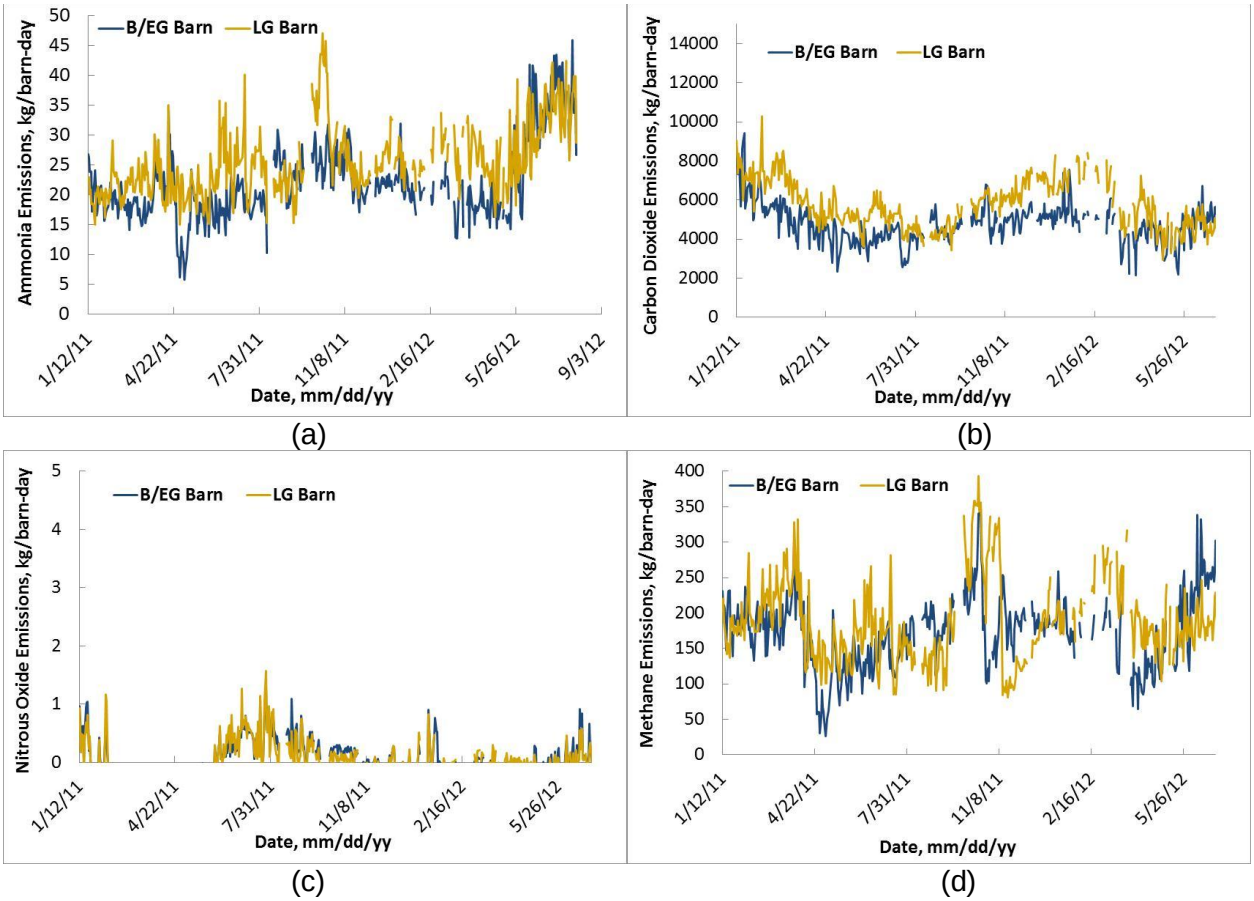
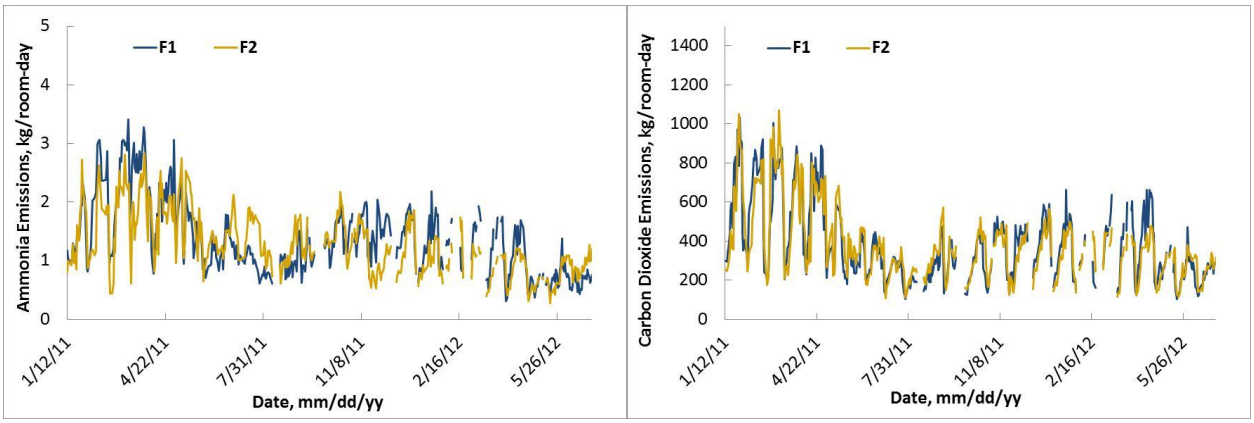
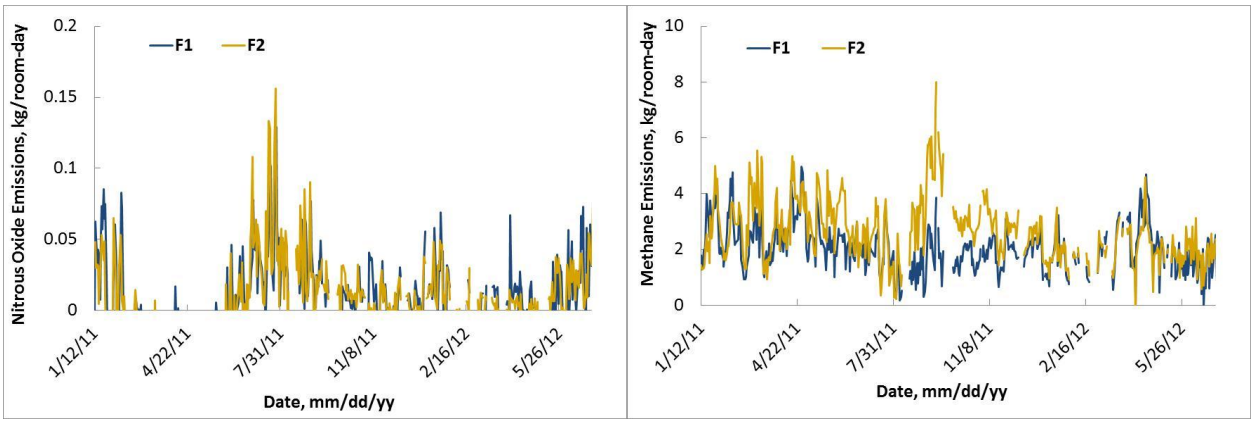


Figure 6: Daily emission data for deep-pit breeding/early gestation (B/EG) and late gestation (LG) barns for January 2011-June 2012 in kg/(barn-day), (a) ammonia, (b) carbon dioxide, (c) nitrous oxide, (d) methane



(a) (b)



(c) (d)

Figure 7: Daily emission data for shallow-pit farrowing rooms 1 and 2 (F1 & F2) for January 2011-June 2012 in kg/(room-day), (a) ammonia, (b) carbon dioxide, (c) nitrous oxide, (d) methane

A summary of the monitoring period and results is shown in Table 2 with each barn/room's population, ventilation rate, and gaseous emission rate on a gram per day per animal unit (1 AU = 500 kg live weight) basis.

Table 2. Mean (SD) gaseous emission rates (g/d-AU) of the two monitored breeding/gestation barns and two monitored farrowing rooms (AU = animal unit = 500 kg body mass)

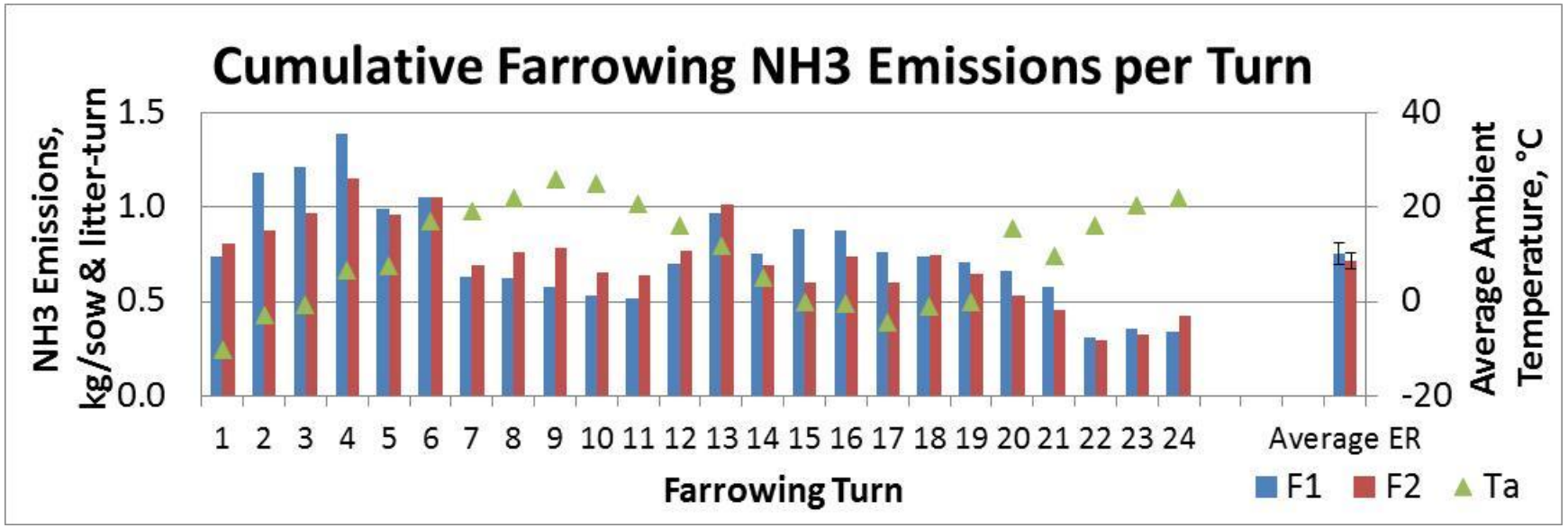
Barn or Room*	# of Days Monitored	# Pigs or Crates	VR (m^3/hr-pig)	Gaseous Emission Rate (g/d-AU)			
				NH_3	CO_2	N_2O	CH_4
B/EG	459	1652	106.35	33.1	7723	1.0	274
			(74.8)	(7.1)	(1821)	(0.4)	(80.3)
LG	459	1800	119.89	34.2	8075	0.2	260
			(81.1)	(7.7)	(1859)	(0.3)	(89.9)
F1	459	40	376.37	80.1	22300	0.8	118
			(244.2)	(35.1)	(11180)	(1.2)	(49.5)
F2	459	40	380.26	73.6	21767	0.8	152
			(283.6)	(30.0)	(10627)	(1.2)	(63.8)
Farrowing Room Average			378.32	76.9	22034	0.80	135
			(263.89)	(32.6)	(10904)	(1.2)	(56.7)

* B/EG = breeding and early gestation; LG = late gestation; F1, F2 = farrowing room 1 and 2

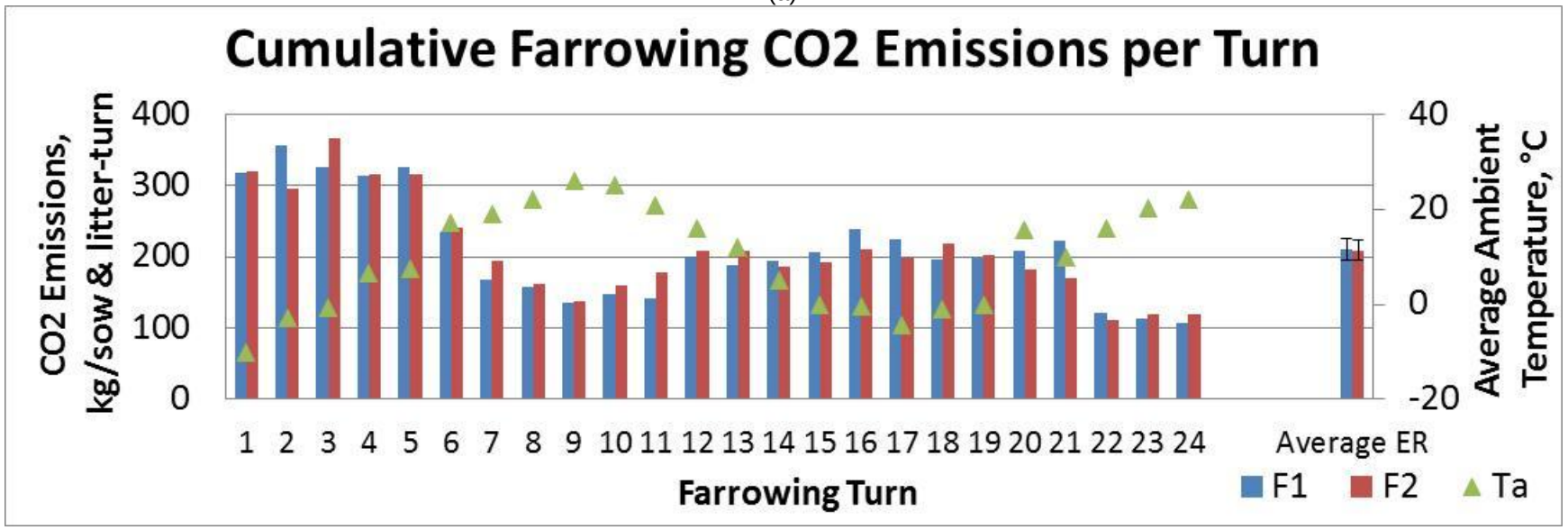
A summary of each turn's duration, average litter size at weaning, and average weaned piglet weight is provided in Table 3. Another way to look at the emissions from the farrowing rooms is on a cumulative per turn basis. Figure 8 shows the cumulative emissions of each constituent per turn and the running average per turn.

Table 3. Summary of farrowing production with turn duration, average weaned litter size, and average weaned weight for rooms F1 and F2

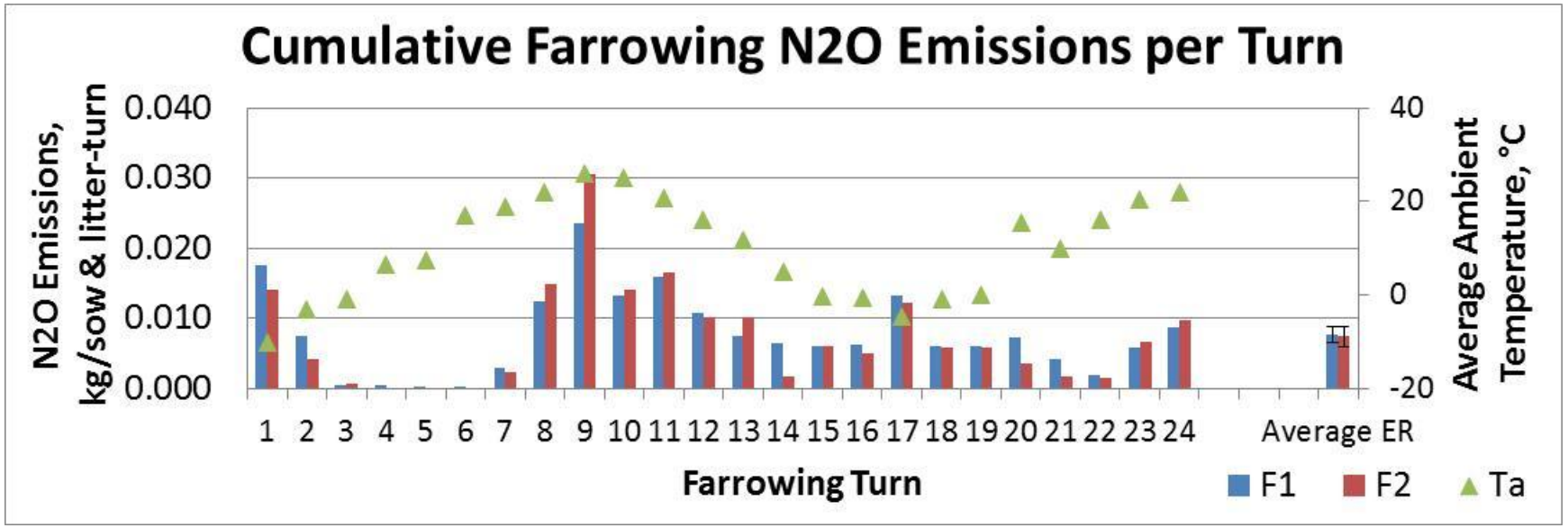
Turn	F1				F2			
	Weaning Date	Turn Length (days)	Ave. Litter Size	Ave. Weaned Weight (kg)	Weaning Date	Turn Length (days)	Ave. Litter Size	Ave. Weaned Weight (kg)
1	2/1/11	21	10.1	5.81	2/3/11	23	10.2	6.01
2	2/23/11	22	10.0	5.62	2/24/11	21	11.0	5.57
3	3/17/11	22	10.4	5.45	3/18/11	22	10.7	5.14
4	4/8/11	22	10.8	5.61	4/11/11	24	10.3	5.46
5	4/29/11	21	10.3	5.68	5/2/11	21	10.9	5.89
6	5/23/11	24	10.7	5.08	5/24/11	22	10.7	5.75
7	6/14/11	22	10.8	5.70	6/15/11	22	10.8	5.05
8	7/4/11	20	10.4	5.85	7/6/11	21	11.0	5.67
9	7/26/11	22	10.2	5.44	7/27/11	21	9.7	5.28
10	8/16/11	21	9.9	6.05	8/17/11	21	9.9	5.70
11	9/6/11	21	10.1	5.80	9/7/11	21	10.2	5.85
12	9/29/11	23	9.5	6.45	9/30/11	23	10.4	5.66
13	10/27/11	28	10.5	5.74	10/28/11	28	10.5	5.77
14	11/15/11	19	9.7	5.94	11/16/11	19	10.2	5.83
15	12/9/11	24	9.6	6.01	12/12/11	26	9.7	6.00
16	1/2/12	24	9.9	5.90	1/3/12	22	9.9	6.11
17	1/26/12	24	10.3	5.89	1/27/12	24	10.7	5.16
18	2/17/12	22	9.9	5.90	2/20/12	24	10.1	5.81
19	3/12/12	24	10.2	6.06	3/13/12	22	10.5	6.41
20	4/3/12	22	10.6	5.55	4/4/12	22	10.3	5.65
21	4/23/12	20	10.2	6.03	4/24/12	20	9.9	5.57
22	5/10/12	17	10.2	5.58	5/11/12	17	10.2	5.64
23	5/30/12	20	10.6	6.16	5/31/12	20	10.3	5.78
24	6/18/12	19	10.4	5.61	6/19/12	19	10.1	5.42
Average		**22**	**10.2**	**5.79**		**22**	**10.3**	**5.66**


Cumulative Farrowing NH3 Emissions per Turn
NH3 Emissions, kg/sow & litter-turn
1.5
1.0
0.5
0.0
40
20
0
-20
Average Ambient Temperature, °C
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Average ER
Farrowing Turn
F1
F2
Ta

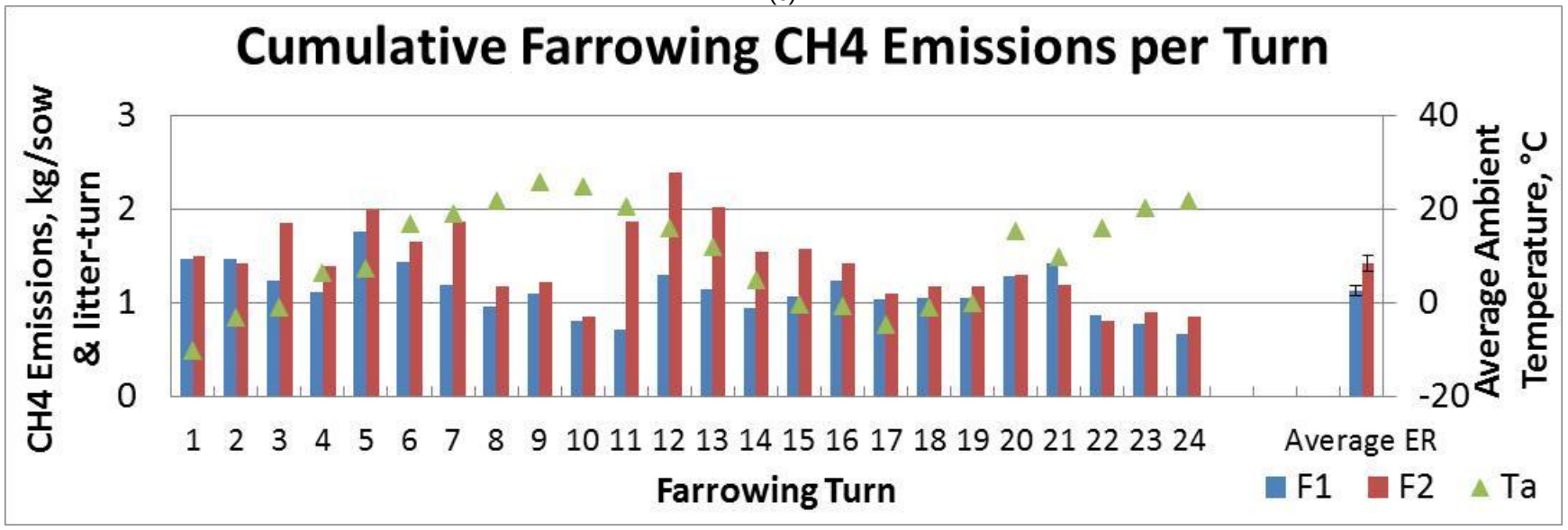
(a)


Cumulative Farrowing CO2 Emissions per Turn
CO2 Emissions, kg/sow & litter-turn
400
300
200
100
0
40
20
0
-20
Average Ambient Temperature, °C
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Average ER
Farrowing Turn
F1
F2
Ta

(b)



(c)



(d)

Figure 8. Cumulative emissions per farrowing turn for F1 and F2 of (a) ammonia, (b) carbon dioxide, (c) nitrous oxide, and (d) methane

Ammonia (NH_3) and GHG (CO_2, CH_4, N_2O) Emissions from the External Manure Storage

Figure 9 shows emission rates from the external manure storage as measured by the dynamic flux chamber at an air exchange rate of 30 air changes per hour (ACH). The emissions rates were correlated to the average daily ambient temperature, which allowed the flux values to be extrapolated for the entire monitoring period. Table 4 shows the resulting average daily emission rate from external storage based on the measured ambient temperatures during the monitored period. Table 4 also shows the average daily emissions from the farrowing barns, the LG Barn, and the B/EG Barn in kg/day along with the percentage of daily emissions each source is responsible for.

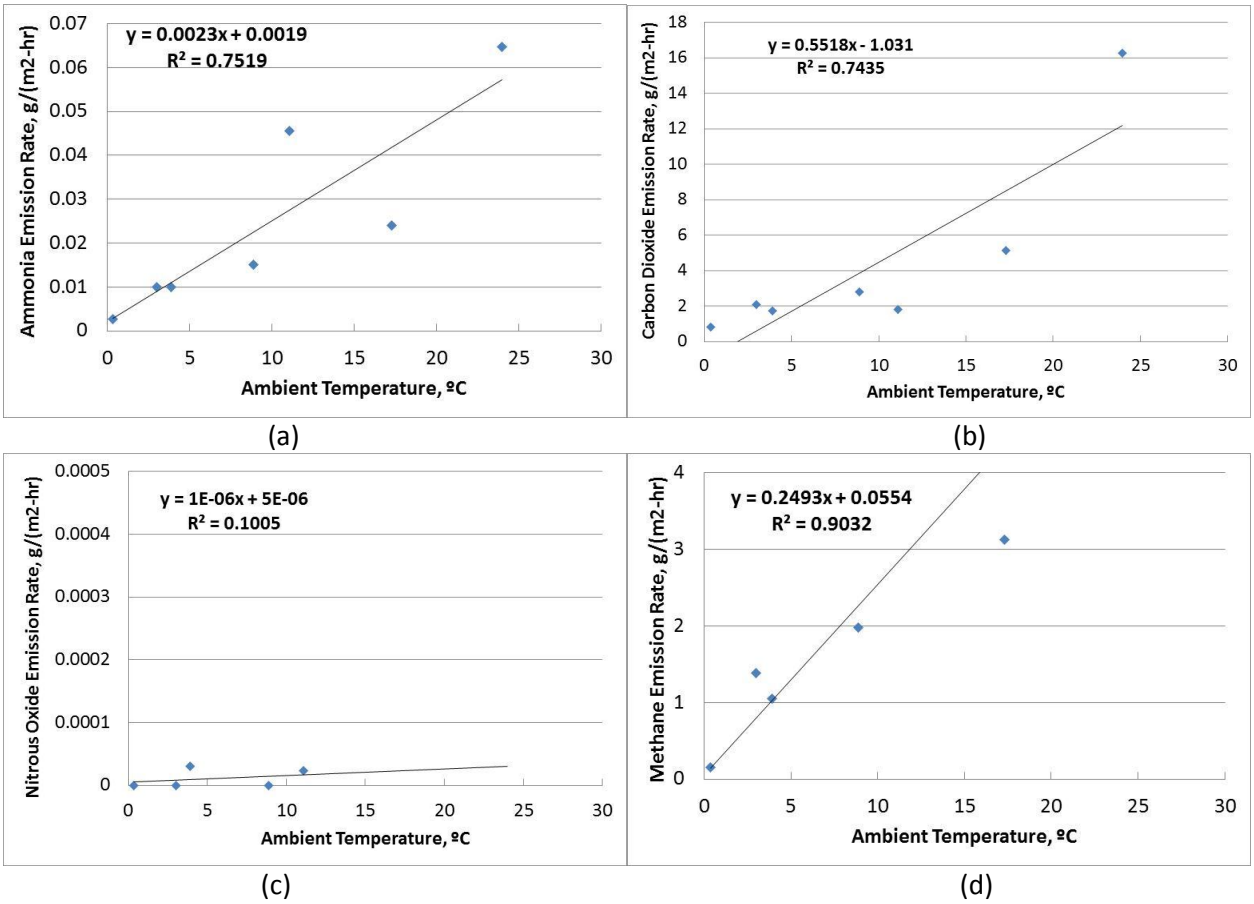


Figure 9. Average emission rates for (a) ammonia, (b) carbon dioxide, (c) nitrous oxide, and (d) methane from external manure storage measured with dynamic flux chamber at 30 air changes per hour.

Table 4. Average daily emission rates and percentage of whole farm emissions for external manure storage, farrowing barns, LG Barn, and B/EG Barn

Source		NH_3	CO_2	N_2O	CH_4
B/EG Barn	kg/day	22.0	4810	0.07	180
	% Farm Emissions	36.1%	33.9%	32.1%	35.5%
LG Barn	kg/day	25.6	5671	0.01	187
	% Farm Emissions	42.0%	40.0%	5.3%	37.0%
Farrowing Barns	kg/day	12.2	3490.1	0.1	21.3
	% Farm Emissions	20.0%	24.6%	62.2%	4.2%
External Storage	kg/day	1.1	221	0.001	118
	% Farm Emissions	1.9%	1.6%	0.3%	23.2%

Stored Manure Characteristics during the Emissions Monitoring Period

Table 5 shows the constituent concentrations, physical and chemical characteristics of the manure samples collected from the B/EG Barn, LG Barn, F1 Room, F2 Room, and the external manure storage. Samples were collected monthly from the B/EG and LG Barn and the external storage. Samples from F1 and F2 were collected at the end of each farrowing turn. Samples were shipped to an external laboratory for analysis.

Table 5. Average values of manure properties for monthly samples from B/EG Barn, LG Barn, F1 Room, F2 Room, and the external manure storage

Manure Property	B/EG Barn	LG Barn	F1 Room	F2 Room	Storage
Ammonium Nitrogen, ppm	2209	2142	1955	1821	2008
Organic Nitrogen, ppm	1110	553	703	500	1200
Total Nitrogen, ppm	3319	2695	2655	2321	3208
Phosphorus, ppm	2422	1061	906	509	2744
Potassium, ppm	1457	1541	1737	1670	1972
Sulfur, ppm	305	206	266	249	361
Calcium, ppm	1396	527	644	401	1749
Magnesium, ppm	498	190	234	141	608
Sodium, ppm	356	339	362	330	418
Copper, ppm	10	2	2	1	15
Iron, ppm	119	37	34	20	132
Manganese, ppm	16	7	5	3	19
Zinc, ppm	57	17	12	7	80
Total Solids, %	2.7%	2.2%	1.7%	1.5%	2.7%
Volatile Solids, %	57.9%	55.9%	64.3%	62.7%	60.8%
pH	8.15	8.32	7.88	7.85	8.12

Discussion

The results of this study to date indicate that gaseous emission rates from the Midwest swine breeding, gestation and farrowing facility are possibly higher than the current literature values in all cases except for CH_4 emissions from the farrowing rooms. Zhu et al. (2000) measured NH_3 emissions from several swine facilities in Minnesota, including a deep-pit gestation and deep-pit farrowing building. The gestation building had an emission rate of 0.007 to 0.014 g/h-m^2, which when scaled to the B/EG and LG barns gave a range of 0.76 to 1.52 kg/d-barn. This is far below the measured 25.6 and 22.0 kg/d-barn from this study. For the farrowing barns, Zhu et al. reported a range of 0.01 to 0.18 g/h-m^2, which would scale to 0.36 to 0.93 kg/d-room. This was again lower than the measured 1.32 and 1.26 kg/d-room for F1 and F2. Zhang et al. (2007) measured GHG emissions from two mechanically ventilated farrowing farms. The farrowing barns followed the same 3-week pit-flushing period as used for F1 and F2. Emission rates of CH_4 ranged from 73 to 351 g/d-AU, encompassing the measured emission rates of 118 and 152 g/d-AU of our current study. Zhang et al. also reported CO_2 emission rates of 16.6 and 11.6 kg/d-AU, which were lower than the measured 22.3 and 21.8 g/d-AU emission rates in the current study. Zhang et al. did not measure any significant N_2O emissions, while the emissions from the farrowing rooms 1 and 2 averaged 0.8 and 0.8 g/d-AU.

The higher emission rates are likely due to this facility being a deep-pit system for the B/EG Barn (breeding and early gestation) and the LG Barn (late gestation) and the nearly continuous sampling employed in this study as compared to the intermittent sampling used in the literature studies. The high variability of emission rates from day to day and the significant diurnal changes in both gas concentrations and ventilation rates stress the importance of developing and verifying a less labor and cost intensive system for quantifying barn-level emissions.

For cumulative farrowing emissions on a per turn basis, ammonia and carbon dioxide emissions seem to have an inverse correlation to ambient temperature. Nitrous oxide emissions seem to be positively correlated to ambient temperature. Methane emission does not show any clear relationship to ambient temperature. The increase in carbon dioxide emissions with decrease in temperature is partially explained with the increased heater usage and possibly increase in feed intake under colder climate.

When the external manure storage and farrowing barn emissions are compared, the manure storage is the main methane emission source (85% of total farrowing emissions), but a small source of ammonia (8.5%), carbon dioxide (6%), and nitrous oxide (5%) emissions. When compared to the whole farm emissions, the external manure storage was responsible for 23% of the methane, 1.9% of ammonia, 1.6% of carbon dioxide, and 0.3% of nitrous oxide emissions.

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Simultaneous Chemical and Sensory Characterization of Volatile Organic Compounds and Semi-Volatile Organic Compounds Emitted from Swine Manure using Solid Phase Microextraction and Multidimensional Gas Chromatography–Mass Spectrometry–Olfactometry

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Swine manure is associated with emissions of odor, volatile organic compounds (VOCs) and other gases that can affect air quality on local and regional scales. In this research, a solid phase microextraction (SPME) and novel multidimensional gas chromatography–mass spectrometry–olfactometry (MDGC-MS-O) system were used to simultaneously identify VOCs and related odors emitted from swine manure. Gas samples were extracted from manure headspace using Carboxen/polydimethylsiloxane (PDMS) 85-µm SPME fibers. The MDGC-MS-O system was equipped with two columns in series with a system of valves allowing transfer of samples between columns (heartcutting). The heartcuts were used to maximize the isolation, separation, and identification of compounds. The odor impact of separated compounds was evaluated by a trained panelist for character and intensity. A total of 295 compounds with molecular weights ranging from 34 to 260 were identified. Seventy one compounds had a distinct odor. Nearly 68% of the compounds for which reaction rates with OH·radicals are known had an estimated atmospheric lifetime <24 h.

Swine operations are sources of aerial emissions of odors, volatile organic compounds (VOCs), particulate matter, and other gases including NH_3, H_2S, and methane (NRC, 2003). Several research groups have investigated odor emissions from swine operations (Jacobson et al., 2003; Lim et al., 2003). The main source of malodor is microbial degradation in the anaerobic environment of manure storage. A number of studies have been conducted to identify compounds emitted from swine manure. However, a limited number of studies have attempted to determine the relationship between VOCs and corresponding odor. Schaefer (1977) identified 20 VOCs from liquid swine manure. More than 30 VOCs were identified as being responsible for malodor in fresh and rotten swine manure in the research conducted by Yasuhara et al. (1984). Twenty five odorous compounds were identified by Kai and Schafer (2004). Zahn et al. (1997) and Clanton and Schmidt (2000) have also reported recognition and identification of odorous VOCs from swine manure. To date, Schiffman et al. (2001) has by far the most comprehensive list of VOCs and fixed gases in air around swine production facilities that has been published with 324 compounds being tentatively identified. Comparison of sampling locations, methods, and VOCs related to swine manure and swine operations is presented in Table 1.

Volatile organic compounds identified in and around swine operations can be classified into different chemical groups including acids, alcohols, aldehydes, amines, volatile fatty acids (VFAs), hydrocarbons, ketones, indoles, phenols, nitrogen-containing compounds, sulfur-containing compounds, and other compounds (Schiffman et al., 2001). Thus, the chemical and sensory characterization of these compounds is quite challenging due to the wide range of physicochemical properties. Organic compounds with molecular weights from C_2 to C_9 were recognized as having the most impact to air quality at swine operations (Zahn et al., 1997). The boiling point (BP) of the key odorous VOCs such as indoles and VFAs ranged from less than 10°C to greater than 250°C and vapor pressures (VP) ranged from less than 10 Pa to greater than 100,000 Pa (Willig et al., 2004). Published detection thresholds (DTs) of VOCs identified in and around swine

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Abbreviations: BP, boiling point; DT, detection threshold; FID, flame ionization detector; GC, gas chromatograph; HAP, hazardous air pollutant; HC, heartcut; HS, headspace; MSD, mass selective detector; O, olfactometry; PDMS, polydimethylsiloxane; RT, column retention time; SPME, solid phase microextraction; TIC, total ion chromatogram; VOC, volatile organic compound; VP, vapor pressure.

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Table 1. Comparison of analytical methods used to characterize volatile organic compounds (VOCs) emitted from swine operations.

References	Sample type	Methodology†	Odor detection	No. of compounds identified
Schaefer, 1977	Liquid swine manure	GC-MS	human assessments	10 VOCs
Yasuhara et al., 1984	Fresh and rotten swine manure	GC-MS (packed column)	GC-FID with sniff port	31 compounds
Zahn et al., 1997	Air samples around swine facilities	GC-MS, GC-FID	n/a‡	27 VOCs
Yo, 1999	Swine wastewater	SPME-GC/MS	n/a	10 fatty acids
Clanton & Schmidt, 2000	Headspace of stored swine and dairy manure; and air inside swine buildings	GC, Jerome meter	dynamic olfactometry	20 sulfur-containing compounds
Schiffman et al., 2001	Air and lagoon wastewater at swine operations	GC/MS, GC/FID, GC/FPD	dynamic olfactometer, human assessments	324 VOCs
Begnaud et al., 2003	Swine manure headspace and air inside animal housing facilities	SPME-GC-MS	n/a	101 compounds
Kai and Schafer, 2004	Pig house air	GC-MS	GC-O	17 compounds (GC-MS); 25 compounds (GC-O)
Blunden et al., 2005	Air samples from areas included lagoons, ventilation fans, and upwind/downwind of swine facilities	GC-MS, GC-FID	n/a	17 sulfur-containing compounds

† GC-MS, gas chromatography–mass spectroscopy; GC-FID, gas chromatography–flame ionization detection; SPME-GC, solid phase microextraction–gas chromatography.

‡ n/a = not available.

operations in North Carolina ranged from greater than 100 μL L^{-1} to less than 0.001 μL L^{-1} (Schiffman et al., 2001). Large uncertainties are associated with published DTs (Devos et al., 1990; AIHA, 1989; Rychlik et al., 1998). For many compounds, the estimates of DTs continue to be adjusted or are not known.

Sample collection methods include the use of sorbent traps (e.g., Tenax, Tenax-TA), Tedlar bags, whole air sampling, and solid phase microextraction (SPME). Several standard methods based on sorbent tubes (USEPA TO-17) and whole canisters (USEPA TO-15) were developed for VOCs in ambient air in typical urban and less polluted rural environments (Woolfenden and McClenny, 1999; McClenny and Holdren, 1999). However, no standard method is available for odor-causing VOCs in livestock environments. This is because these compounds are often polar and reactive, can undergo reactions with themselves and interact with sampling lines and containers, and can be affected by the presence of moisture (Keener et al., 2002; Koziel et al., 2005). Thus, it has been challenging to develop robust sampling and analysis methods for these compounds. Some have attempted to modify existing TO-15 and TO-17 to sample the VOCs in and around swine operations (Schiffman et al., 2001; Zahn et al., 2001; Blunden et al., 2005). However, caution should be exercised when standard methods are modified for other compounds. SPME is an alternative for air sampling (Pawliszyn, 1997; Koziel and Pawliszyn, 2001).

SPME combines sampling and sample preparation into one step, reducing the sampling/sample preparation time. No solvent or pump is needed with SPME, and it is a reusable sampling technique suitable for laboratory and field work. SPME extractions are facilitated on a polymeric coating that has a high affinity for organic compounds. One potential useful characteristic of SPME fibers is that the polymeric coatings used are not affected by the presence of moisture when long sampling times are used (Miller and Woodbury, 2006). SPME has been used for sampling of volatile compounds in air (Koziel and Pawliszyn, 2001; Begnaud et al., 2003). Quantitative sampling of airborne compounds such as alkanes, aromatic hydrocarbons, and formaldehyde is possible with SPME (Martos and Pawliszyn, 1997; Martos and Pawliszyn, 1997; Koziel and Pawliszyn, 2001; Koziel et al., 2001). Larreta et al. (2006) quantified VOCs in cow slurry and Cai et al. (2007) used SPME to evaluate the effectiveness of zeolite to control VOCs and odors emissions from poultry manure. To date, relatively little progress has been made with SPME applications for the quantification of odorous gases in and around livestock operations. However, SPME has been useful for qualitative characterization and screening of livestock gases. Sampling of livestock VOCs and odorants with SPME has been used to characterize swine dust odorants (Cai et al., 2006), downwind odor impact of beef cattle feedlots (Wright et al., 2005), and downwind odor impact of swine finisher operations (Bulliner et al., 2006; Koziel et al., 2006).

Gas Chromatography–Olfactometry (GC-O)

Gas chromatography coupled with a flame ionization detector (FID) is often used for chemical separation and analysis of VOCs emitted from livestock operations (Schiffman et al., 2001; Begnaud et al., 2003; Kai and Schafer, 2004). The addition of a sniff port enables simultaneous chemical and olfactometry analysis of livestock odor (Kai and Schafer, 2004; Wright et al., 2005; Cai et al., 2006). To date, most GC-O applications are related to agriculture, food chemistry, and the consumer products industry. Another option is to combine olfactometry with GC-mass spectrometry (MS) for compound identification (Pollien et al., 1997). Cai et al. (2006) reported partitioning of odorants to various fractions of swine dust. Koziel et al. (2006) used GC-MS-O to analyze air samples downwind from swine finisher barns. Separation of livestock VOCs is typically accomplished on a single-column GC. However, a single column does not always have the capability to completely separate a complex air sample. Thus, multidimensional GC provides a new powerful way to resolve the complex livestock air.

Multidimensional Gas Chromatography

Multidimensional GC (MDGC) utilizing multiple columns represents the state-of-the-art refinement for the separation of VOCs and semi-VOCs. Most compounds emitted from livestock manure are polar and many characteristic odorants are semi-volatile. The use of a single column without enough resolution power may result in incomplete chromatographic separa-

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tion. Co-elution of two or more compounds is a critical obstacle in GC analysis (Bertsch, 1999) and it is even more critical for odor characterization. To date, conventional MDGC with heartcut (HC) has been used in the tobacco industry, the petroleum industry, and in food chemistry studies. Recently, the multidimensional gas chromatography–mass spectrometry–olfactometry (MDGC-MS-O) approach was used to analyze complex odorous samples from swine operations (Bulliner et al., 2006).

The overall objective of this research was to identify and characterize VOCs emitted from swine manure using SPME and MDGC-MS-O. To date, no study related to VOCs emitted from livestock operations has been conducted using the MDGC-MS-O system. The advantage of using MDGC-MS-O is the enhanced VOC separation and the simultaneous odor identification. It is critical to characterize swine manure VOCs and malodorous gases to improve the understanding of the environmental impact of swine operations. This knowledge is also needed to develop and evaluate odor and gas mitigation strategies and technologies.

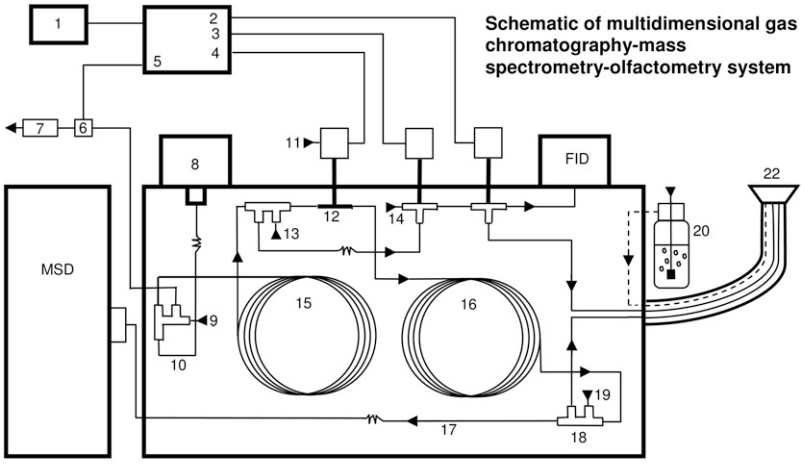

Fig. 1. Schematic of multidimensional gas chromatography–mass spectrometry–olfactometry (MDGC-MS-O).

Materials and Methods

Manure samples were collected from the nursery pit, the finisher pit and the outside storage pit at the Swine Nutrition and Management Research Farm (Ames, IA). Manure samples were then transported to the laboratory and dispensed 15 mL into 40 mL screw-capped vials with a polytetrafluoroethylene (PTFE)-lined silicone septum (Supelco, Bellefonte, PA). All vials were stored in a fume hood at room temperature up to 4 d before sampling.

Sampling and Sample Preparation of Swine Manure Headspace with Solid Phase Microextraction

Four commercially available SPME fibers, including Carboxen/PDMS 85 µm, PDMS 100 µm, Polyacrylate 85 µm, and PDMS/DVB 65 µm (Supelco, Bellefonte, PA), were first used to select the most efficient fiber coating in extracting VOCs and semi-VOCs emitted from swine manure. All SPME fibers were used for extracting headspace samples from replicates. All fibers were conditioned before first use according to the manufacturer's instruction. SPME fibers were inserted into each vial through the septum exposing the SPME fiber to the vial headspace. Preliminary experiments were conducted to determine the optimal SPME sampling time. Exposure times between 10 s and 24 h were examined. The number of compounds and the intensity of odor events increased with sampling time. Thus, samples with longer extraction times had a greater potential to reveal new compounds and odors. For practical reasons, a 24 h SPME extraction at room temperature was selected. It was assumed that long storage simulated anaerobic environment associated with higher malodor. With each extraction, the SPME fiber was removed immediately from the vial and was inserted into the GC injection port for analysis. All GC injector conditions were the same as reported in Cai et al. (2006).

Analyses of Swine Manure Headspace Samples with Multidimensional Gas Chromatography–Mass Spectrometry–Olfactometry

Simultaneous chemical and sensory analyses of gases emitted from swine manure were completed using the MDGC-MS-O (Microanalytics, Round Rock, TX) system. The system GC–MS-O components, the software, and basic GC oven programs are described in detail in Cai et al. (2006). The GC was operated in a constant pressure mode where the mid-point pressure, i.e., pressure between pre-column and analytical column (Fig. 1), was always at 5.8 psi and the HC sweep pressure was 5.0 psi. Multidimensional capability was used for better separation of gases and odors of compounds associated with swine manure. The MDGC-MS-O system was capable of working in three modes, i.e., GC-FID only, GC-FID-O, and GC-MS-O. The MultiTrax (Microanalytics, Round Rock, TX) software was used to control the timing of valves and HC for each mode.

Heartcut is as a fraction of a sample "cut" from the non-polar pre-column and transferred to the polar column with a Dean's switch between the two columns. Compounds were further separated on the polar column and then simultaneously analyzed on the mass selective detector and the sniff port. When the HC valve was opened (GC-MS-O mode), the gas sample was transferred from the pre-column into the polar column. When the HC valve was closed (GC-FID or GC-FID-O modes), the sample was not transferred into the polar column. Compounds were further separated on the polar analytical column and then simultaneously analyzed on the mass selective detector (MSD) and by the panelist at the sniff port. Only one trained panelist was responsible for odor determination throughout the entire study. A series of 30-s-wide HCs starting from 0.05 to 24 min (e.g., 0.05 min–0.5 min, 0.5 min–1 min, and so on) were used to methodically expand the

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chromatographic separation and enhance identification of new compounds. The total number of separate HCs was therefore 48.

Data Analysis and Interpretation

Three sets of signals were generated for each sample including the total ion chromatogram (TIC), the FID signal, and the aromagram (Bulliner et al., 2006). Data were analyzed using the AromaTrax, BenchTop/PBM (Palisade Corp., Ithaca, NY) and MSD ChemStation (Agilent Inc., Wilmington, DE) software as well as information from the NIST library (NIST, 2005). Compounds recorded in TICs for each HC were recognized and identified according to criteria: match of sample mass spectrum, retention time, and odor. Based on the recorded odor events, TIC were analyzed around the time in which the odor event began and the compound responsible for the odor was recognized. Whenever feasible, compounds were positively identified by matching the retention time and its mass spectra with that of a pure standard (Sigma-Aldrich, St. Louis, MS). Odor character related to a particular compound was recorded and compared with the odor databases at LRI & Odour Database (2005) and Flavornet (Acree and Arn, 2004).

Physicochemical properties for the identified compounds were selected to better characterize compounds emitted from swine manure. These physical and chemical properties included carbon number, BP, VP, water solubility (S), Henry's law constant (H_c), octanol-water partitioning coefficient (log-K_{ow}), atmospheric lifetime (τ), and the liquid- and gas-phase molecular diffusion coefficient (D_l and D_g, respectively). Examination of these properties is useful to develop air sampling methods and to model a chemical's fate once emitted from manure. Recently, the reactivity of VOCs released from livestock operations has been of interest to many researchers and regulatory agencies. In this research, τ was estimated based on the reaction with OH radicals using the following formula:

$$\tau = \frac{1}{k \times [\mathrm{OH}\cdot]} \quad [1]$$

where k is a rate constant at 298 K (cm^3 $molecule^{-1}sec^{-1}$) and [OH·] is an average atmospheric OH concentration of 1.0×10^6 molecule cm^{-3}. Values of k were obtained from Syracuse Research Corporation (2004) and ranged from 0 (H_2S) to 2.27 E-10 (Tropex). The estimation of D_g was more accurate using the Wilke and Lee method (Lyman, 1982). The estimation of D_l was made using the Hayduk and Laudie method (Lyman, 1982). Detection threshold for odor was based on Devos et al. (1990), AIHA (1989), and Rychlik et al. (1998).

Results and Discussion

Selection of Solid Phase Microextraction Fiber Coating

Four commercially available SPME fibers (85 µm Carboxen/PDMS, 100 µm PDMS, 85 µm Polyacrylate, and 65 µm PDMS/DVB) were used for selecting the most efficient coating. All four fibers were exposed to manure headspace for 24 h. Comparison of chromatograms obtained in GC-FID mode showed that all four SPME fibers were very efficient. However, the Carboxen/PDMS 85 µm coating was capable of extracting compounds in a wide range of column retention times (RTs) from very volatile to semi-volatile compounds (Lo, 2006). The Carboxen/PDMS 85 µm coating was more efficient in extracting very volatile compounds eluting with RTs up to 8 min. The second most efficient fiber in this region was the PDMS/DVB 65 µm, followed by the Polyacrylate 85 µm and the PDMS 100 µm coatings, respectively. Both the Carboxen/PDMS 85 µm and the PDMS/DVB 65 µm were also very efficient for midrange VOCs eluting between 8- and 23-min RT. The PDMS 100 µm and the PDMS/DVB 65 µm were the most efficient for semi-VOC compounds eluting later than 23 min. These observations were consistent with general guidelines for fiber selection (Pawliszyn, 1997).

Comparison of TIC signals of air samples collected in headspace of swine manure with four SPME fiber coatings and analyzed using the MDGC-MS-O mode was then completed (Lo, 2006). The identical 30 s heartcut between 11 and 11.50 min representing midrange volatility compounds was selected where all four fibers were expected to be very effective (Pawliszyn, 1997). The Carboxen/PDMS 85 µm coating was the most efficient in extracting the largest number of detectable (above the TIC baseline) compounds. The number of compounds identified with the same detection criteria were 9, 6, 6, and 3 for the Carboxen/PDMS 85 µm, PDMS/DVB 65 µm, PA 85 µm, and the PDMS 100 µm fiber coating, respectively. Also, no additional compounds were found in the TICs collected with SPME fibers other than those collected with the Carboxen/PDMS 85 µm coating.

The use of different SPME fiber coatings and its effects on odor were also examined. The comparison of aromagrams of air samples collected with four SPME fiber coatings and analyzed in the MDGC-MS-O mode resulted in concluding that the Carboxen/PDMS 85 µm coating was more effective in capturing odorous compounds. The number of odor events recorded using AromaTrax were 7, 4, 4, and 2 for Carboxen/PDMS 85 µm, PDMS/DVB 65 µm, Polyacrylate 85 µm, and the PDMS 100 µm fiber coating, respectively. In addition to number of odor events detected, odor intensity and odor event area were also compared (Lo, 2006). Odor event areas were calculated by the software using the following equation:

$$\text{Odor event area} = \text{odor duration} \times \text{odor intensity} \times 100 \quad [2]$$

where odor duration = odor event end time – event start time.

Carboxen/PDMS 85 µm and PDMS/DVB 65 µm coatings had the highest average odor intensities (22.3 and 22.8%, respectively), while Polyacrylate 85 µm coating ranked third (14.25%) and the PDMS 100 µm fiber coating yielded the lowest odor intensity recorded (7.5%). Among these four different SPME coatings, the Carboxen/PDMS 85 µm coating had the highest total peak area count while the PDMS 100 µm coating ranked last. Carboxen-containing coatings were very efficient in extracting VFAs and sulfur compounds. Fibers with a divinylbenzene (DVB) phase were generally more efficient in extracting phenolics.

Based on the comparison of both the chemical and olfactometry data analysis, Carboxen/PDMS fiber coating was the most effective coating for VOCs/semi-VOCs extraction in terms of number of compounds extracted (both in GC-FID

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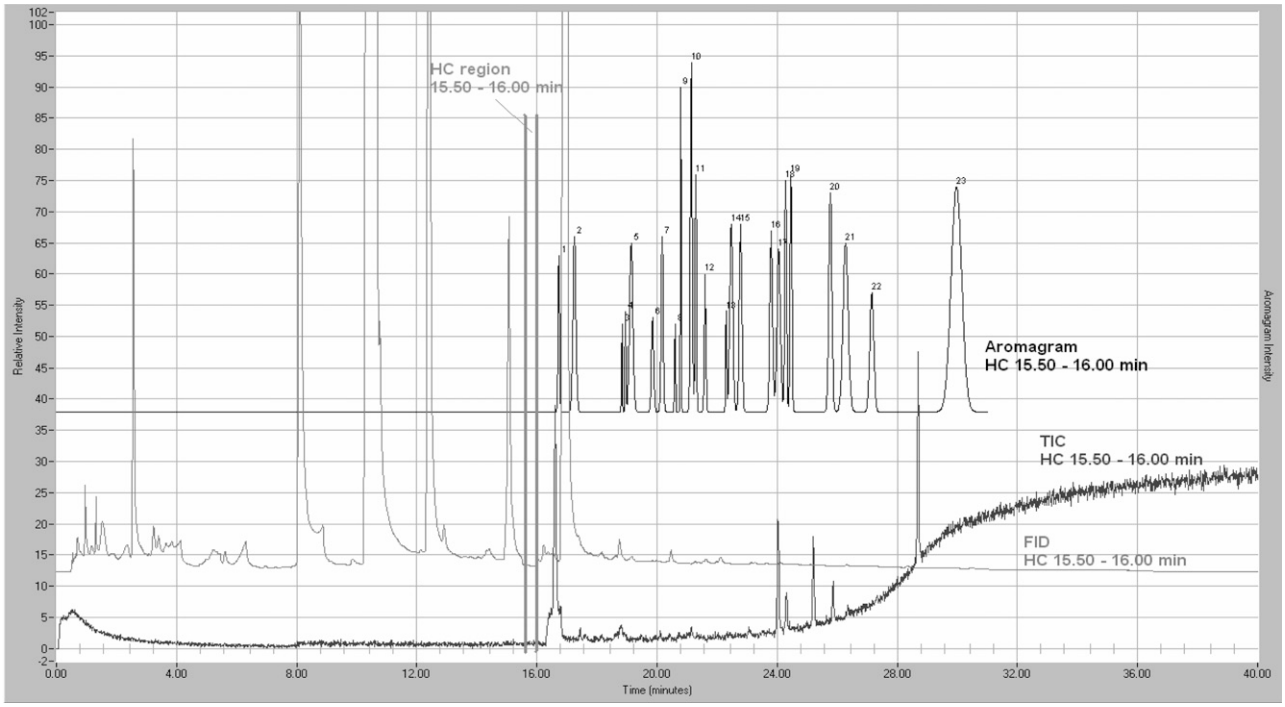

Fig. 2. Comparison of aromagram, flame ionization detector (FID), total ion chromatogram (TIC) signals with heartcut (HC) between 15.50 and 16.00 min.

mode and MDGC-MS-O mode), number of odor events recorded, odor intensity, and odor event peak area count. Therefore Carboxen/PDMS 85 µm coating was selected for subsequent extractions of gases from swine manure headspace.

Solid Phase Microextraction Replications

Three replications of the same 30-s-wide HC using three different Carboxen/PDMS 85 µm fibers were analyzed using MDGC-MS-O mode to determine variability between the TIC signals and odor events. All three fibers were exposed to manure headspace for 24 h under room temperature. Five of the most significant peaks from these three replicates were selected for qualitative comparisons using peak area integrations with MSD ChemStation. The relative standard deviation (RSD) of the peak area count were 40.7, 20.7, 27.3, 1.3, and 3.9% for 5-undecene, 1-octanethiol, benzeneethanol, phenol, and 4-methylphenol, respectively. These apparent variations are likely due to uncontrolled microbial activity in manure replicates. These variations did not have a significant effect on the detection and identification of compounds.

Aromagrams recorded using AromaTrax from the three replicates analyzed in the MDGC-MS-O mode were compared for odor intensities. Seven odor events were consistently detected and recorded for the HC 11 to 11.50 min. Average odor intensities varied from 11.3 to 29.0% on 100% relative scale. The RSD for these odor intensities varied from 6.0 to 54.4% (mean = 25.2%). Besides the variability introduced by the panelist, the results were also affected by uncontrolled microbial activity and resulting variability in gaseous emissions in each vial.

The comparison of both chemical and olfactometry data obtained from experiments comparing SPME fiber coatings and comparing the three replicates using the same fiber coating (i.e., Carboxen/PDMS 85 µm) were satisfactory and suitable to address the objectives of this research. Identification of compounds and their odor character was consistent in all replicates, and aroma peaks analysis was consistent in all three replicates, with an acceptable variation in odor intensity and peak area count. Therefore Carboxen/PDMS 85 µm SPME fiber for swine manure headspace extractions was selected for all remaining air sampling for the chemical and sensory analysis in this research.

Multidimensional Gas Chromatography–Mass Spectrometry–Olfactometry

Headspace samples were analyzed with the MDGC-MS-O mode utilizing 30-s-wide HCs. During those HCs, the midpoint valve was opened for only 30 s allowing a narrow range of separated compounds from the pre-column to be transferred to the analytical column for better separation. An example of a 30-s HC is shown in Fig. 2. The aromagram recorded was only for the odors detected from the 30-s-wide HC and sent from the pre-column to the polar column. It is interesting to note that only 23 odor events were recorded, much less than the events from the full HC (Lo, 2006), which allowed for easier matching of odor events and chemical compounds. The chromatographic separations were improved. Sample background from co-eluting compounds was also lower, allowing for improved spectral matches. Note that only one panelist was responsible for odor determination in this study. If multiple panelists were used, it is natural to expect some variations related to odor character and intensity between panelists due to subjective human response. Discussion of RSDs related to human perception of *p*-cresol for three panelists using MDGC-MS-O was reported by Bulliner et al. (2006).

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Identification of Volatile Organic Compounds and Semi-Volatile Organic Compounds

A summary of all compounds identified in swine manure headspace is shown in Table 2. Table 2 contains the chromatographic retention time, compound name, the CAS number and the heartcut timing for which a compound was first detected. Some compounds were identified in several HCs. This was due to the insufficient chromatographic separation on the 12 m nonpolar precolumn where the peaks were often wide. Thus, HCs set for equal 30-s intervals were transferring them to the column several times. It is interesting to mention that the resulting retention time of the compound shifted slightly toward longer times if the compound was heartcutted from a wide peak. This was due to the change of mid-point pressure during each heartcut. For semi-VOC, the shift of RTs was greater than the RT shift for VOCs.

Whenever applicable, published or detected odor character (CambridgeSoft Corporation, 2006; NIST, 2005), detection threshold (Devos et al., 1990; AIHA, 1989; Rychlik et al., 1998), presented in μL L^{-1}, and estimated atmospheric lifetime (using Eq. [1]) are also presented in Table 2. Odor descriptors recorded by the panelist in this study were presented, along with odor descriptors obtained from Flavornet (Acree and Arn, 2004) and LRI & Odour Database (2006).

A total of 295 compounds emitted from swine manure were identified. These compounds can be classified into 12 chemical classes with the numbers of compounds in each class, i.e., acids (9), alcohols (33), aldehydes (4), aromatics (32), esters (6), ethers (10), fixed gases (2), hydrocarbons (36), ketones (71), nitrogen-containing compounds (35), phenols (19), and sulfur-containing compounds (38). Molecular weights ranged from 34 to 260. Of these 295 compounds, 113 were positively confirmed with pure standards. Approximately 25% of the total compounds had distinct odor. Approximately 107 compounds had been reported in previous studies (Table 1) (Yasuhara et al., 1984; Clanton and Schmidt, 2000; Zahn et al., 2001; Schiffman et al., 2001; Begnaud et al., 2003; Willig et al., 2004; Kai and Schafer, 2004). The total of 188 compounds was reported here for the first time (Tables 1 and 2) and 26 of them had a distinct odor. The difference in chemical/odor distribution between the three different locations (nursery pit, finisher pit, and outside storage) where manure was collected was not the scope in this study. However, it is reasonable to assume that some differences in emission rates of the majority of VOCs emitted from manure are associated with variables such as the diet, manure origin and age, manure management, season, and location. Zahn et al. (1997) reported some evidence that there is a link between the source and the specific VOCs related to swine manure. However, more work is needed to provide such chemical and odor profiles as a function of aforementioned variables.

To date, the most comprehensive list of VOCs associated with swine manure was published by Schiffman et al. (2001) with 324 compounds listed. However, close inspection of the data shows that this list was made based on chemical analysis of swine manure and air samples collected around swine operations in North Carolina. If only the compounds found in air samples are considered, the list is reduced to 251 compounds (Schiffman et al., 2001). In this research, a total of 295 compounds were found in the headspace of swine manure. In addition, Schiffman et al. (2001) quantified 81 compounds based on surrogate calibrations for a subset of 14 compounds only. There is no information about the number of compounds that were confirmed with pure standards except the listed 14 (for calibrations). In this research, 113 compounds were positively confirmed with standards.

Sixteen compounds found in this research are listed as hazardous air pollutants (USEPA, 2002). Note that quantification of chemicals emitted from swine manure was not part of the objective of this research, thus the concentrations of these 16 compounds were not estimated. Future research is warranted to determine concentrations, emission rates, and fate of these compounds. The 16 compounds classified as hazardous air pollutants (HAPs) were: carbon disulfide, 2-butanone, benzene, 4-methyl-2-pentanone, toluene, ethyl-benzene, 1,4-dimethyl-benzene, 1,3-dimethyl-benzene, 1,2-dimethyl-benzene, ethenyl-benzene, naphthalene, quinoline, phenol, 2-methyl-phenol, and 4-methyl-phenol.

Only 77 compounds identified had DTs published in previous studies (AIHA, 1989; Devos et al., 1990; Rychlik et al., 1998). Detection thresholds are summarized in Table 2 and Fig. 3 where the DTs are presented in a frequency distribution chart with ranges from 0.001 nL L^{-1} to 1 μL L^{-1}. The majority (∼80%) of compounds had their DTs between 1 nL L^{-1} and 1 μL L^{-1}. The six compounds with a DT less than 1 nL L^{-1} (i.e., most odorous compounds) were 2-bromo-phenol, indole, 2,4-hexadienal, skatole, 2-chloro-phenol, and 2,6-dimethyl-phenol. Approximately 47% of compounds summarized in Fig. 3 had odor character that can be considered "offensive," 31% had odor character that can be considered "neutral," and 22% had "pleasant" odor character. This summary was based on the assessment of odor descriptors summarized from this research as well as from Flavornet (Acree and Arn, 2004) and LRI & Odour Database (2006).

Characterization of Physicochemical Properties of Volatile Organic Compounds

Physicochemical properties of VOCs are useful for the comprehensive characterization, including analytical methods development, measurements, modeling, fate, and development, of emissions abatement approaches. These parameters were obtained from several databases including the Syracuse Research Corp. (2004), NIST WebBook (National Institute of Standard and Technology, 2005) and CambridgeSoft Corp. (2006), while the gas phase and liquid phase diffusion coefficients were calculated based on the methods from Lyman (1982). In general, VOCs emitted from manure represent very wide ranges of physicochemical properties. A summary of all findings was presented by Lo (2006). Approximately 89% of the compounds identified fell into the category of VOCs and semi-VOCs (<12C) (De Nevers, 1995; Peterson, 2005) with about 74% within C_5 to C_{10}. The compound identified with the highest carbon number was heptadecane ($C_{17}H_{36}$), and the compounds with the lowest carbon number included methanethiol (CH_4S) and carbon disulfide (CS_2). It is interesting to mention that as many as 31 of the identified compounds (∼11%) had a carbon number ≥12. In a straight sense these compounds were

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Table 2. Summary of compounds identified from swine manure headspace.†

Compound name	RT	CAS #	HC	Odor descriptors	Detection threshold‡	Estimated Tau(OH)§	References¶						
							1	2	3	4	5	6	7
	min		min		μL L^{-1}	h							
Acids													
2-Ethyl-hexanoic acid	21.78	149-57-5	11.00–11.50	paint, varnish#			x						
Acetic acid	13.26††	64-19-7	1.50–2.00	acidic/sour‡‡/acetic, vinegar#	1.45E-01		x	x		x	x		x
Benzenepropanoic acid	31.15	501-52-0	16.00–16.50	balsamic‡‡	3.89E-03		x						
Butanoic acid	16.48††	107-92-6	4.00–4.50	fatty acid, musty/rancid, cheese, sweat‡‡/ butter, butyric#	1.95E-02		x	x	x	x	x		x
Isobutyric acid	15.41††	79-31-2	2.50–3.00	rancid, butter, cheese‡‡	2.45E-03		x	x	x	x	x		x
Isovaleric acid	17.16††	503-74-2	4.50–5.00	fatty acid, foul, sweat, buttery, fecal/aci,	2.45E-03		x	x		x	x		x
Pentanoic acid	18.35††	109-52-4	5.50–6.00	body odor, burnt/sweat‡‡/dirty socks, parmesan cheese, sweaty#	4.79E-03		x	x		x			x
Propanoic acid	14.88††	79-09-4	1.50–2.00	fatty acid, body odor/pungent, rancid, soy‡‡	0.066§§		x	x	x	x	x		x
Alcohols													
(-)-Lavandulol	18.05	498-16-8	12.00–12.50	sulfury/herb‡‡		1.89E+00							
1-Butanol	6.90††	71-36-3	1.00–1.50	fruit/medicine, fruit‡‡/floral, fragrant, sweet#	4.90E-01	3.24E+01	x	x		x			
1-Hexanol	11.48††	111-27-3	5.00–5.50	grassy, Musty/resin, flower, green‡‡	4.37E-02	2.22E+01	x	x					
1-Menthol	17.61	2216-51-5	12.00–12.50	Mint/peppermint‡‡/mint#		1.15E+01							
1-Methylcyclopentanol	8.91	1462-03-9	2.50–3.00			3.45E+01							
1-Pentadecanol	20.20	629-76-5	18.00–18.50			1.24E+01							
2-(2-Ethoxyethoxy)-ethanol	16.68	111-90-0	9.50–10.00			4.86E+00	x						
2-(Methylthio) ethanol	14.73††	5271-38-5	4.00–4.50										
2,3-dimethyl-2-butanol	6.28	594-60-5	2.00–2.50			3.13E+01							
2-Butanol	4.48††	78-92-2	0.50–1.00	wine‡‡/alcoholic#	1.70E+00	2.89E+01	x	x					
2-ethyl-1-hexanol	14.48††	104-76-7	9.00–9.50	Grassy/rose, green‡‡	2.45E-01	2.10E+01	x	x					
2-Heptanol	11.05††	543-49-7	5.50–6.00	Mushroom/melon, mushroom‡‡#		1.96E+01		x					
2-Hexanol	7.61	626-93-7	2.00–2.50		7.41E-01	2.30E+01							
2-Methyl-1-pentanol	10.40††	105-30-6	4.00–4.50		7.76E-02	2.78E+01							
2-Methyl-2-pentanol	6.25††	590-36-3	1.50–2.00	pungent‡‡		4.05E+01	x	x					
2-Methyl-3-pentanol	7.51	565-67-3	2.50–3.00			1.93E+01							
2-Octanol	13.33††	123-96-6	8.50–9.00	Mushroom/fat, coconut, oil, rancid, walnut, mushroom‡‡#	5.62E-03	1.78E+01							
2-Pentanol	6.46	6032-29-7	1.50–2.00	green‡‡/alcoholic,ethery,fruit,nutty, raspberry#		2.35E+01							
3-Heptanol	10.61	589-82-2	5.50–6.00	herb‡‡		1.75E+01							
3-Hexanol	8.33††	623-37-0	3.00–3.50			1.92E+01		x					
3-Methyl-2-pentanol	8.31	565-60-6	2.50–3.00		1.10E+00	2.12E+01	x						
3-Methyl-3-buten-1-ol	9.11††	763-32-6	1.50–2.00	fecal, skunky		4.89E+00							
3-Methyl-3-pentanol	6.61††	77-74-7	2.00–2.50			3.43E+01							
3-Octanol	12.88††	589-98-0	8.00–8.50	mushroom/moss, nut, mushroom‡‡#		1.61E+01		x		x			
4-Methyl-1-pentanol	10.65††	626-89-1	4.00–4.50	nutty		2.86E+01							
4-Methyl-2-pentanol	7.60††	108-11-2	2.00–2.50		1.10E+00	2.17E+01							
Benzeneethanol	21.31††	60-12-8	11.00–11.50	floral, sweet/honey, spice, rose, lilac‡‡	1.70E-02	2.72E+01	x			x			
Cyclohexanol	12.45††	108-93-0	5.00–5.50		6.17E-02	1.60E+01							
Isoamyl alcohol	8.26††	123-51-3	2.00–2.50	winey/whiskey, malt, burnt‡‡	4.47E-02	2.12E+01	x			x			
Isogeraniol	20.16	5944-20-7	13.50–14.00	rose‡‡									
α,α-Dimethylbenzenemethanol	18.80††	617-94-7	4.00–4.50			5.08E+01							
α-Ethylbenzeneethanol	20.05	701-70-2	11.50–12.00										
α-Terpineol	18.48††	98-55-5	12.50–13.00	oil, anise, mint‡‡	3.72E-02	2.70E+00							
Aldehydes													
2,4-Hexadienal	4.46	142-83-6	1.50–2.00	aldehyde, herb/green‡‡	5.50E-04	4.25E+00							
2-Ethylhexanal	9.96††	123-05-7	7.00–7.50			8.17E+00							
2-Thiophenecarbox-aldehyde	17.85††	98-03-3	8.50–9.00	sulfur‡‡		1.28E+01							
Benzaldehyde	14.96	100-52-7	7.50–8.00	aldehyde, herb/burnt sugar, almond‡‡#	4.17E-02	2.15E+01	x	x					
Aromatics													
1-(Methoxymethyl)-4-methylnaphthalene	23.06	71,235-76-2	17.00–17.50										
1,2,3,4-Tetramethylbenzene	14.86††	488-23-3	11.00–11.50	solvent		1.36E+01							
1,2,3-Trimethylbenzene	12.63	526-73-8	8.50–9.00			8.49E+00							
1,2,4,5-Tetramethylbenzene	14.71††	95-93-2	11.00–11.50	rancid, sweet‡‡	2.63E-02	1.36E+01							

(continued)

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Table 2. Cont'd.

Compound name	RT	CAS #	HC	Odor descriptors	Detection threshold‡	Estimated Tau(OH)§	References¶ 1	2	3	4	5	6	7
	min		min		μL L^{-1}	h							
1,2-Dihydro-1,1,6-trimethylnaphthalene	20.35	30,364-38-6	16.00–16.50	sewer/licorice‡‡									
1,2-Dimethylbenzene	8.26	95-47-6	5.00–5.50	geranium‡‡	8.51E-01	2.03E+01	x						
1,3-Dimethyl-5-(1-methylethyl)-benzene	16.40	4706-90-5	12.50–13.00										
1,3-Dimethylbenzene	8.23††	108-38-3	4.50–5.00	plastic‡‡	3.24E-01	1.18E+01							
1,4-Dimethylbenzene	8.16	106-42-3	4.50–5.00		4.90E-01	1.94E+01	x	x					
1-Ethyl-2,3-dimethylbenzene	13.46	933-98-2	10–00–10.50			1.64E+01							
1-Ethyl-3,5-dimethylbenzene	12.93	934-74-7	9.50–10.00			8.07E+00							
1-Ethyl-4-methoxybenzene	15.86	1515-95-3	11.00–11.50			9.89E+00							
1-Ethyl-4-methylbenzene	10.53	622-96-8	7.00–7.50			2.30E+01	x						
1-Methoxy-2-(methylthio)-benzene	21.70	2388-73-0	14.00–14.50										
1-Methoxy-4-methylbenzene	13.91	104-93-8	8.50–9.00		9.55E-03	1.02E+01							
1-Methyl-4-(1-methylethyl)-benzene	11.93	99-87-6	9.00–9.50	solvent, gasoline, citrus‡‡	2.14E-03	1.84E+01		x					
1-Propenylbenzene	13.53	637-50-3	9.00–9.50			4.71E+00							
2,3-Dihydro-4,7-dimethyl-1H-indene	18.08	6682-71-9	14.00–14.50										
2-Methylnaphalene	21.23	91-57-6	14.50–15.00			5.31E+00	x						
4,4′-Dimethyl 1,1′-biphenyl	26.48††	613-33-2	20.00–20.50			3.24E+01							
4-Ethyl-1,2-dimethylbenzene	13.73	934-80-5	10.00–10.50			1.64E+01							
Benzene	3.51††	71-43-2	1.00–1.50		3.63E+00	2.26E+02	x						
Dibenzyl	25.13	103-29-7	19.00–19.50			2.31E+01							
Diethylbenzene	12.61	25,340-17-4	9.50–10.00			3.43E+01							
Ethenylbenzene	10.10††	100-42-5	5.00–5.50	balsamic, gasoline‡‡	1.45E-01	4.79E+00		x					
Ethylbenzene	7.91	100-41-4	4.50–5.00		2.88E-03	3.91E+01	x						
Indane	10.80	496-11-7	6.50–7.00			3.02E+01							
Methoxybenzene	11.65††	100-66-3	6.00–6.50		1.86E-01	1.61E+01							
Naphthalene	19.20	91-20-3	12.50–13.00	tar‡‡/camphoric, greasy, oily#	1.48E-02	1.29E+01	x						
Octylbenzene	21.20	2189-60-8	18.00–18.50			1.93E+01	x						
Pentamethylbenzene	18.75	700-12-9	14.50–15.00			5.26E+00							
Toluene	5.65††	108-88-3	2.00–2.50	gasoline, paint‡‡	1.55E+00	4.66E+01	x	x					
Esters													
2-Ethyl-1-hexyl propionate	16.33		13.50–14.00										
2-ethylhexyl acetate	14.61	103-09-3	11.50–12.00		3.24E-01	2.55E+01							
2-Ethylhexyl butanoate	16.93		14.50–15.00										
Heptyl formate	10.56	112-23-2	7.50–8.00										
Methyl 2-ethylhexanoate	12.03	816-19-3	9.00–9.50	sweet									
S-methyl thioacetic acid	5.28	1534-08-3	1.50–2.00		2.34E-03								
Ethers													
(S)-2-Ethyltetrahydrofuran	21.11	102,108-34-9	15.50–16.00										
2,3-Dihydrofuran	2.28††	1191-99-7	0.50–1.00			3.48E+00							
2-Acetylfuran	14.45††	1192-62-7	6.00–6.50	sweet, cabbage/balsamic‡‡/abalsamic, sweet, tobacco#		7.51E+00							
2-Butylfuran	8.41	4466-24-4	5.50–6.00	noncharacteristic#									
2-Hexanoylfuran	21.23	14,360-50-0	15.00–15.50										
2-Methyl-3-(methylthio)furan	12.00		7.00–7.50										
2-Methylfuran	2.55	534-22-5	0.50–1.00			4.49E+00	x	x					
2-Pentylfuran	10.96	3777-69-3	8.00–8.50	fruity/green bean, butter‡‡/green, pungent, sweet#	0.0478¶¶	2.62E+00	x						
3-Methylfuran	2.80	930-27-8	0.50–1.00			2.97E+00		x					
Tetrahydrofuran	2.63	109-99-9	1.00–1.50	butter, caramel#	31[d]	1.73E+01							
Fixed gases													
Carbon disulfide	1.73††	75-15-0	0.50–1.00	sulfury/cabbage, sulfurous, sweet, vegetable#	9.55E-02	9.58E+01	x	x				x	
Sulfur dioxide	3.18††	7446-09-5	0.50–1.00	burnt match, sulfurous#	7.08E-01	4.63E+00	x	x				x	
Hydrocarbons													
1,1-bis(methylthio)-ethane	11.08	7379-30-8	6.50–7.00										
1,2-Dithiacyclopentane	14.50	557-22-2	7.50–8.00										
1,2-Dithiecane	22.86	6573-66-6	17.50–18.00										

(continued)

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Table 2. Cont'd.

Compound name	RT	CAS #	HC	Odor descriptors	Detection threshold‡	Estimated Tau(OH)§	References¶					
							1	2	3	4	5	6	7
	min		min		μL L^{-1}	h							
1-Chlorohexadecane	14.35	4860-03-1	12.50–13.00			1.45E+01							
1-MethylcycloPentadiene	14.03	96-39-9	7.50–8.00										
1-Octene	4.25††	111-66-0	2.50–3.00		6.17E-02	8.42E+00	x	x					
1-Pentadecane	20.36	13,360-61-7	18.50–19.00			6.48E+00							
1-Tridecene	23.11	2437-56-1	18.00–18.50			6.93E+00							
2,5-Dimethyl-2,4-hexadiene	8.01	764-13-6	6.00–6.50			1.32E+00							
2,6,10-Trimethyl-2,6,10-dodecatriene	20.08		17.50–18.00										
2-Methyltetradecane	19.58	1560-95-8	18.00–18.50										
2-Methyltridecane	17.66	1560-96-9	16.00–16.50										
2-Octene	4.66††	111-67-1	3.00–3.50		7.59E-02	4.49E+00							
3,7-Dimethylocta-1,6-diene	8.48		6.50–7.00										
3-Ethyl-2,5-dimethyl-1,3-hexadiene	10.40	62,338-07-2	8.50–9.00										
3-Methyltetradecane	19.75	18,435-22-8	18.00–18.50										
4-Ethyl-3-heptene	12.51	33,933-74-3	8.50–9.00										
4-Methyl-1-(1-methylethyl)-cyclohexene	9.60	500-00-5	7.50–8.00			2.89E+00							
5-Propyldecane	17.41	17,312-62-8	15.50–16.00	alkane‡‡									
5-Undecene	12.05	4941-53-1	10.50–11.00										
6-Methyl-1-heptane	10.93	5026-76-6	4.00–4.50			8.42E+00							
Butylcyclohexane	10.63	1678-93-9	9.00–9.50			1.88E+01							
Cyclododecane	20.81	294-62-2	18.50–19.00			1.66E+01							
Decane	9.58††	124-18-5	8.00–8.50	floral/alkane‡‡	7.41E-01	2.39E+01	x						
Ethylcyclohexane	11.83	1678-91-7	7.00–7.50			2.31E+01	x						
Heptadecane	23.71††	629-78-7	21.50–23.00	alkane‡‡		1.32E+01	x						
Hexadecane	22.03††	544-76-3	20.00–20.50	cabbage/alkane‡‡		1.12E+01	x						
Limonene	11.31††	138-86-3	9.00–9.50	fruity/lemon, orange‡‡/citrus, ethereal#	4.37E-01	1.86E+00		x					
Methylcyclopentane	10.70	96-37-7	4.00–4.50			4.91E+01	x						
Nonane	6.86††	111-84-2	5.50–6.00	alkane‡‡/linseed oil, oily, sweaty#	1.26E+00	2.72E+01							
Octane	4.25††	111-65-9	3.00–3.50	alkane‡‡	5.75E+00	3.20E+01	x						
Octylcyclohexane	19.60	1795-15-9	17.50–18.00			1.36E+01							
Pentadecane	20.26††	629-62-9	18.50–19.00	alkane‡‡		1.25E+01	x						
Propylcyclohexane	7.75	1678-92-8	6.00–6.50			2.07E+01							
Tetradecane	18.45††	629-59-4	16.50–17.00	alkane‡‡		1.45E+01	x						
trans 2,6-Dimethyl 2,6-octadiene	10.20	2609-23-6	8.00–8.50										
Ketones													
1-(2-hydroxyphenyl)-ethanone	19.95	118-93-4	12.00–12.50			9.08E+00							
1-(2-methyl-1-cyclopenten-1-yl) ethanone	7.33	3168-90-9	4.50–5.00										
1-(3-thienyl)ethanone	19.33††	1468-83-3	10.50–11.00			3.16E+01							
1-Mercapto-3-pentanone	14.80		8.00–8.50										
1-Methylthio-2-propanone	11.16		4.00–4.50										
1-Phenyl-2-propanone	18.71	103-79-7	11.50–12.00			4.92E+01							
2(5H)-Thiophenone	20.01	3354-32-3	9.50–10.00										
2,3-Butanedione	3.75††	431-03-8	0.50–1.00	buttery/butter, cream‡‡#		1.17E+03	x						
2,3-Pentanedione	5.48††	600-14-6	1.50–2.00	cream, butter‡‡/almond, estery apple, malt#		2.09E+02	x						
2′,4′,5′-Trihydroxy butyrophenone	25.26	1421-63-2	19.50–20.00			1.36E+00							
2,5-Hexanedione	14.55††	110-13-4	7.00–7.50	ketone		3.90E+01							
2,6-Dimethyl-4-heptanone	10.11	108-83-8	7.50–8.00			1.01E+01							
2′-Aminoacetophenone	25.75††	551-93-9	15.00–15.50	taco shell/foxy, sweet‡‡		2.83E+00							x
2-Butanone	2.71††	78-93-3	0.50–1.00	phenolic, skunky/ether‡‡		2.42E+02	x	x					
2-Decanone	15.33††	693-54-9	12.00–12.50	fruity, musty#		2.10E+01	x						
2-Dodecanone	19.55	6175-49-1	16.00–16.50	fruity, musty#		1.84E+01							
2-Heptanone	9.00††	110-43-0	5.50–6.00	musty/soap‡‡/blue cheese, fruity, musty#		2.37E+01	x	x					
2-Hexanone	6.46††	591-78-6	2.50–3.00	ether‡‡/fruity, ketone#		3.05E+01	x	x					
2-Methylcyclopentanone	8.66††	1120-72-5	4.00–4.50			3.49E+01		x					
2-Nonanone	13.96††	821-55-6	10.50–11.00	hot milk, soap‡‡/blue cheese, fatty, fruity#		2.28E+01	x	x					
2-Octanone	11.58††	111-13-7	3.50–4.00	ketone, gasoline/soap‡‡/floral, fruity, musty#		2.53E+01	x	x					

(continued)

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Table 2. Cont'd.

Compound name	RT	CAS#	HC	Odor descriptors	Detection threshold‡	Estimated Tau(OH)§	References¶						
							1	2	3	4	5	6	7
	min		min		μL L^{-1}	h							
2-Pentadecanone	23.05	2345-28-0	19.50–20.00			1.42E+01	x						
2-Pentanone	4.11††	107-87-9	1.00–1.50	ketone/ether, fruit‡‡/acetone, sweet fruity ketone#		5.96E+01	x	x					
2-Pentylcyclopentanone	17.85		13.50–14.00										
2-Tridecanone	21.28	593-08-8	18.00–18.50	solvent, grassy/fruity, green, rancid, tallow#		1.66E+01	x						
2-Undecanone	18.26††	112-12-9	14.50–15.00	onion, garlic, spicy/orange, fresh, green‡‡/dusty, floral, fruity#		2.01E+01	x	x					
3-Decanone	15.83	928-80-3	12.50–13.00			2.30E+01							
3-Dodecanone	19.91	1534-27-6	16.50–17.00										
3-Heptanone	6.95	106-35-4	4.00–4.50			3.52E+01		x					
3-Hexanone	6.01††	589-38-8	2.50–3.00	ether, grape‡‡		4.03E+01		x					
3-Methyl 2-(2-pentenyl) cyclopentanone	18.66	7051-39-0	14.50–15.00										
3-Methyl-2-cyclooctenone	10.86	60,934-87-4	8.50–9.00										
3-Methyl-2-cyclopenten-1-one	14.98	2758-18-1	8.00–8.50			3.42E+00							
3-Methyl-2-pentanone	5.16††	565-61-7	2.00–2.50			4.46E+01							
3-Methylcyclopentanone	9.06	1757-42-2	4.00–4.50					x					
3-methylindole-2(3H)-one	34.05	1504-06-9	18.50–19.00										
3-Nonanone	13.63††	925-78-0	10.50–11.00			2.60E+01							
3-Octanone	11.15††	106-68-3	8.00–8.50	ketone, earthy, musty/herb, butter, resin‡‡/earthy, mushroom#	6.03E-02	2.99E+01	x	x					
3-Octen-2-one	13.80	1669-44-9	9.50–10.00	mushroom/nut, crushed bug‡‡/fatty, green fruit#									
3-Pentanone	4.21††	96-22-0	1.50–2.00	burnt/ether‡‡	3.16E-01	1.39E+02	x	x					
3-Penten-2-one	6.85††	625-33-2	2.00–2.50			5.45E+00							
3-Undecanone	17.95	2216-87-7	14.50–15.00			2.06E+01							
4-(2,6,6-Trimethyl-1-cyclohexen-1-yl)-2-butanone	21.83	17,283-81-7	17.50–18.00										
4-(2,6,6-Trimethyl-2-cyclohexa-1,3-dienyl)-butan-2-one	22.06		17.00–17.50										
4-(2,6,6-Trimethyl-2-cyclohexen-1-yl)-2-butanone	21.51	31,499-72-6	17.00–17.50	phenolic									
4-Heptanone	8.06††	123-19-3	5.00–5.50			2.97E+01							
4-Hydroxy-3-propyl-2-hexanone	6.48	62,338-17-4	3.00–3.50										
4-Methyl-2-pentanone	4.93††	108-10-1	2.00–2.50		5.37E-01	1.97E+01	x						
4-Methyl-3-penten-2-one	7.38	141-79-7	3.00–3.50	sweet, chemical‡‡	5.62E-02	3.53E+00							
4-Phenyl-2-butanone	20.98	2550-26-7	14.00–14.50			2.94E+01							
4-Undecanone	17.50	14,476-37-0	14.50–15.00			1.78E+01							
5-Decanone	15.40	820-29-1	12.50–13.00	grassy/fruity, musty#									
5-Methyl-2-heptanone	11.01	18,217-12-4	7.50–8.00										
5-Methyl-2-hexanone	8.06	110-12-3	4.50–5.00	sweet#	4.17E-02	2.70E+01							
5-Methyl-3-hexanone	6.95	623-56-3	4.00–4.50			2.78E+01							
6-Methyl-2-heptanone	10.55	928-68-7	7.00–7.50			2.90E+01							
6-Methyl-3,5-heptadien-2-one (E)	16.70	16,647-04-4	11.00–11.50										
6-Methyl-5-hepten-2-one	12.20††	110-93-0	8.00–8.50	pepper, mushroom, rubber‡‡/sweet fruity#	3.80E-02	1.77E+00							
6-Methyl-6-(5-methyl-2-furanyl)-2-heptanone	22.25	50,464-95-4	17.50–18.00										
6-Octen-2-one	12.31	74,810-53-0	8.00–8.50										
Acetone	1.91††	67-64-1	0.50–1.00	ketone, sweet	1.45E+01	1.27E+03	x	x					
Acetophenone	17.35	98-86-2	10.00–10.50		3.63E-01	1.01E+02							
cis-Jasmone	22.75††	488-10-8	17.00–17.50			1.74E+00							
Cyclohept-4-enone	14.53		8.50–9.00										
Cyclopentanone	8.15††	120-92-3	2.50–3.00		1.70E+00	9.45E+01	x	x					
Dihydro-2(3H)-furanone	16.61	96-48-0	6.00–6.50	caramel, sweet‡‡		1.20E+02		x					
Dihydro-2(3H)-thiophenone	17.03	1003-10-7	8.50–9.00			3.74E+01							
Dihydro-3-methyl-2(3H)furanone	16.06	1679-47-6	7.50–8.00			2.50E+00							
Dihydro-5-pentyl-2(3H)-furanone	23.55	104-61-0	16.00–16.50	coconut, peach‡‡		2.87E+01							
Tetrahydro-6-propyl-2H-pyran-2-one	21.85	698-76-0	14.00–14.50			2.62E+01							
Tetrahydroionone	20.83	60,761-23-1	17.00–17.50										

(continued)

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Table 2. Cont'd.

Compound name	RT	CAS#	HC	Odor description	Detection threshold‡	Estimated Tao(OH)§	Reference						
							1	2	3	4	5	6	7
	min		min		μL L^{-1}	h							
Nitrogen containing													
1H-Indole	28.75††	120-72-9	14.50–15.00	barnyard, piggy/mothball, burnt‡‡/musty fecal#	3.16E-05	1.80E+00	x	x	x	x	x		x
1H-Pyrrole	14.43††	109-97-7	2.00–2.50	coffee liquor, cracker#		2.53E+00		x					
1-Methylpyrrole	7.10††	96-54-8	2.00–2.50			2.53E+00		x					
2,3-dimethyl-1H-indole	30.61	91-55-4	18.50–19.00			1.39E+00							
2,4-Dimethylthiazole	10.48	541-58-2	5.00–5.50	moldy, skunky/rubber‡‡/cocoa, meat, oily#		5.85E+01							
2,4-Pentadienenitrile	7.88	1615-70-9	2.00–2.50			1.65E+01	x						
2,5-Dimethyl-1H-Pyrrole	16.08	625-84-3	6.00–6.50			1.39E+00							
2,5-Dimethylpyrazine	11.30††	123-32-0	6.00–6.50	musty, earthy/cocoa, roasted nut‡‡/cornnuts, grass#		2.75E+02							
2,6-Dimethylpyridine	10.38	108-48-5	6.50–7.00			9.96E+01							
2-Acetyl-4-methylthiazole	18.16		11.00–11.50										
2-Ethyl-1H-pyrrole	16.43††	1551-06-0	6.50–7.00			1.38E+00							
2-Ethyl-6-Methylpyridine	11.80	1122-69-6	8.00–8.50			7.63E+01							
2-Methyl-1H-indole	29.23	95-20-5	16.50–17.00	piggy, plastic		1.39E+00					x		
2-Methylbenzoxazole	17.98††	95-21-6	11.00–11.50			1.39E+00	x						
2-Methyl-Pyridine	8.95††	109-06-8	4.00–4.50	sweat‡‡	4.27E-02	2.53E+02							
2-Methylpyrrole	15.21	636-41-9	4.00–4.50			1.39E+00							
2-Propylpyridine	17.18	622-39-9	13.00–13.50	sulfury, cabbage		8.22E+01							
3-Ethylpyridine	13.05	536-78-7	8.50–9.00	tobacco#		1.38E+02							
3-Methyl-1H-indole	29.26††	83-34-1	17.00–17.50	naphthalenic/mothball, fecal‡‡	5.62E-04	1.39E+00	x	x	x	x	x		x
3-Methylisothiazole	9.91	693-92-5	3.50–4.00										
4-Methylthiazole	10.05††	693-95-8	3.50–4.00			7.33E+01							
5-Acetyl-2-methylpyridine	25.88	42,972-46-3	16.00–16.50										
5-Methylthiazole	10.45	3581-89-3	4.00–4.50										
6,7-dihydro-3,7-dimethyl-5H-pyrrole[1,2-c]imidazole	14.83	123,845-12-5	9.00–9.50										
8-Quinolinol	25.50††	148-24-3	16.00–16.50	phenolic		1.39E+00							
Benzenamine	18.76††	62-53-3	7.50–8.00		6.76E-01	2.50E+00	x						
Benzonitrile	16.36	100-47-0	8.00–8.50	rancid‡‡/almond#		8.42E+02	x	x					
Hexanenitrile	10.71	628-73-9	5.00–5.50			8.99E+01							
Isothiazole	8.51	288-16-4	1.50–2.00										
Methylpyrazine	9.86††	109-08-0	4.00–4.50	burnt/popcorn‡‡/roasted#		3.77E+02	x						
N-Acetylpyrrole	15.23	609-41-6	7.00–7.50					x					
Nonanenitrile	17.55	2243-27-8	12.50–13.00	sulfury		3.79E+01							
Octanenitrile	15.40	124-12-9	10.50–11.00			4.70E+01							
Pyridine	8.00††	110-86-1	2.50–3.00	rancid‡‡/burnt, diamine, pungent, solvent#	8.51E-02	7.51E+02		x					
Quinoline	22.11	91-22-5	14.00–14.50		1.48E-02	2.39E+01							
Phenols													
2,3,5-trimethylphenol	25.85	697-82-5	14.50–15.00			1.38E+00							
2,4-Dimethylphenol	24.76	105-67-9	12.50–13.00		3.24E-03	3.89E+00							
2,6-Dimethylphenol	21.26††	576-26-1	10.50–11.00	solvent	7.59E-04	4.22E+00							
2-bromophenol	22.15	95-56-7	10.00–10.50		2.51E-06	2.87E+01							
2-Chloro-5-Methylphenol	21.71	615-74-7	10.50–11.00			1.08E+01							
2-Chlorophenol	20.28††	95-57-8	8.00–8.50	phenolic, medicinal	7.24E-04	2.81E+01							
2-Ethoxyphenol	20.48††	94-71-3	11.50–12.00	phenolic, medicinal		7.91E+00							
2-Ethylphenol	23.63††	90-00-6	11.50–12.00			6.65E+00	x						
2-Methoxyl-4-methylphenol	16.45	93-51-6	11.50–12.00			6.98E+00							
2-methyl-5-(1-methylethyl)-phenol	25.60††	499-75-2	15.00–15.50			2.79E+00							
2-Methylphenol	22.60††	95-48-7	9.50–10.00	phenolic/phenol‡‡	1.70E-03	6.61E+00	x						
3,4-dimethoxyphenol	23.40	2033-89-8	14.00–14.50										
3-propylphenol	26.33	621-27-2	15.50–16.00			3.25E+00							
4-(1-methylethyl)-phenol	25.75††	99-89-8	13.50–14.00			6.54E+00	x						
4-Ethyl-Phenol	25.05††	123-07-9	12.00–12.50	phenoloic, medicinal/spice, horse manure, woody‡‡#		6.65E+00	x	x		x			x
4-Methylphenol	23.73††	106-44-5	10.00–10.50	barnyard, medicinal, phenolic, plastic/ phenolic, smoky‡‡#	1.86E-03	5.91E+00	x	x	x	x	x		x

(continued)

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Table 2. Cont'd.

Compound name	RT	CAS#	HC	Odor description	Detection threshold‡	Estimated Tao(OH)§	References					
							1	2	3	4	5	6	7
	min		min		μL L^{-1}	h							
4-Propylphenol	26.35††	645-56-7	14.00–14.50			6.43E+00							
4-Vinylphenol	28.01	2628-17-3	13.00–13.50	smoky, burnt/almond shell‡‡		4.81E+00							
Phenol	22.58††	108-95-2	8.00–8.50	phenolic, medicinal/phenol‡‡	1.10E-01	1.06E+01	x	x		x			x
Sulfur containing													
1-(Methylthio)-butane	6.03	628-29-5	3.50–4.00			1.92E+01	x	x				x	
1-Heptanethiol	11.61††	1639-09-4	8.50–9.00	smoky		6.20E+00							
1-Hexanethiol	8.80††	111-31-9	6.00–6.50	plastic, skunky/sulfur‡‡/diffusive#		5.91E+00						x	
1-Octanethiol	14.06††	111-88-6	11.00–11.50			5.58E+00							
1-Pentanethiol	6.23††	110-66-7	3.50–4.00			6.09E+00	x	x				x	x
2-(1-Methylethyl)-thiophene	10.76	4095-22-1	7.00–7.50			1.12E+01	x						
2-(Methylthio)-thiophene	18.45	5780-36-9	9.00–9.50										
2,3-Dihydro-5-methylthiophene	8.08	4610-02-0	4.00–4.50										
2,4-Dimethylthiophene	9.46	638-00-6	5.00–5.50	fried onion#		4.26E+00							
2,5-Dimethylthiophene	8.50	638-02-8	4.50–5.00	fried onion#		9.02E+00		x					
2-Amino-5-formylthiophene	20.81		14.50–15.00										
2-Butylthiophene	13.26	1455-20-5	9.50–10.00			1.01E+01							
2-Ethyl-5-methylthiophene	11.23	40,323-88-4	7.50–8.00										
2-Ethylthiophene	8.61	872-55-9	4.50–5.00	styrene#		1.12E+01							
2-Furanmethanethiol	13.18	98-02-2	6.00–6.50	burnt, sulfury/coffee, roast‡‡		1.38E+00							
2-Hexylthiophene	17.71	18,794-77-9	14.00–14.50										
2-Methyl-5-propylthiophene	12.83	33,933-73-2	9.50–10.00				x	x		x		x	x
2-Methylthiophene	6.51††	554-14-3	2.50–3.00	gasoline, green, onion, paraffinic, sulfurous, sweet‡‡#		1.11E+01							
2-octylthiophene	21.63	880-36-4	18.00–18.50	grassy, musty									
2-Pentylthiophene	15.55	4861-58-9	12.00–12.50	sweet, fruit‡‡									
2-Phenylethanethiol	18.75	4410-99-5	12.50–13.00									x	
3,4-Dimethoxythiophene	17.38		11.50–12.00										
3,4-Dimethylthiophene	9.01	632-15-5	5.00–5.50	fried onion#								x	
3-Ethylthiophene	9.26	1795-01-3	5.00–5.50			1.12E+01							
3-Methylthiophene	6.98††	616-44-4	2.50–3.00			1.11E+01	x					x	
4-Methylthiane	10.13	5161-17-1	6.50–7.00			1.09E+01							
Benzenemethanethiol	17.01	100-53-8	10.00–10.50		1.58E-03	6.23E+00							
Cyclopentanethiol	7.46	1679-07-8	4.00–4.50			5.47E+00	x	x					
Dimethyl disulfide	5.60††	624-92-0	1.00–1.50	onion, garlic/cabbage, fecal sulfurous‡‡#	1.23E-02	1.22E+00		x				x	
Dimethyl tetrasulfide	18.28	5756-24-1	1.00–1.50	sulfury/cabbage, sulfur‡‡									
Dimethyl trisulfide	11.46††	3658-80-8	1.00–1.50	onion/sulfur, fish, cabbage‡‡	1.66E-03								
Hydrogen sulfide	1.26††	7783-06-4	0.50–1.00	rotten egg, sewer, foul/sulfurous#	1.78E-02	0							
Methanethiol	1.46††	74-93-1	0.50–1.00	onion, sewer, fecal, sulfury/sulfur, garlic, cabbage‡‡#	1.05E-03	8.44E+00							
Methyl ethyl disulfide	7.90	20,333-39-5	4.00–4.50		1.66E-02			x					
Methyl ethyl sulfide	2.33	624-89-5	0.50–1.00	sulfur, garlic‡‡	3.80E-03	3.27E+01	x					x	x
Thiophene	4.70††	110-02-1	1.00–1.50	skunky/garlic‡‡	3.31E-01	2.91E+01	x	x			x	x	
Tropex	9.03††	556-61-6	2.00–2.50		1.29E-02	2.04E+03							
α-n-butylthiophan	15.13		11.50–12.00										

† RT, column retention time; HC, heartcut.

‡ Devos et al. (1990).

§ Syracuse Research Corporation (2004), NIST WebBook (National Institute of Standard and Technology, 2005), and CambridgeSoft Corporation (2006).

¶ References: 1, Schiffman et al. (2001); 2, Begnaud et al. (2003); 3, Kai and Schafer (2004); 4, Yasuhara (1984); 5, Willig et al. (2004); 6, Clanton and Schmidt (2000); 7, Zahn et al. (1997).

LRI & Odour Database (2005).

†† Compound confirmed with pure standard.

‡‡ Flavornet (Acree and Arn, 2004).

§§ AIHA (1989).

¶¶ Rychlik et al. (1998).

not classified as VOCs (De Nevers, 1995) because of the carbon number threshold (<12). These compounds also tended to have high BPs and low VP, which made them difficult to sample and analyze. It is remarkable that the Carboxen/PDMS SPME fiber was capable of extracting these compounds.

The BP of 215 compounds (for which BPs were known or published) ranged from −60.3 to 322°C with a mean BP of 168°C. As many as 66% of the compounds had a BP between 120 and 220°C. Approximately 17% of the compounds had a BP below 120°C and 18% were above 220°C. Vapor pressure and water

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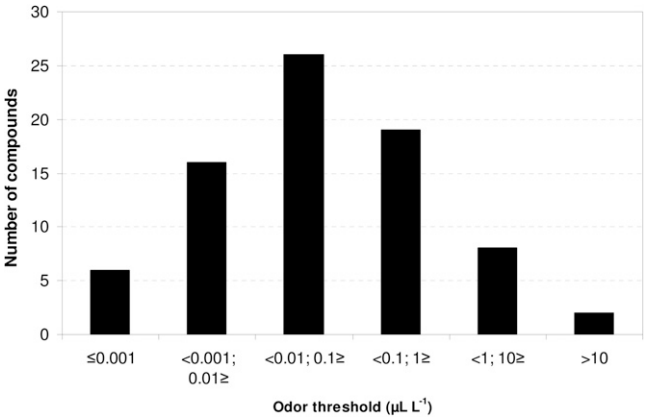

Fig. 3. Distribution of odor threshold for 77 out of 295 compounds emitted from swine manure.

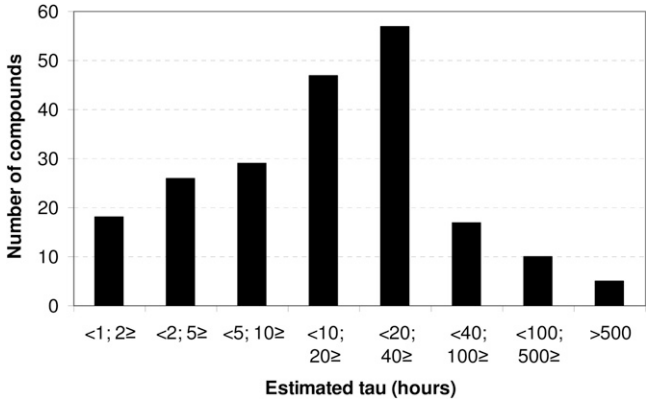

Fig. 4. Distribution of estimated τ for 210 compounds emitted from swine manure.

solubility are important in determining the emission of VOCs in swine manure. A compound with a high VP and low solubility is considered as more volatile than those with low VP and high water solubility (Verscherene, 2001). Vapor pressure and solubility of 219 compounds (for which VP was known or published) were summarized (Lo, 2006). As many as 63% of the compounds had a VP greater than 69.33 Pa with a range from 4.6E–5 Pa Hg to 2.08E + 6 Pa. About 68% of the 219 compounds had solubility between 100 and 1.00E + 5 mg L^{-1} (for which water solubility was known or published), which are considered very soluble in water. As many as 86% of compounds had a Henry's law constant, defining the solubility of gases in pure water <0.01 (atm-m^3mole^{-1}). Water-octanol partitioning coefficients (for which were known or published) (logK_{ow}) ranged from –2.2 to 9.26, with about 82% out of 228 volatiles having a logK_{ow} of less than 4. The compound with the highest logK_{ow} was 1-heptanethiol, with a logK_{ow} = 9.26. The estimated D_g and D_l ranged from 0.043 to 0.18 cm^2 s^{-1} and 4.54E–06 to 1.93E–05 cm^2 s^{-1}, respectively. As many as 76% of the 216 VOCs fell between D_g 0.06 to 0.09 cm^2 s^{-1}, and 82% of the 217 VOCs fell between D_l 6.00E–06 to 1.00E–05 cm^2 s^{-1} (for those VOCs with chemical structure and BPs known or published).

Many VOCs emitted into the atmosphere take part in the degradation/transformation reactions (Atkinson et al., 1999). The estimation of atmospheric lifetime of VOCs depends on the reaction with hydroxyl radical (OH·) as this compound dominates the daytime atmospheric reactions. The frequency distribution of the estimated atmospheric lifetime for 210 VOCs (for which atmospheric OH·rate constants used to calculate the atmospheric lifetime were known or published) is presented in Fig. 4. More than half of compounds (approximately 68%) had an estimated τ less than 24 h, which are considered as very reactive, with dimethyl disulfide (τ = 1.224 h) being the most reactive compound emitted from swine manure. In general, the shorter the atmospheric lifetime, the more reactive a compound is. This, in turn, could be detrimental to the chain of reactions leading to the net production of ozone. Reactivity causes transformations into new compounds and potentially affects the odor. Thus, atmospheric reactivity may also affect the overall odor. This reactivity-odor link has not yet been characterized.

Conclusions

The following conclusions can be drawn from this research:

(1) SPME combined with MDGC-MS-O was a powerful tool used to extract and separate VOCs and gases emitted from swine manure, to identify compounds, and to determine their odor characteristics. The use of heartcut improved chromatographic separations and compound identification.

(2) A wide range of VOCs and gases were emitted from swine manure. As many as 295 compounds were identified from the gas samples using MDGC-MS-O. Seventy one compounds were recognized as odorous compounds. Sixteen of the compounds identified were listed as HAPs. The six compounds with DT less than 1 nL L^{-1} were 2-bromo-phenol, indole, 2,4-hexadienal, skatole, 2-chloro-phenol, and 2,6-dimethyl-phenol.

(3) Among the 295 compounds identified, 188 were not reported in previous studies. This total number (295) also represents an improvement by 44 of the total number of compounds listed in the most comprehensive summary of compounds present in swine manure and/or air around swine operations (Schiffman et al., 2001).

(4) Physical and chemical properties of the compounds emitted from swine manure were studied and summarized. The 295 compounds identified were classified into 12 chemical classes: acids (9), alcohols (33), aldehydes (4), aromatics (32), esters (6), ethers (10), fixed gases (2), hydrocarbons (36), ketones (71), nitrogen-containing compounds (35), phenols (19), and sulfur-containing compounds (38).

(5) Nearly 68% of the total 210 compounds (for which the reaction rate with OH was known) had an estimated atmospheric lifetime (τ) <24 h, with dimethyl disulfide (τ = 1.22 h) being the most reactive.

(6) Measurement of actual concentrations and emission rates for specific VOCs of interest is warranted.

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REVIEWS

Understanding Farmstead Odors: An Annotated Review

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Abstract

There are few issues in animal agriculture today more contentious than odors. Although odors are generally considered a swine problem, all livestock producers may have to address the changing public attitude toward rural air quality eventually. Adding to the problem of farmstead odors is a lack of standardization in odor measurement and description. A review of the literature reveals that there is little consensus among scientists on odor description.

The authors of this paper attempt to clarify the situation using terminology employed by the perfume industry to provide structure to the definition of farmstead odors. Odor-causing chemicals called odorants mix to form distinct scents called odor notes, and odor notes mix to form complex farmstead odors. Odor description is accomplished by answering four questions. How many molecules of odor-causing chemicals are present in the air? How bad does the odor smell? How strong is the odor? How long do the various components of the odor last? Among the numerous odor measurements currently in use, these questions are best answered using the parameters concentration (as measured by odor units), character (as measured by degree of offensiveness), intensity, and persistence.

All of the parameters mentioned previously can be measured by a trained panel of sniffers. Using a dynamic olfactometer to present odor samples to a panel is becoming the standard for odor measurement. This article concludes with a very brief description of the ability of olfactometers and other analytical techniques (scentometers, electronic noses, and gas chromatographs) to quantify farmstead odors following the analysis scheme set forth by the authors.

(Key Words: Odors, Odorants, Odor Notes, Odor Intensity, Odor Measurement.)

Odor Perception

The nose and the brain work together to create what is perceived as odor. The sense of smell is activated when the nose captures odor-causing chemicals called odorants from the air. Humans are equipped with two separate systems for collecting and processing odorant stimuli. Some animals (e.g., rats, dogs, cats, horses) have a third system called the vomeronasal organ with receptors located in the roof of the mouth to define odors further. As it is, humans smell using two systems: the olfactory organ and the trigeminal nerve. The human olfactory organ uses receptors located at the top of the nasal passages to collect odors from the air. Signals from several receptors are grouped and preprocessed in the olfactory bulb before they are sent on to the brain. Odor messages are processed in the more primitive part of the brain known as the limbic system. The limbic system is also the seat of memory and emotion in humans, which helps explain why smells often release old, long-forgotten memories. The olfactory organ does not have a monopoly on smelling odors. The trigeminal nerve is primarily responsible for feeling in the face. In mammals, this nerve also reacts to certain chemical substances, including smells. The general function of the trigeminal nerve is to protect against harmful external influences, which is why the perception of a substance such as ammonia leads to a pain or repellent response. There is some interplay between the olfactory and trigeminal systems. Many substances, such as alcohol, ammonia, and acetic acid, are perceived by both systems (32).

Science has identified thousands of odorants forming the bouquet of smells known as farmstead odors. Table 1 is a list of manure odorant

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groups compiled from the literature. Under each group is a list of individual chemical compounds that are commonly found in manure odors. The two numbers listed next to the odorants in Table 1 are concentrations at which the brain makes decisions about the odorant. The first number, the detection level, is the concentration at which the average, healthy person first notices an odor. People cannot recognize the odor at the detection level, but they know they smell "something". For example, when the concentration of ammonia in air reaches 17 ppb, the brain detects a smell, but it does not recognize the smell as ammonia. The second number listed in Table 1 is the recognition level. At this concentration, the brain begins to recognize the odorant as a distinct scent. The average human recognizes the scent of ammonia cleanser when the concentration of ammonia reaches 37,000 ppb in air.

Values for detection and recognition levels can be difficult to comprehend. Consider the following. A person is standing on the floor of the Louisiana Superdome. The Superdome is a very large, domed stadium containing 3.5 billion L of air space. Ammonia is released into the Superdome. A person would detect "something" if 17 ppb, or 57 g, of ammonia gas were mixed with clean air in the Superdome. The observer would begin to recognize a faint ammonia smell once the concentration reached 37,000 ppb, or 100 kg, of ammonia gas mixed in the airspace.

Most odorants are not gases. Skatole is a N-containing compound largely responsible for causing manure to smell like manure. Skatole is a solid below 98°C, but it is soluble in both polar and non-polar liquids. Solutions of skatole release minute amounts of the compound at the air-liquid interface. It only takes a minute amount to create an effect because the detection level of skatole is 1.2 ppb (<30 g in the Superdome airspace). The recognition level of skatole is much higher (470 ppb); therefore, the brain would not recognize a manure-like smell in the Superdome until 10 kg of skatole were released.

The large range between detection and recognition levels for most odorants may explain the ambivalent feeling humans have about odors. The Superdome observer smells "something" in the air at low doses of skatole. He cannot describe the smell, but he knows he does not like it. As skatole concentration increases, the observer waivers on the edge of recognition. Finally, he recognizes the scent, and it brings back unpleasant memories (e.g., dirty diapers, the outhouse at grandma's, an open sewer).

TABLE 1. Components of manure odors[a].

Groups and individual odorants	Detection level[b]	Recognition level[c]	Odor description
	(ppb)		
Organic acids			
Acetic acid	10.2	1000	Vinegar
Propionic acid	3.6	300	
Butyric acid	1.1	1	Sour meat
Iso-valeric acid	1.2	—	
Valeric acid	—	20	
Alcohols, aldehydes, ketones			
Methanol	—	100,000	Sweet
Formaldehyde	—	1000	Straw, pungent
Acetylaldehyde	—	210	Fruity, pungent
Acetone	4.0	100,000	Sweet, pungent
Methyl ethyl ketone	—	10,000	Sweet
Phenolic compounds			
Phenol	5.7	1000	Medicinal
p-Cresol	8.0	—	
N compounds			
Ammonia	17	37,000	Sharp, pungent
Methylamine	—	2.1	Fishy, pungent
Dimethylamine	37	37	Fishy, pungent
Diethylamine	—	500	Fishy, pungent
Indole	1.0	—	Fecal
Skatole	1.2	470	Fecal, pungent
S compounds			
Hydrogen sulfide	0.5	4.7	Rotten egg
Methyl mercaptan	0.5	2.1	Rotten cabbage
Dimethyl sulfide	1.1	1.1	Rotten vegetable
Diethyl sulfide	6.0	6.0	Rotten vegetable

[a]Literature citations: 1, 11, 13, 14, 16, 29, 33.

[b]Level at which an odorant is detected as an unidentified smell.

[c]Level at which an odorant is recognized as a distinct scent.

Odor Notes

Farm odors are never pure samples of one odorant but a mixture of many different odorants. When chemists analyzed an air sample taken from a German hog building, they measured at least 11 different organic acids, but none of the individual acids were present at detectable levels (10). Because the individual odorants were below the detection level does not mean that they could not be smelled. Stimuli from many receptors are combined as a group in the olfactory bulb. Because of this grouping, the brain

analyses the multiple organic acids as one "fatty" or "sour" smell.

Perfumers call a mixture of odorants making a distinct scent an odor note. A single note may contain hundreds of different odorants. Returning to the Superdome analogy, our observer is standing in the middle of the football field; he cannot hear one person way up in the stands blowing softly into a plastic trumpet. If a hundred people blow into plastic, brass, and tin trumpets all at the same time, he hears a "note," and he perceives it as a general blaring sound, not a mosaic of individual trumpets. Add cowbells and cheering, and the situation becomes analogous to perfume or farmstead odors.

Odor Concentration

Farmstead odors always occur as mixtures of notes. Notes, in turn, are mixtures of odorants. It is difficult and expensive to measure the concentration of each odorant in a sample. Instead, odor scientists measure the concentration of odors as a whole by presenting a sample to a panel of trained sniffers. The sample is diluted with odorless gas until one-half of the panel can no longer smell anything. When 50% of the sniffers can no longer detect an odor, the sample has been diluted to the detection threshold. Detection threshold is similar to detection level, which was discussed in the odor perception section. Detection threshold is the detection level of a mixture of odorants under specific experimental conditions.

The ratio of odorless gas to sample volume is called the dilution factor. Dilution factor is a good measure of odor concentration. The odor threshold standard used by the European Union (5) assigns odor concentration at the detection threshold the arbitrary value of one odor unit (OU) per cubic meter. For example, if an air sample is taken inside a dairy barn and diluted 100 times so that one-half of an odor panel can no longer detect an odor, then the air inside the dairy barn has an odor concentration of 100 OU/m^3. Other odor threshold standards do not designate odor concentration in OU per volume. Because the dilution factor is a ratio, it has no units; therefore, the inverse of dilution factor is simply assigned OU (3). No matter what standard is used, the concept is the same: dilute the sample to the detection threshold, then use the inverse of the dilution factor as odor concentration.

Odor Character

The term "character" describes what an odor smells like. In general, odor character does not change with concentration. Ammonia at 10 OU/m^3 smells the same as ammonia at 100 OU/m^3. Of course, there are always exceptions. At high doses, humans are likely to sense ammonia through the trigeminal system, and the response is more a feeling of repulsion than a true smell. The character of some odorants changes dramatically with concentration. At concentrations usually detected in farmstead odors, indole smells like feces. At very low concentrations, however, indole has the scent of flowers (4, 32).

The fourth column of Table 1 lists identifying terms used to describe the character of selected odorants. Because farmstead odors are mixtures of many odor notes, it is hard to quantify their character based on simple descriptors. Two descriptors used to assign numerical values to the character of complex odors are hedonic tone and offensiveness.

Hedonic Tone. Hedonic tone is a measure of the relative pleasantness of an odor. Odor panelists compare an unknown sample with a set of known odorants. The panel decides which of the known odorants best describes the odor. The odor is assigned a rating based on the comparisons. Pleasant odors have positive hedonic tones, and negative hedonic tones indicate unpleasant odors (7). Table 2 lists hedonic tones for common agricultural odors as well as those for some of the odorants listed in Table 1. If an apple has a hedonic tone of 2.61, and rotten fruit has a hedonic tone of 2.76, it is safe to assume that most people find rotting fruit more offensive than a fresh cut apple.

Offensiveness. It is difficult to describe exactly what farmstead odors smell like, and, in the final analysis, the exact description of the smell may not matter. People know if they enjoy the smell or not. Offensiveness is an attempt to add degrees of good and bad to odor phenomena. Offensiveness is measured by an odor panel. A series of samples is diluted to equal odor intensity. Panelists are asked to rank the offensiveness of each sample on a scale of 0 to 5 (0 = inoffensive to 5 = strongly offensive) (22). Because the relative "badness" of a farmstead odor is more important than the exact description of the odor, agricultural scientists have generally adopted offensiveness as a measure of character for farmstead odors.

Odor Intensity

Offensiveness indicates how bad an odor smells, and OU can be correlated to the number of odorant molecules floating in the air, but neither character nor concentration provides a measure of how strong an odor smells. A third measurement is required—odor intensity. Odor intensity is the direct measurement of a person's reaction to an odor. To measure odor intensity, scientists ask a panel to describe the strength of an unknown odor without knowing the odor concentration or dilution factor. A commonly used scale ranks intensity between 0 and 6 (0 = no odor to 6 = extremely strong odor). Odor intensity is standardized by having the panel compare the unknown odor with a reference odorant of known concentration. Methods approved by the American Society for Testing and Materials (2)

and the European Committee for Standardization (5) use n-butanol as a reference. With n-butanol as a reference, intensity is reported as a concentration of butanol, regardless of the actual odorants present.

Studies have related odor intensity to concentration using equations of the form: $I = K (C)^n$ or $\log(I) = \log K + n \log(C)$, where I is odor intensity, C is odor concentration, and K and n are empirical constants (33). A recent study conducted in England (19) provided relationships between odor concentration and odor intensity for broiler house exhaust and land-applied hog slurry. The results of that study, shown in Figure 1, demonstrate three concepts needed to understand intensity.

First, every mixture of odorants has its own relationship between concentration and intensity. Similar mixtures of odorants, such as five different samples of broiler house exhaust, have similar relationships between concentration and intensity.

Second, intensity versus concentration is not a one-to-one relationship. Diluting an odor sample in half will not diminish odor intensity by one-half. To diminish a strong broiler house odor (I = 4) to a faint odor (I = 2) requires an eightfold dilution (40 OU/m^3 diluted to 5 OU/m^3).

Third, intensity and character are not related. According to the results shown in Figure 1, if odor concentrations were held equal, the panel would perceive broiler house odor to be more intense than hog slurry odor. This does not mean the broiler house smells *worse* than the hog slurry; it only means the broiler house smells *stronger* than the hog slurry. To describe an odor completely, you must measure both intensity and character. Perfumes emit high intensity odors, but these odors are not considered offensive. An apple pie baking in the oven smells both strong and pleasant. Skunks release strong and offensive odors. A glass of water smells neither strong nor offensive because it has no smell at all.

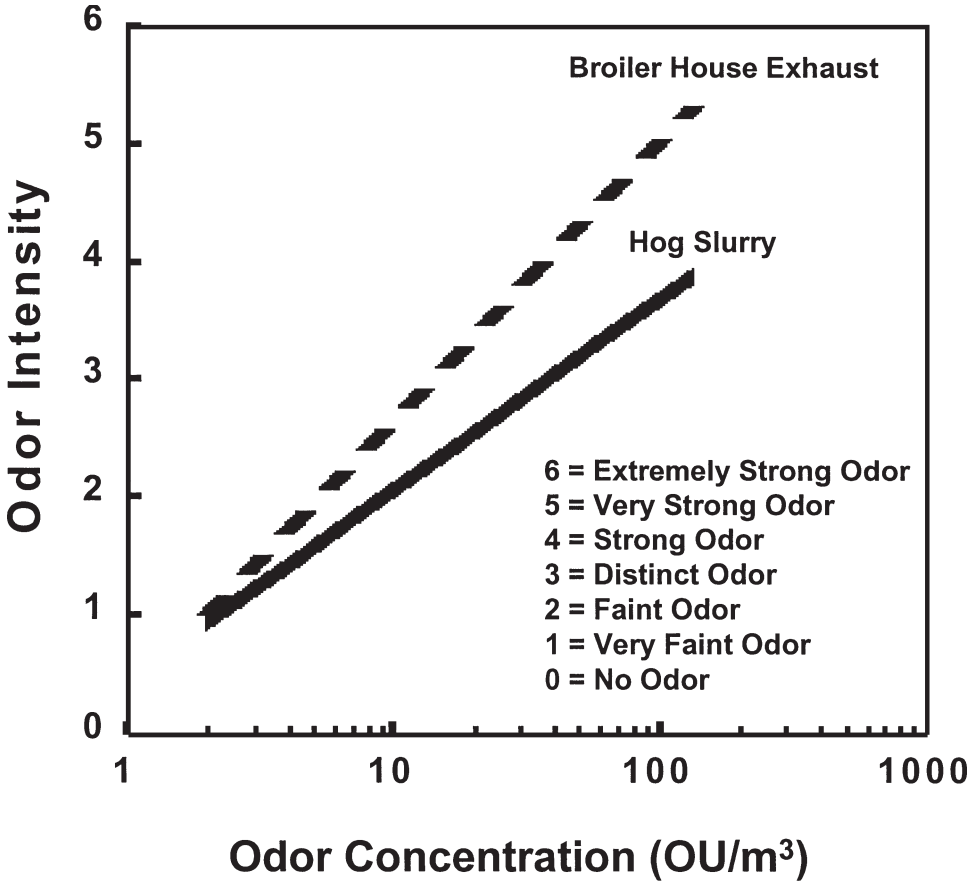

Figure 1. Relationship between odor concentration and intensity for broiler house exhaust and land-applied hog slurry (19). OU = odor unit.

Odor Persistence

Perfumers are masters in the art of blending many odors to form complex mixtures known as perfume. If one distinct odor is a note, then a mixture of many odors is a chord. Perfumers also recognize that a chord of odors can change with time (4, 27). Perfumers group notes according to their relative volatility or persistence. The most persistent odors are base notes or fixiants. The least persistent odors are top notes. Odorants with medium persistence are called middle notes or modifiers. When perfume is placed on the skin, the first scent smelled is the top note. Because top notes are made of volatile or short-lived odorants, they fade with time. Base notes remain long after the top notes have faded. Middle notes give the perfume "lift" or "body" throughout the life of the scent.

Farmstead odors are also chords of many notes. Odorants in the manure chord can be grouped in notes based on relative volatility. Table 3 classifies common manure odorants into top, middle, and base notes (D. Hamilton, unpublished data). Knowing that all notes do not have the same persistence can explain why the strength and character of farmstead odors change over time. Consider the results of a series of land application experiments shown in Table 4. Different types of swine waste were applied 0.2 inches deep to soil inside a wind tunnel. Samples of air were collected and presented to a panel to determine odor offensiveness, concentration, and intensity immediately after spreading. Air sample collection and panel presentation were repeated 4 to 6 h after application.

The panel determined that raw manure was definitely offensive.

Odor intensity was extremely strong immediately after application, and intensity remained extremely strong 6 h after application. The odors released by raw manure exposed at the soil contained persistent, strong-smelling odorants. Using perfume terminology, raw waste is replete with base notes.

Anaerobically digested manure presents a different picture. Anaerobically digested manure was described by the panel as faintly offensive. Initial intensity was extremely strong and similar to raw manure. Odors from anaerobically digested manure were not persistent, however. Six hours after application, the panel only smelled faint odors in the samples; therefore, the anaerobically digested manure contained more top notes and fewer base notes than raw manure. These results are consistent with the chemistry of anaerobic digestion. During digestion, base notes (e.g., organic acids, skatole, large organic sulfides) are converted to top notes (e.g., hydrogen sulfide, ammonia) and odorless gases (e.g., carbon dioxide, methane).

Treating raw manure by aeration reduced odors even further than anaerobic treatment. The panel described screened manure aerated at 1 to 2 mg/L of dissolved oxygen as inoffensive. Odor intensity increased from no odor immediately following application to a faint odor 4 h after application. Why did land application odors increase with time? Aerobic bacteria were produced as raw manure was aerated, creating a large, living biomass. A portion of the aerobic biomass died when exposed to a new environment by land application. The biomass decayed anaerobically, giving off odorants similar to anaerobically digested manure.

Measuring Farmstead Odors

Direct measurement of odor phenomenon with a sensory panel is quickly becoming the standard method of odor measurement. The sensory panel gives immediate measures of odor concentration, character, and intensity. With a time series of observations, the panel can determine odor persistence as well. There are a number of problems associated with odor panels, however. Experimenters must overcome individual bias in observations. It is also important to consider the phenomenon of odor fatigue (i.e., prolonged exposure to an odor lessens an individual's ability to distinguish the odor). Olfactometers and scentometers are two instruments used to measure human odor sensory response. Other methods devised to overcome the problems associated with sensory panels include electronic noses and gas chromatographs.

Odor Collection. The first difficulty an experimenter must overcome is capturing a representative odor sample. Farmstead odors are transitory in nature. They are constantly changing in character, intensity, and composition. There are two ways to sample odor phenomena: take measurements directly as the phenomenon is occurring or collect representative samples of the odor event. Measuring phenomena directly from the environment is called dynamic sampling. Static sampling involves grabbing representative samples of the odor. The most common method of static sampling is to gather whole air samples in nonreactive bags made of Teflon®, Mylar®, or Kedlar® (30) (E. I. Du Pont de Nemours and Company, Wilmington, DE). Another static odor collection method is to trap or adsorb odors onto a surface or chemical reactant. Adsorption creates additional bias because individual odorants can be selected based on the characteristics of the adsorbent. A method of capturing odors on swatches of cotton cloth was shown to measure adequately those odor character and intensity changes caused by a packed column air scrubber (18). More detailed analysis of the cotton swatch method showed that it did not correlate well with observations made on whole air samples, particularly at high odor concentrations. The authors suggested that the fabric became saturated with odorants at lower concentrations, and higher concentrations did not register above the saturated levels (21). The European Committee for Standardization considers only whole air samples in its olfactometry standard (5).

Olfactometer. An olfactometer is a laboratory device that distributes sample dilutions to odor panelists. There are a number of variations on the olfactometer depending on method of sampling and analysis, but all devices perform essentially the same function, to present samples of odors to a panel of sniffers. Flexibility and direct measurement of human sensations are the main advantages of olfactometry. Disadvantages are expense of operation and overcoming human bias (6, 8, 9, 12). Olfactometers are classified into two major categories by method of analysis. Suprathreshold referencing olfactometers present air samples to panelists for comparison with known quantities of n-butanol. Sometimes called butanol olfactometers, suprathreshold referencing olfactometers are used to measure odor intensity. Dilution-to-threshold olfactometers, commonly referred to as dynamic olfactometers, present mixtures of odorous air samples and odor-free gases at known dilutions to a panel. The dynamic olfactometer may be operated in yes/no, choice, forced-choice, triangle forced-choice, or forced-choice/probability mode, depending on method of delivery (5, 30). Dilution-to-threshold olfactometers are used to measure concentration, intensity, and character.

Scentometer. A scentometer is a simple, hand-held, dilution-to-threshold device used to measure odor concentration and intensity in the field. The person taking measurements holds the device up to his nose and breaths through the scentometer. Gases can either pass directly to the nose or pass through an activated carbon filter. The analyst chooses

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TABLE 2. Hedonic tone[a] of common agricultural odors.

Odor	Hedonic tone
Strawberry	2.93
Apple	2.61
Hay	1.30
Grain	0.63
Mushroom	0.52
Iso-valeric acid	–1.57
Butyric acid	–1.77
Mercaptans	–2.30
Ammonia	–2.47
Rotten fruit	–2.76
Urine	–3.34
Manure	–3.36
Dead animal	–3.75

[a]Hedonic tone is a measure of the relative pleasantness of an odor. Pleasant odors have positive hedonic tones. Unpleasant odors have negative hedonic tones. Values for hedonic tone listed in this table were determined by Dravnieks et al. (7).

dilution factor by selecting the size of the hole passing unfiltered air. Advantages of the scentometer are that it is portable, simple to use, and gives immediate values for odor concentration and intensity. It is particularly useful for measuring intensity of odor sources (31). The main disadvantage is that it is hard to overcome the analyst's personal bias in measurement. Odor fatigue is also a problem with repeated analyses (8).

Electronic Nose. Electronic noses mimic the mammalian olfactory system using metal oxide or organic polymer sensors to represent olfactory receptors in the nose and an electronic neural network and a microprocessor to perform the functions of the olfactory bulb and brain (25, 26, 28). The main use of an electronic nose is to differentiate between two odors or to compare an unknown odor with a known odor. They have been used effectively for this purpose in the food processing industry. Researchers have used an electronic nose to determine successfully the onset of estrus in dairy cattle by sampling perineal odors (15). Electronic noses have shown a limited ability to measure odor concentration and to differentiate between groups of some odorants (17, 20). The greatest potential for electronic nose technology is to measure subtle changes in odor character. Electronic noses are also very adaptable to dynamic, real-time sampling and sampling in hazardous environments. Despite recent advances in electronics, the electronic nose is no match for the human nose. The human sense of smell, as used in olfactometry panels, is 10,000 times more sensitive than current electronic analogs (17). Electronic noses become less sensitive in humid conditions because sensor materials respond to water vapor as well as volatile organics. Electronic nose technology is likely to improve in two directions: devices with a limited number of sensors chosen to identify selected odorants and devices with a large number of sensors of varied composition to determine a wide spectrum of odors. Devices of the second type, coupled with improvements in electronics based on recent discoveries in animal olfactory systems, will be required if higher order analyses such as intensity and character are to be measured (25).

Chemical Methods. Chemical methods are used to determine the actual concentration of individual odorants in the air. The most common instrumentation used in odorant analysis is a gas chromatograph with a mass spectrometer detector. Instrumentation can be set up to analyze ambient air dynamically or to analyze samples taken from the field. Similar to the electronic nose, a gas chromatograph distinguishes compounds by comparison with a reference standard. The main disadvantage of chemical methods is the shear number of potential odorants required for analysis in the sampling of farmstead odors. The greatest advantage of chemical methods is the removal of human bias in the determination of the presence of odorants in the air. This advantage is also a downfall, however, because it is very difficult to predict human reactions to odors based on the chemical constituents in a sample.

Implications

Controlling farmstead odors is a major concern of today's livestock producers. A literature search reveals a lack of consensus among scientists on the proper methods of measuring and quantifying agricultural odors. It makes sense, therefore, to return to the terminology of the perfume industry. Perfumers have had little trouble communicating with each other for centuries. In perfumery terms, odor-causing chemicals are called odorants. Several odorants combine to form a distinct scent called an odor note. Complex farmstead odors are mixtures of odor notes. Odor notes can be classified to some extent by grouping compounds in the same chemical family

TABLE 3. Likely grouping of manure odor notes based on relative volatility of odorants.

Top notes	Middle notes	Base notes
Hydrogen sulfide	Aldehydes	Organic acids
Ammonia	Alcohols	Phenolic compounds
	Ketones	Indole and skatole
	Amines	Organic sulfides (>5 carbons)
	Mercaptans	Dust-borne odorants
	Organic sulfides (2 to 4 carbons)	

TABLE 4. Odor offensiveness, concentration, and intensity of land-applied swine wastes based on wind tunnel experiments[a].

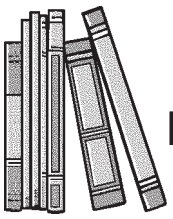
		Highest measured odor concentration (OU^b/m^3)		Highest measured odor intensity	
Type of waste	Offensiveness	Initial	After 4 to 6 h	Initial	After 4 to 6 h
Raw manure	Definitely offensive	1740	320	Extremely strong odor	Extremely strong odor
Raw manure passed through screen	Definitely offensive	250	190	Extremely strong odor	Etremely strong odor
Raw manure stored 14 d	Faintly offensive	460	60	Very strong odor	Distinct odor
Anaerobically digested manure	Faintly offensive	350	45	Extremely strong odor	Faint odor
Anaerobically digested manure stored 14 d	Faintly offensive	83	39	Strong odor	Distinct odor
Screened manure aerated at low dissolved oxygen	Faintly offensive	280	100	Distinct odor	Faint odor
Screened manure aerated at 1 to 2 mg/L dissolved oxygen	Inoffensive	60	61	No odor	Faint odor

[a]Literature citations: 23, 24.
[b]OU = Odor unit.

into three notes based on odorant volatility. Highly volatile compounds form top notes. Persistent compounds form base notes. Middle notes, derived from compounds with medium volatility, complete the odor chord.

Once classified through a system of notes, farmstead odors may be described using two primary measures: intensity and character. These two descriptors measure how strong the odor smells and what the odor smells like at any point in time. Describing the character of farmstead odors may be simplified using offensiveness scales. Mass of odorants in the air, measured as odor concentration, and the changing nature of an odor chord, measured as odor persistence, add depth to the odor description.

Currently, a human sensory panel tested using some form of olfactometer is the most widely accepted method of measuring intensity, character, concentration, and persistence. A hand-held scentometer is another sensory device shown to measure odor intensity and concentration. Electronic noses mimic the mammalian olfactory organ and have been proven to measure differences in odor character. Direct measurement of odorant concentration is achieved through gas chromatography analysis.



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WILSON M. LAIRD, *State Geologist*

BULLETIN 47

NORTH DAKOTA STATE
WATER CONSERVATION COMMISSION

MILO W. HOISVEEN, *State Engineer*

COUNTY GROUND WATER STUDIES 8

GEOLOGY and GROUND WATER RESOURCES

of

CASS COUNTY, NORTH DAKOTA

PART I

GEOLOGY

By

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Geological Survey

United States Department of the Interior

Prepared by the United States Geological Survey in cooperation with the North Dakota State Water Commission, North Dakota Geological Survey, and Cass County Board of Commissioners.

GRAND FORKS, NORTH DAKOTA
1968

001673

This is one of a series of county reports published cooperatively by the North Dakota Geological Survey and the North Dakota State Water Conservation Commission. The reports are in three parts; Part I describes the geology, Part II represents ground water basic data, and Part III describes the ground water resources. Part III will be published later and will be distributed as soon as possible.

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GEOLOGY AND GROUND WATER RESOURCES of Cass County, North Dakota

Part I - Geology

by Robert L. Klausing

ABSTRACT

Cass County comprises an area of 1,749 square miles in the southeastern corner of North Dakota. About one-fourth of the county is in the Drift Prairie physiographic province; the rest is in the Red River Valley (Lake Agassiz basin) physiographic division.

The major stratigraphic units are, in ascending order: crystalline rocks of Precambrian age; Winnipeg Formation of Ordovician age; and Dakota Sandstone, Graneros Shale, and Greenhorn Formation of Cretaceous age. No indurated rocks younger than the Greenhorn are known to be present in the county.

Pleistocene glacial drift covers the entire county. The known thickness of the drift, including the Lake Agassiz deposits, ranges from 132 to 447 feet. All the surficial features of the county are late Pleistocene in age. Drift, probably deposited by more than one ice sheet, is present in the subsurface, but older drift can be differentiated in only a few places. Local zones of oxidized till, extensive bodies of buried outwash, and buried lake clays are valid indications of older drift in the subsurface.

The major surficial features in the county are the ice-marginal drainage channels and the channel of the proglacial Maple River. Minor features include kames, eskers, terraces in the proglacial Maple River channel, ground moraine, and local recessional features referred to as washboard moraines. The trends of the washboard moraines show, at least in part, the configuration of the ice margin at the time they were formed.

The flatness of the Red River Valley is interrupted by the escarpment of the Sheyenne delta and the beaches of glacial Lake Agassiz. The Sheyenne delta covers an area of about 60 square miles in the south-central part of the county. It consists of sand and silt as much as 120 feet thick. The lake-floor deposits include two distinct lithologies; the upper unit is mainly silt and the lower unit is mainly plastic clay.

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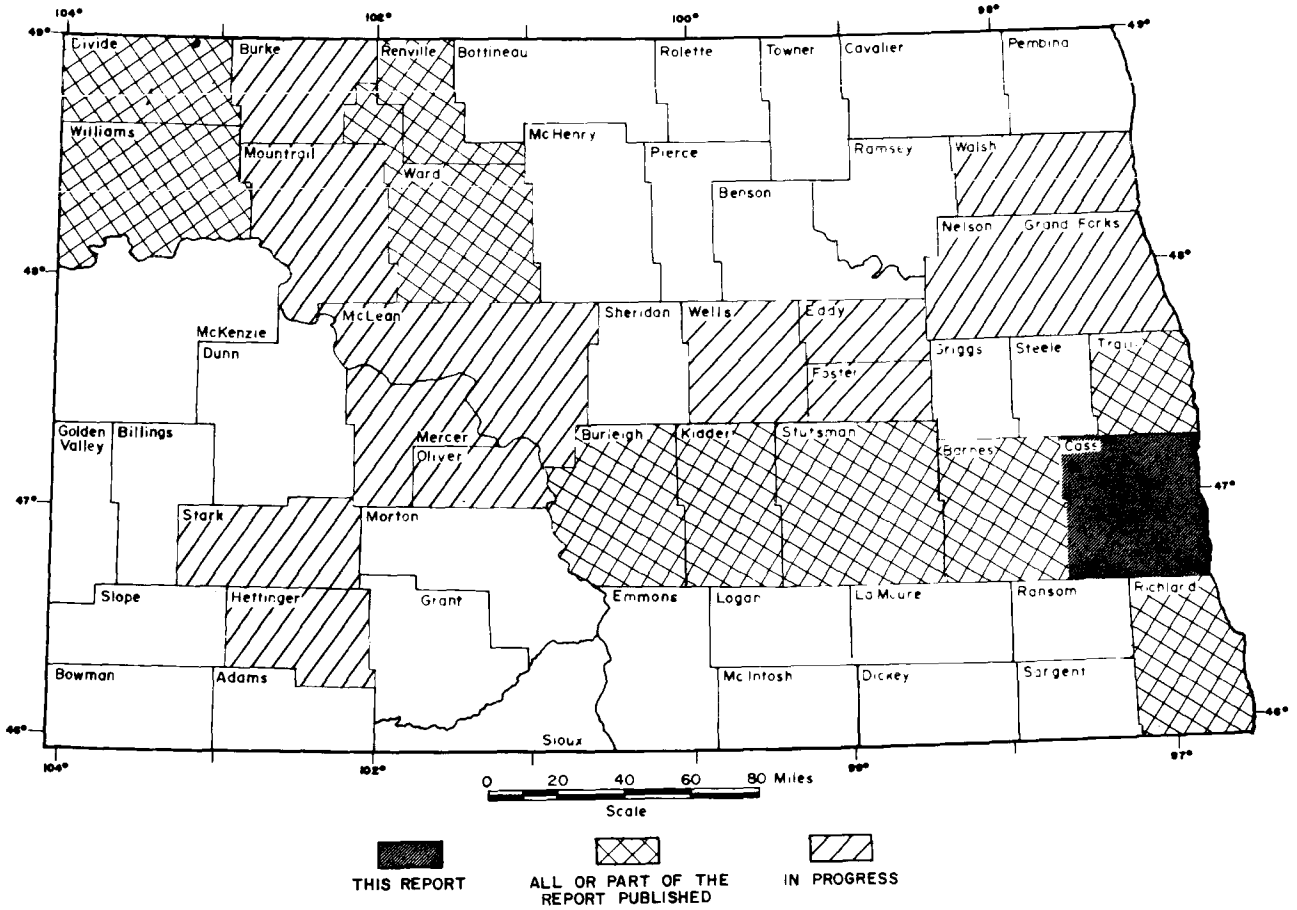

FIGURE 1. County ground-water studies in North Dakota.

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INTRODUCTION

This is the first of three reports describing the results of a study of the geology and ground-water resources of Cass County (fig. 1). The study was made during the period 1962-66 by the U.S. Geological Survey in cooperation with the North Dakota State Water Commission and the North Dakota Geological Survey. The initial request for the study was made by the Cass County Board of Commissioners.

The second report "Geology and Ground Water Resources of Cass County, North Dakota, Part II, Ground Water Basic Data," is a compilation of the data collected during the study (Klausing, 1966). The third report "Geology and Ground Water Resources of Cass County, North Dakota, Part III, Ground Water Resources," is an evaluation of the ground-water resources of the county and will be published later.

Purpose of study

The primary purpose of the study was to determine the occurrence, availability, and quality of ground water in Cass County. This report describes the geology of the county to the extent necessary to provide a framework for the discussion of the ground-water resources.

Fieldwork and acknowledgments

The surficial geology of the county was mapped by the author during the field seasons of 1964 and 1965. Field data were plotted on topographic quadrangle maps (scale 1:24,000) where available, and on aerial photographs (scale 1:20,000) in areas not covered by topographic maps. The data were later transferred to a base map (scale 1:63,360), which had been compiled from the North Dakota State Highway Department general highway maps of Cass County.

Subsurface data were obtained mainly from 92 test holes drilled during the field seasons of 1963, 1964, and 1965. The test holes were drilled by the North Dakota State Water Commission, Frederickson's Inc., and Lako Drilling Co. The test holes were logged by personnel of the North Dakota State Water Commission and the U.S. Geological Survey. The data collected during 1963-65 were supplemented with test-hole data collected during previous ground-water

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studies and with logs of wells and test holes provided by other State and Federal agencies and by private firms. The logs of most of these test holes were given by Byers and others (1946), Dennis and others (1949), Dennis and others (1950), Brookhart and Powell (1961), and Klausing (1966) and are not repeated in this report.

The following companies and agencies were particularly helpful in supplying data and material: Frederickson's Inc., Lako Drilling Co., U.S. Soil Conservation Service, U.S. Bureau of Reclamation, North Dakota State Highway Department, and the Cass County Road Department.

Previous work

The glacial deposits in Cass County were described first by Warren Upham in 1895. He gave a detailed description of the beach and deltaic deposits laid down in glacial Lake Agassiz; he also described certain aspects of the morainal terrain bordering the former lake basin.

In 1905, C.M. Hall and D.E. Willard described the geology of the Casselton and Fargo quadrangles (scale 1:125,000), and in 1909, D.E. Willard described the geology of the Tower quadrangle (scale 1:125,000). Willard's map shows some of the morainal tracts and outwash channels in southwestern Cass County that are described in this report.

Simpson (1929) gave a general summary of the geology and hydrology of Cass County in his report on the ground-water resources of North Dakota.

Leverett (1912, 1932) mapped the southern end and outlet of the Lake Agassiz basin, and described the geology in the extreme southern and western parts of Cass County.

Byers and others (1946) summarized the geology in the Fargo area in a report on ground water in the Fargo-Moorhead area, North Dakota and Minnesota.

Dennis and others (1949) described the geology and ground water resources of Cass and Clay Counties, North Dakota and Minnesota.

Dennis and others (1950) described the geology of the Kindred area in a report on ground water in the Kindred area, Cass and Richland Counties, N. Dak.

Horberg (1951), Colton (1958), and Clayton and others (1965) described and presented differing theories regarding the occurrence of intersecting low ridges on the plain of glacial Lake Agassiz.

Brookhart and Powell (1961) described the geology and ground-water resources in the vicinity of Hunter, N. Dak.

Cass County is included in the map by Colton and others (1963), which shows the general glacial features of North Dakota.

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Well-numbering system

The wells, springs, and test holes in the county are numbered according to a system based on the location in the public land classification of the U.S. Bureau of Land Management. It is illustrated in figure 2. The first numeral denotes the township north of a base line, the second numeral denotes the range west of the fifth principal meridian, and the third numeral denotes the section in which the well is located. The letters a, b, c, and d designate, respectively, the northeast, northwest, southwest, and southeast quarter sections, quarter-quarter sections, and quarter-quarter-quarter sections (10-acre tract). For example, well 138-50-15daa is in the NE1/4NE1/4SE1/4 sec. 15, T. 138 N., R. 50 W. Consecutive terminal numerals are added if more than one well is recorded with a 10-acre tract.

GEOGRAPHY

Location and general features

Cass County is in the southeastern part of North Dakota and has an area of 1,749 square miles. In 1960, the population of the county was 66,947. Fargo, the largest city in North Dakota, had a population of 46,662, and South West Fargo had a population of 3,328. The next largest city is Casselton, with a population of 1,394. There are 15 communities in the county having populations of less than 600. The area is served by the Northern Pacific and Great Northern Railways, both of which have main lines and numerous trunk lines crossing the county. Two Federal highways provide access to the area. U.S. Highway 81 crosses from north to south along the eastern edge of the county. U.S. Interstate Highway 94 crosses the county from east to west. State and county highways that are paved or gravel surfaced generally are accessible throughout the year.

Physiography and topography

Cass County is in the western lake section of the Central Lowland physiographic province of Fenneman (1938, p. 559), and occupies parts of the Drift Prairie and Red River Valley divisions, as described by Simpson (1929, p. 4-7) (fig. 3).

About 480 square miles in the western part of the county is in the Drift Prairie. This area is a youthful glaciated plain, which is interrupted only by minor glacial

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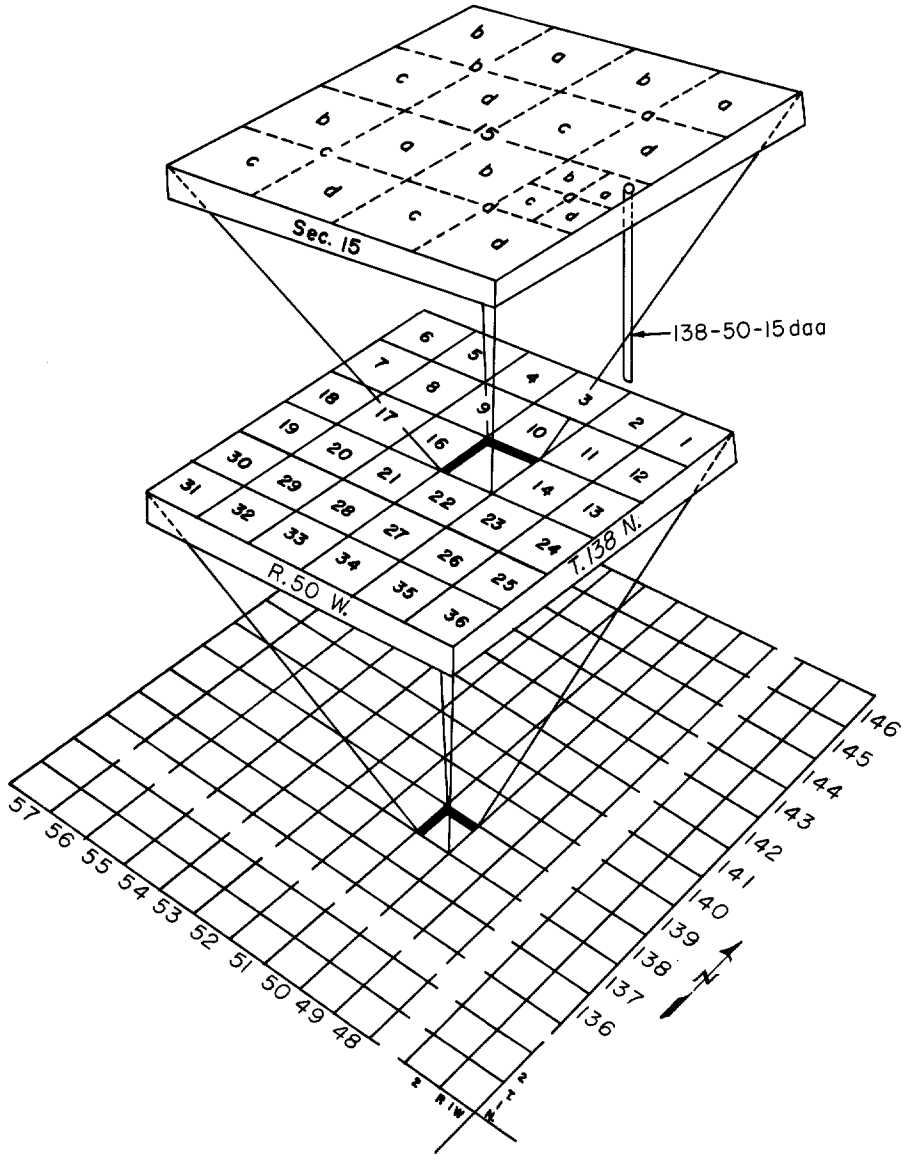

FIGURE 2. System of numbering wells, springs, and test holes.

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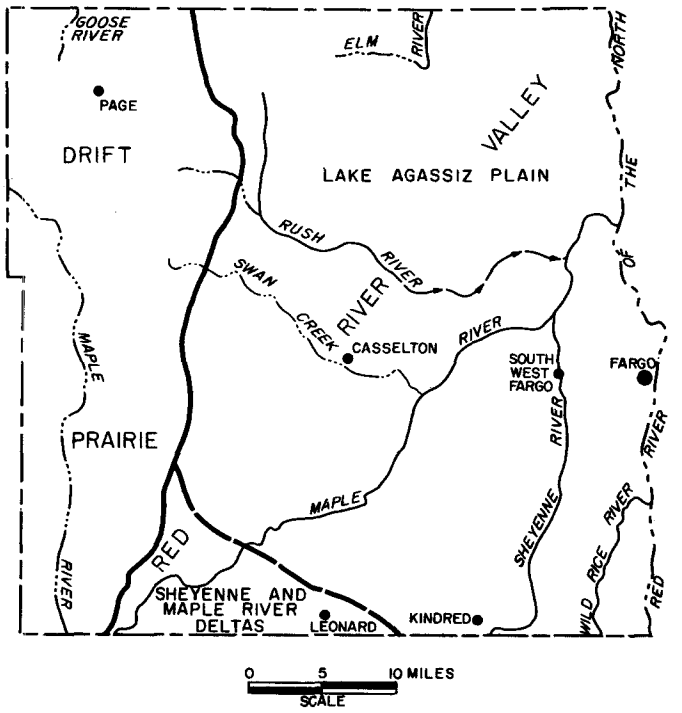

FIGURE 3. Physiographic divisions and drainage.

landforms and stream valleys. The land surface varies from strongly rolling to nearly flat. Local relief generally ranges from 10 to 20 feet per mile, but in some areas it may be as much as 40 feet.

The Red River Valley area can be divided into two units: (1) the Sheyenne and Maple River deltas, which together occupy an area of about 70 square miles; and (2) the flat, nearly featureless plain once occupied by glacial Lake Agassiz.

Northeast of Leonard, the Sheyenne delta rises 75 to 100 feet above the lake plain. To the west, it merges with the Maple River delta and the shore deposits of glacial Lake Agassiz. The surface of the Sheyenne delta in Cass County is relatively flat, and the local relief usually does not exceed 5 feet. Relief on the Maple River delta ranges from 5 feet per mile to 20 feet per mile. The Maple River crosses the delta in a northeasterly direction through a valley that ranges from a quarter of a mile to three-quarters of a mile wide and is as much as 50 feet deep.

The Lake Agassiz plain is a flat, nearly featureless plain that has a northward slope of about 1-1/2 feet per mile and an eastward slope that ranges from 2 feet per mile near the Red River to 20 feet per mile farther west. The most prominent relief features of the lake plain are the north-south trending beaches that lie along

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the western edge of the plain, and a few isolated ridges in the eastern part of the plain. These features rarely exceed 15 feet of height and generally range from 5 to 10 feet in height. The Red River of the North and its tributaries are entrenched 15 to 30 feet into the plain. Except in the vicinities of the beaches, isolated ridges, and stream valleys, local relief is generally less than 5 feet.

Drainage

The Red River of the North, which flows north along the east edge of the county, is the major stream in the area (fig. 3). Natural drainage in the lake plain is not well integrated, and a large part of the runoff is through manmade drains. The Elm River heads in the northern part of the county and drains northward. Swan Creek flows southeastward across the lake plain and empties into the Maple River a few miles southeast of Casselton. The Rush River heads in the NE cor. T. 143 N., R. 53 W., and flows south for a distance of about 13 miles before turning in a southeasterly direction. About 6 miles southeast of Amenia, the channel disappears. During periods of runoff, water flowing down the Rush River is channeled into the Sheyenne River through a manmade drain. The Wild Rice River enters the county near the southeastern corner and flows in a northeasterly direction for a distance of about 10 miles before entering the Red River of the North. The Sheyenne River, which enters the county about 1 mile southeast of Kindred, flows northward for about 30 miles before emptying into the Red River of the North, north of Fargo.

Drainage in the Sheyenne and Maple deltas is largely subsurface. The surficial drainage pattern is poorly developed because the soils and underlying deposits are highly permeable. The Maple delta is drained in part by the Maple River, which flows in a northeasterly direction across the delta. Surficial drainage in the Sheyenne delta consists of a few short, deep gullies in the northeast-facing slope of the delta. These gullies carry runoff only during periods of heavy rainfall and (or) snow melting.

Drainage in the Drift Prairie is mostly interior. Numerous small depressions collect runoff during periods of melting snow and heavy rainfall. The Drift Prairie is also drained by the Maple River, Swan Creek, and the south branch of the Goose River. The Maple River flows from north to south through the western part of the county. It leaves Cass County at the southern edge of sec. 34, T. 137 N., R. 55 W. and then reenters the county about 3 miles to the east. From this point, the river flows northeasterly across the Maple delta and the lake plain before emptying into the Sheyenne River about 3 miles north of South West Fargo.

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Soils and land use

Most of the soils in Cass County are characterized by a thick black organic topsoil and limey subsoil. Omodt and others (1961) divided the soils of Cass County into the following general types: Barnes-Hamerly clay loam, Barnes-Svea clay loam, Glyndon-Gardena loam, Embden-Ulen sandy loam, Hecla-Hamar sandy loam, Fargo clay, Bearden clay, and Hamerly-Svea-Tetonka clay loam (fig. 4). The Fargo clay is the dominant soil type, and, along with the Bearden clay, it covers the greater part of the lake plain. The Glyndon-Gardena loam and the Embden-Ulen sandy loam cover an area that roughly corresponds to the zone of littoral deposits bordering the lake plain on the west. The Hecla-Hamar sandy loam covers most of the area occupied by the Sheyenne-Maple River deltas. The Barnes-Hamerly, Barnes-Svea, and Hamerly-Svea-Tetonka clay loams cover most of the Drift Prairie.

Most of Cass County is cultivated; however, portions of the county lying in the Sheyenne delta are used only for grazing because the light sandy soils are subject to wind erosion when tilled. Parts of the Drift Prairie, also, are used mainly for grazing because they have considerable relief and are subject to erosion by water.

Climate

The climate of the area is characterized by long, cold winters and short summers. During the winter, temperatures as low as 35° F below zero have been recorded. The summers are usually warm, and midday temperatures occasionally rise to 100° F. However, the average maximums are in the 80's. The mean annual temperature is 39.9 degrees. Mean annual precipitation for the period 1939 through 1963 was 19.30 inches; most of the precipitation falls between May and September.

PRE-PLEISTOCENE GEOLOGY

Stratigraphy of pre-Pleistocene rocks

Cass County is covered with a thick mantle of glacial drift and no outcrops of pre-Pleistocene rocks exist in the county. Information obtained from well logs and test holes indicates that no rocks of Tertiary age are present. In most parts

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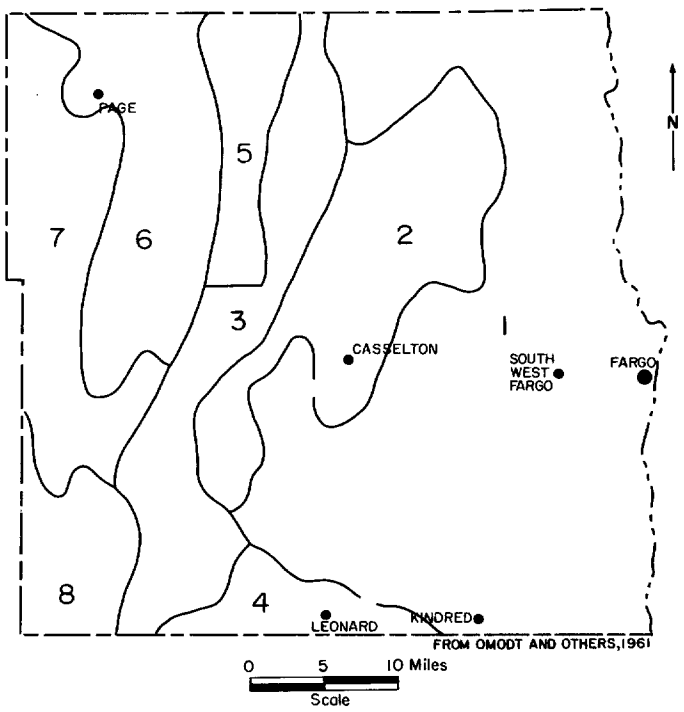

EXPLANATION

1 FARGO CLAY

2 BEARDEN CLAY LOAM

3 GLYNDON-GARDENA LOAM

4 HECLA-HAMAR SANDY LOAM

5 EMBDEN-ULEN SANDY CLAY

6 BARNES-SVEA CLAY LOAM

7 HAMERLY-SVEA-TETONKA CLAY LOAM

8 BARNES-HAMERLY CLAY LOAM

FIGURE 4. General soil types.

of the county, the pre-Pleistocene rocks immediately below the glacial drift are of Cretaceous age. The Cretaceous rocks generally rest on Precambrian rocks; however, in the northwestern part of the county, they may overlie Paleozoic rocks. The stratigraphic relations of the bedrock units and the overlying drift are shown in table 1.

TABLE 1. Stratigraphic sequence and lithologic characteristics of bedrock units.

(U.S. Geological Survey nomenclature)

Era	System		Formation	Description	Thickness
Cenozoic	Quaternary	Recent	Alluvium	Silt and clay on flood plains of modern streams.	0-15
		Pleistocene	Glacial drift	Glacial till, glaciofluvial deposits, and glacial lake deposits.	132-447
Mesozoic	Cretaceous		Greenhorn Formation	Shale, grayish-black, calcareous; thin beds of limestone, abundant white specks and shell fragments.	0-110
			Graneros Shale	Shale, dark-greenish-gray to black, noncalcareous; interbedded silt and fine sand, commonly laminated, carbonaceous.	0-157
			Dakota Sandstone	Sandstone, mostly fine-grained with interbedded black shale and silt, some carbonaceous material.	0-143
Paleozoic	Ordovician		Winnipeg Formation	Greenish-gray shale with a thin basal sandstone.	0-200
Precambrian			Undifferentiated crystalline rocks	"Granite," dark-green to red on fresh surface; weathered granite commonly consists of red, green, or white clay.	Unknown

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PRECAMBRIAN CRYSTALLINE ROCKS

The crystalline rocks underlying Cass County are referred to the Precambrian and commonly are termed "granite." Very little is known about the composition of these rocks because drilling is generally stopped when hard rock is reached. Because Precambrian granite crops out in southwestern Minnesota, it is assumed that the crystalline rocks underlying Cass County are also of granitic composition.

In the eastern part of the county, the depth to the crystalline rocks ranges from 132 to 300 feet. In the central and south-central parts, they are from 400 to 600 feet below land surface. No test holes or wells are known to have reached the Precambrian in the western part of the county. However, wells tapping Cretaceous aquifers at depths of as much as 900 feet below land surface indicate that the Precambrian rocks lie below this depth.

In most places, the upper part of the Precambrian rocks consists of varicolored clay that is generally referred to as "weathered granite." This material commonly contains granitic fragments and angular quartz grains, and is believed to be the weathered residuum of granitic rocks that were exposed to prolonged subaerial erosion.

In most of the area, the Precambrian rocks are overlain by Cretaceous rocks; however, locally the Cretaceous rocks are absent and the Precambrian is overlain directly by glacial deposits. The maximum thickness of Precambrian rocks penetrated by test drilling is 243 feet.

PALEOZOIC ROCKS

Winnipeg Formation

According to Ballard (1963, pl. 3), the Winnipeg Formation of Middle Ordovician age extends into the northwest corner of the county. In eastern North Dakota, the Winnipeg Formation is composed mainly of greenish-gray shale that generally has a thin basal sandstone member (Ballard, 1963, p. 5). Where it has been identified in eastern North Dakota, the Winnipeg unconformably overlies Precambrian rocks.

The Winnipeg Formation is not known to have been penetrated by any wells or test holes drilled in Cass County.

CRETACEOUS ROCKS

Cretaceous rocks underlie most of Cass County. These rocks have been extensively eroded in the central and eastern parts of the county; consequently, their distribution is not well known. The Cretaceous rocks tentatively are subdivided into the Dakota Sandstone, Graneros Shale, and Greenhorn Formation.

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Dakota Sandstone

The oldest Cretaceous rocks in eastern North Dakota generally are referred to as the Dakota Sandstone. However, lack of knowledge concerning the thickness and lithology of these rocks prevents definite correlation with the Dakota Sandstone in areas farther west and south. The basal Dakota generally consists of fine to coarse white sand, but in some places it consists of interbedded silt, sand, and gray clay. The sand is generally clean, well sorted, angular to subrounded, and is composed largely of quartz. The sand beds are generally poorly cemented or not cemented at all. The upper part of the Dakota consists of interbedded black and gray shale, silt, and very fine, gray sand. Locally, lignite and other carbonaceous materials are present. The variation in lithology and a general decrease in grain size from east to west indicate that the Dakota Sandstone in Cass County is probably a littoral deposit formed in a transgressing sea.

The thickness of the Dakota Sandstone in Cass County ranges greatly. The greatest thickness of Dakota penetrated was 143 feet in test hole 3119 (139-52-27aaa). In the eastern part of the county it is considerably thinner, and a maximum of 20 feet was penetrated in test hole 3099 (143-50-31ccc2). The formation seems to be absent in many places in the eastern part, even where younger Cretaceous shales are present.

Graneros Shale

In previous geologic studies of Cass County, the Cretaceous shales were grouped under the general term Benton Shale (Brookhart and Powell, 1961, p. 70). Collection of additional subsurface data, however, has permitted differentiation of the shales into the Greenhorn Formation and the Graneros Shale -- based on lithologic correlations with similar rocks described by Flint (1955, p. 23-25) in northeastern South Dakota, and Baker (1967, p. 14-19) in southeastern North Dakota.

The Graneros Shale is predominantly a black, silty, noncalcareous to calcareous shale containing white or gray silt laminae and thin beds and lenses of fine white sand. Lignite and other carbonaceous material, pyrite crystals, and fish scales are locally abundant. The presence of thin beds and lenses of sand, carbonaceous material, and pyrite indicates that the shale probably was deposited in a shallow-water environment of restricted circulation.

The Graneros Shale underlies all of the county except the eastern part, where it probably was removed by preglacial erosion. In western Cass County, the Graneros conformably overlies the Dakota Sandstone, but in the eastern part of the county, the Graneros, in places, unconformably overlies the Precambrian rocks. The Graneros Shale is known to range in thickness from 0 to 157 feet; the greatest thickness penetrated was in a well drilled completely through the Graneros and into the Dakota Sandstone (143-51-18dad).

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Greenhorn Formation

The Greenhorn Formation is a grayish-black marine shale that contains thin strata of limestone. The shale is highly calcareous and commonly contains abundant white specks and unidentifiable shell fragments of apparent marine origin.

Formerly, the Greenhorn Formation probably was coextensive with the Graneros Shale and covered the entire county. However, post-Cretaceous erosion removed the Greenhorn from the approximate eastern two-thirds of the county.

The Greenhorn Formation ranges in thickness from 0 to 110 feet. The greatest thickness penetrated was in a well drilled to the Dakota Sandstone at 140-54-19cdd (Klausing, 1966, p. 139).

Four test holes penetrated Cretaceous bedrock in the westernmost range of townships in Cass County. These were located 2 to 6 miles east of the Cass-Barnes county line, and the youngest Cretaceous unit penetrated was the Greenhorn Formation. However, Kelly (1964, p. 68, 131) reported the Carlile Shale and the Niobrara Formation in test holes located 1 to 2 miles west of the Cass County boundary. It is not known if these units extend into Cass County.

Topography of the bedrock surface

The topography of the bedrock surface in Cass County (pl. 1 in pocket) was formed during Tertiary time by subaerial erosion and later was altered by glacial erosion. The map is based entirely on subsurface data, and is therefore somewhat conjectural.

The bedrock surface in the western part of the county seems to be rather flat, but in the central and eastern parts it is greatly dissected. The general slope of the bedrock surface is to the east. The most prominent features are the two northward-trending valleys in the central and eastern parts of the county. The two valleys differ in that the westernmost one is wider and generally not so steep sided as the one to the east. The eastern valley is a northward continuation of a valley originating in southern Richland County (Baker, 1967, pl. 2). This valley, which may be the ancestral Red River, turns east at Fargo and extends into Minnesota.

Pre-Pleistocene history

Very little is known about the geologic history of the Precambrian to Cretaceous interval in Cass County. The area is located on the eastern flank of the Williston Basin and may not have received sediments during the Paleozoic and Mesozoic

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Eras, with the possible exception of the Middle Ordovician (Ballard, 1963, p. 30). Rather, it seems likely that much of Cass County, especially the eastern part, was topographically high during most of Paleozoic and Mesozoic time. During this long interval, the Precambrian rocks were deeply weathered and probably served as sources for some of the basin sediments to the west.

When the Cretaceous seas invaded the area, they covered an irregular and deeply weathered surface. The first advance of the sea was slow, and shallow water probably covered all of the area except for hills and knobs of Precambrian rocks that protruded above the sea as islands. The sediments deposited during this advance consist of interbedded clay and sand that were deposited in a littoral environment. The rock unit formed from these sediments is called the Dakota Sandstone.

Later in Cretaceous time, the area was completely covered by water. The sediments deposited were mostly black organic mud (Graneros Shale). The presence of pyrite and carbonaceous material in the shale indicates a brackish-water environment; numerous thin beds and lenses of fine sand suggest that the shoreline was not far away. Apparently, the brackish-water conditions gave way to a marine environment resulting in the formation of carbonate sediments interspersed with calcareous muds. These sediments, on compaction and lithification, formed the Greenhorn Formation. The younger Cretaceous deposits that are present farther west (Carlile Shale, Niobrara Formation, and Pierre Shale) are not known to be present in the county. Undoubtedly the sediments forming these rocks were deposited in the county, but were subsequently removed.

After the Cretaceous seas receded, the area was subjected to subaerial erosion. This period of erosion lasted throughout the Cenozoic Era and was terminated when the Pleistocene glaciers overrode the area.

PLEISTOCENE GEOLOGY

Cass County is completely covered with glacial drift. The thickness of the drift (including the glacial Lake Agassiz deposits) ranges from 132 to 447 feet and averages more than 250 feet. The variations in thickness are due primarily to bedrock irregularities, as shown on plate 1.

The surficial deposits of the county were formed as the last ice sheet receded from the area in late Wisconsin time. However, evidence of older drift deposits in several parts of the county was discovered by test drilling. The age of the older drift deposits is largely unknown.

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Subsurface units

The major subsurface units discussed in this section are buried outwash, undifferentiated stratified drift, older till, and buried lake deposits.

OLDER TILL

Studies made by Flint (1955) in South Dakota and by Lemke and Colton (1958) and others in North Dakota indicate that eastern North Dakota was glaciated several times during Pleistocene time. Thus, it seems reasonable to assume that the relatively thick deposits of drift underlying Cass County are composed of several tills of different ages. There are, however, no outcrops in the county in which more than one till has been differentiated; and differentiation of tills by examination of drill cuttings is very uncertain.

The till penetrated in the test holes drilled during this study was chiefly light to olive gray in color, but in places the test holes penetrated both olive-gray and dark-greenish-gray till. The darker till appeared to have no common horizon and its color may be a local phenomenon caused by included bedrock fragments.

Seven test holes, 139-49-28bab, 140-49-14dcd, 140-49-29ddd, 141-49-9baa2, 141-51-25ddd, 142-50-3bbb, and 142-53-1bab, drilled during the course of this study, penetrated brown, oxidized (?) till at depths of 116 to 332 feet below land surface. These oxidized (?) zones, which range in thickness from 4 to 42 feet, are evidence of older till underlying the surficial drift. Dennis and others (1949, p. 26-29) recognized older till in the subsurface in the vicinity of Casselton; however, a reevaluation of their sample logs indicates that the older till is not as thick and extensive as previously indicated. The altitudes of the weathered zones vary greatly, and several older drift sheets may be represented.

The paucity of weathered zones within the till probably is a result of glacial erosion. As each ice sheet moved across the area, it probably removed much of the drift left by the preceding ice sheet, including most of any weathered surface that had formed.

BURIED OUTWASH

Test drilling revealed the presence of a few bodies of buried outwash. The approximate boundaries of the outwash bodies are shown on figure 5.

The most extensive outwash body underlies an area of about 155 square miles in the northwestern part of the county. The outwash body is overlain and underlain by glacial till, and its top is between 40 and 140 feet below land surface.

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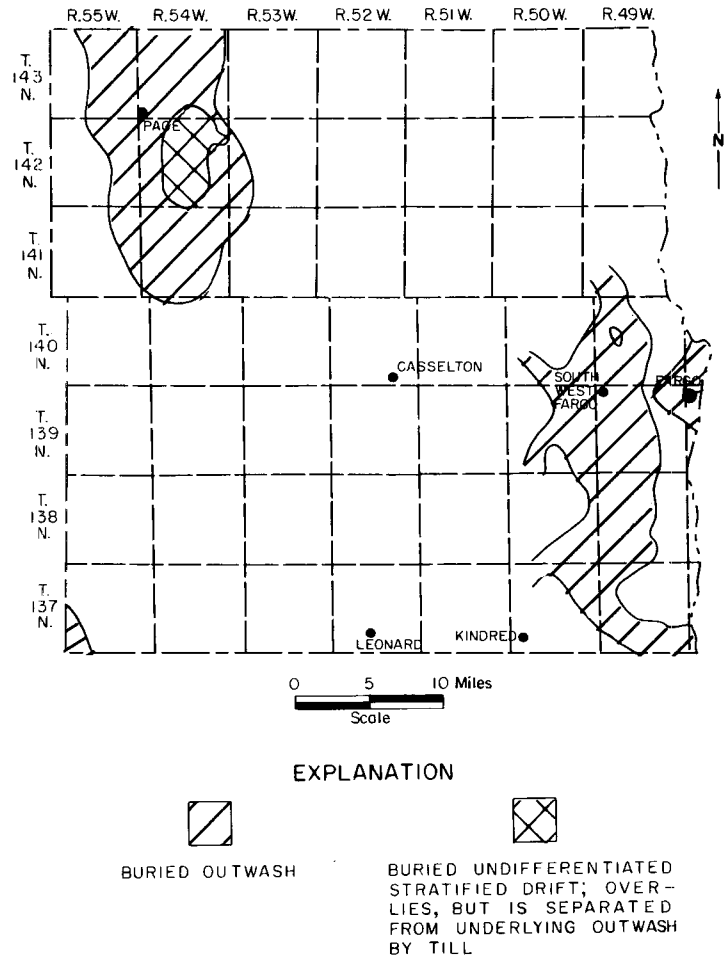

FIGURE 5. Approximate location of larger bodies of buried outwash.

The deposits range in texture from fine sand to coarse gravel, but the dominant texture is fine to medium sand. This outwash body, which ranges in thickness from 0 to 51 feet, is a water-supply source for the city of Page and surrounding farms.

A large body of outwash underlies the community of West Fargo. Test-hole data and well records indicate that the deposit underlies parts of Tps. 137 to 140 N., R. 49 W. South of T. 140 N., the thicker parts of the outwash body are confined to two separate channels that extend southward and converge into a single outwash channel. This channel trends south and east and probably extends into

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Minnesota.

The outwash in the vicinity of West Fargo is overlain by till and generally rests on Cretaceous or Precambrian rocks; however, in a few places it rests on till. The outwash body lies between 90 and 140 feet below land surface and is composed of materials ranging in size from fine sand to boulder. The thickness of this unit ranges from 0 to 140 feet.

Large quantities of ground water are withdrawn from this outwash body. Dennis and others (1949, p. 34) identified the aquifer associated with the deposits as the "West Fargo aquifer."

A small buried outwash deposit underlies an area of about 6 square miles in the vicinity of Fargo. This deposit is overlain by till and rests either on till or granite. Generally its top lies between 90 and 150 feet below land surface. The deposit consists of sand and fine gravel and ranges in thickness from 0 to 160 feet. Test-hole data and well records indicate that the outwash body extends into Minnesota. A few industrial wells in Fargo withdraw water from this outwash deposit, and Dennis and others (1949, p. 34) named the aquifer the "Fargo aquifer."

A buried outwash deposit underlies an area of about 10 square miles in the southwestern part of the county. This deposit is overlain by 5 to 30 feet of till and rests on till. It consists of sand and coarse gravel and has a known maximum thickness of 80 feet. Sand and gravel, believed to be part of this deposit, is exposed along the south wall of an intermittent stream channel in the NE1/4 sec. 31, T. 137 N., R. 55 W. These deposits have an exposed thickness of 10 to 15 feet. The uppermost part consists of poorly sorted gravel that overlies laminated, fairly well-sorted sand (fig. 6). Several farm wells pump water from an aquifer associated with this outwash body.

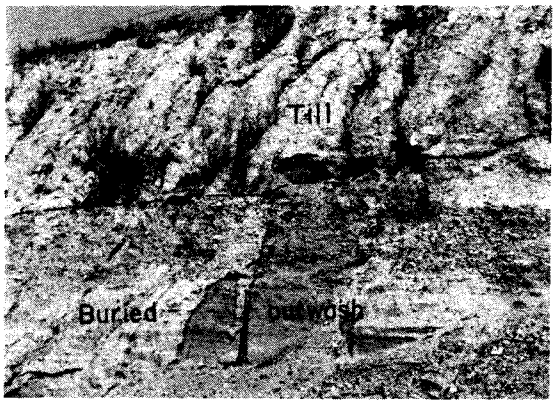

FIGURE 6. Buried outwash exposed on south side of intermittent stream channel (NE1/4 sec. 31, T. 137 N., R. 55 W.).

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BURIED STRATIFIED DRIFT, UNDIFFERENTIATED

Deposits of silt and very fine sand, capped by 1 to 5 feet of till, are exposed in a railroad cut in the NE1/4NW1/4 sec. 20, T. 142 N., R. 53 W. These deposits have an exposed thickness of 10 to 20 feet (fig. 7). Similar deposits are exposed in railroad cuts in secs. 21 and 28, and in several other localities in T. 142 N., R. 54 W. Fine to coarse sand, overlain by 9 to 14 feet of till, was penetrated in two test holes (142-54-1bbb and 142-54-8ddd) drilled in the northern part of T. 142 N. Fine to medium, clayey sand, capped by 19 feet of till, was penetrated in a test hole drilled near the south edge of the township. The silt and sand deposits are not known to be continuous, but the similarity of stratigraphic position suggests that they may represent a single large body of stratified drift. The deposits are known to range in thickness from 10 to 78 feet.

FIGURE 7. Buried stratified drift, undifferentiated, exposed in railroad cut in NE1/4 NW1/4 sec. 20, T. 142 N., R. 53 W. (view looking north).

BURIED LAKE DEPOSITS

Dennis and others (1949, p. 26) described older lake deposits within the till near Casselton and discussed the probability that a lake existed in that area prior to the formation of glacial Lake Agassiz. The "older lake deposits" described by Dennis and others (1949) are not extensive, and very few examples of older

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lake clay were found within the Lake Agassiz basin during the present study. This is to be expected, however, because much of such a deposit probably would be destroyed by glacial erosion.

Thick deposits of silt and clay were penetrated in two test holes drilled in the northeastern part of the county. The silt and clay are as much as 180 feet thick (pl. 2, section A-A'; in pocket), and probably represent a former glacial lake.

Drift of late Wisconsin age

TILL AND ASSOCIATED STRATIFIED DRIFT

The surficial features in Cass County are composed of glacial drift of late Wisconsin age, and have been altered very little by post-Pleistocene erosion. The features can be separated into till and associated stratified drift deposits of the Drift Prairie physiographic division, and the lacustrine deposits of the Red River Valley physiographic division. Surficial geologic features are shown on plate 3 (in pocket).

Upham (1895) and Leverett (1912, 1932) mapped separate end moraines in western and southwestern Cass County. However, work done during the present study did not reveal any evidence of end moraines in the county. The proposed end moraines do not coincide with existing topographic "highs," and aerial photographs do not show any lineation patterns coincident with the courses described. Most of the area through which Upham's "Fergus Falls moraine" (1895, pl. XIX) passes is nearly flat to slightly rolling and has none of the characteristics generally ascribed to end moraines. Also, according to Upham (1895, p. 160), the eastern boundary of the Fergus Falls moraine in Cass County was marked by numerous kames of sand and gravel. However, no kames were found in this area. T.E. Kelly (oral communication) did not identify the Fergus Falls moraine in adjacent Barnes County. Leverett (1912, fig. 1; 1932, p. 111) mapped a north-south "morainal belt" in southwestern Cass County; however, there are no topographically high areas or other indications of morainal deposition in that part of the county.

Till

The composition of the till varies greatly. In places it consists chiefly of silt, but in other places it consists largely of clay intermixed with sand and gravel. Boulders are common but not abundant; cobbles are locally abundant. In surface exposures, the color of the till is moderate yellowish brown because of oxidation. The thickness of the zone of oxidation generally ranges from 10 to 30 feet.

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No exposures of unoxidized till are known to occur within the county, but samples from test holes are olive gray to dark greenish gray.

Three till landforms have been recognized in Cass County: ground moraine, washboard moraine, and a kettle chain.

Ground moraine.--Areas of till having low relief and lacking definite linear trends are called ground moraine (Flint, 1955, p. 111).

Ground moraine covers about 480 square miles in western Cass County (pl. 3), and extends into Barnes and Steele Counties. It is bounded on the east by beach deposits of glacial Lake Agassiz. The topography varies from nearly flat to strongly rolling, with local relief ranging from 5 to 50 feet.

Washboard moraines.--Washboard moraines are characterized by numerous

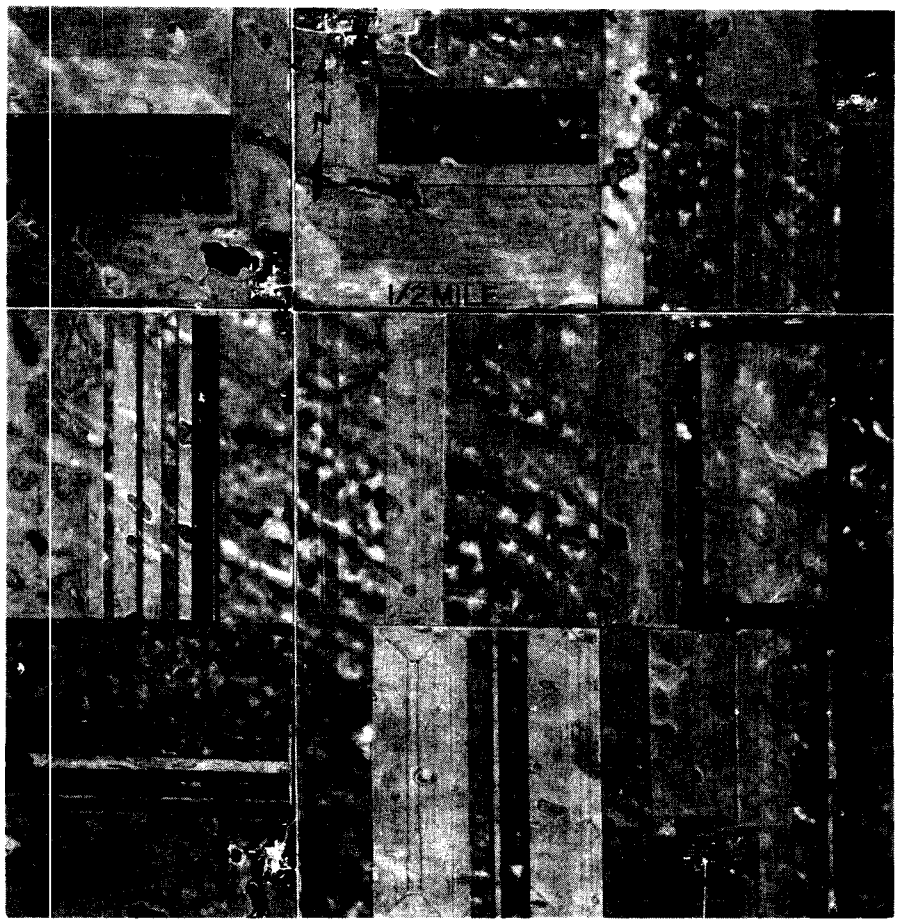

FIGURE 8. Washboard moraines in southwestern Cass County. Vertical airphoto.

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low, subparallel, discontinuous ridges of till. In Cass County, these ridges trend northwest-southeast and rise from 10 to 15 feet above the surrounding terrain. The ridges are minor recessional features that mark cyclic pauses of the ice front during deglaciation (Winters, 1963, p. 19). They are slightly convex to the southwest, indicating that the last ice sheet receded in a northeasterly direction. The linear pattern displayed by the ridges and the intervening depressions is not apparent in the field, but is easily seen on aerial photographs (fig. 8). Washboard moraines are common in the southwestern part of the county and extend into adjacent areas in Barnes and Ransom Counties.

Kettle chain.--A kettle is a depression in the drift caused by the wasting away of a completely or partially buried ice block. According to Flint (1953, p. 148), the largest and most conspicuous kettles result from the melting of relatively thick projecting ice masses. This type of kettle has steep-sided slopes that were formed by slumping of the sediment when the supporting ice melted away. Smaller buried ice masses result in shallow kettles.

A rather prominent chain of kettles extends south of Alice for about 8 miles in southwestern Cass County. The kettles are elongate in a north-south direction and some are as much as 1-1/2 miles long. They range in width from about half a mile or less to nearly a mile, and have flat bottoms and steep sidewalls in which till is exposed. Some are as much as 25 feet deep, nearly all contain lakes or marshes that become dry during periods of prolonged drought.

Stratified drift

Surficial deposits of stratified drift in Cass County consist of kames, eskers, outwash channel deposits, and river terrace deposits. The location of these units is shown on plate 3.

Kames.--Kames are low mounds and irregular-shaped hills composed of washed drift that was deposited within, or at the edge of, glacial ice by melt-water streams. The kames in Cass County range in height from 5 to 25 feet and have gently sloping sides (fig. 9). They are composed of poorly sorted silt, sand, and gravel. The sand and gravel deposits generally are poorly stratified, but well-stratified silt and sand beds are not unusual. The bedding ranges from horizontal to tilted. The tilted bedding was caused by slumping after the supporting ice walls melted.

Many of the kames or kamelike features are closely associated with eskers, and in places the two types of features cannot be differentiated; therefore, they are shown on the landforms map as one unit.

Eskers.--Eskers, which are sinuous ridges of stratified drift deposited by melt-water streams flowing in tunnels or channels in the glacial ice, are unusually

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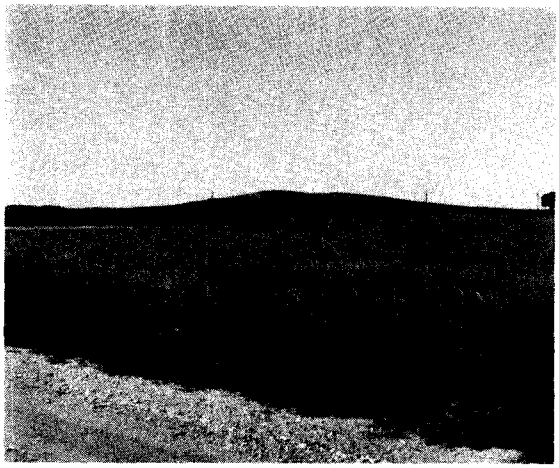

FIGURE 9. Typical kame in NE cor. sec. 3, T. 137 N., R. 55 W. View looking southwest.

common in western Cass County. They are most abundant in the vicinity of Page where they stand from 10 to 40 feet above the adjacent ground moraine. Most of the larger eskers consist of sinuous to nearly straight segments that are as much as 1-1/2 miles in length. The gaps between the segments generally are less than a quarter of a mile in length. The longest esker in the county is 1 mile west of Page and has a total length of about 7 miles, including the gaps. It consists of a series of steep-sided, irregular ridges and mounds that rise between 10 and 20 feet above the adjacent ground moraine.

Most of the eskers are composed of poorly sorted sand and gravel. Generally the range in grain size is small, but some deposits range widely in grain size. Till is commonly draped over the flanks of the eskers and, in places, forms a thin mantle on their crests (fig. 10). In some eskers, till is locally intermixed with sand and gravel. The degree of bedding in the sand and gravel varies considerably. Some of the deposits are distinctly bedded, but in others the bedding is very indistinct (figs. 10 and 11). The bedding is horizontal to tilted.

Exposures of eskers in pits and road cuts show thicknesses of stratified drift ranging from 3 to 10 feet. Auger holes, drilled by the Cass County Road Department in an esker in the NW1/4 sec. 36, T. 143 N., R. 55 W., showed thicknesses of as much as 20 feet.

Maple River deposits and associated terraces.--The proglacial Maple River valley extends southward from the north edge of T. 140 N., R. 55 W. into Ransom County. The valley ranges in width from about one-tenth to half a mile and has gently to steeply sloping walls. North of its confluence with the outwash channel that extends southeasterly from Tower City, the Maple River valley is from 10

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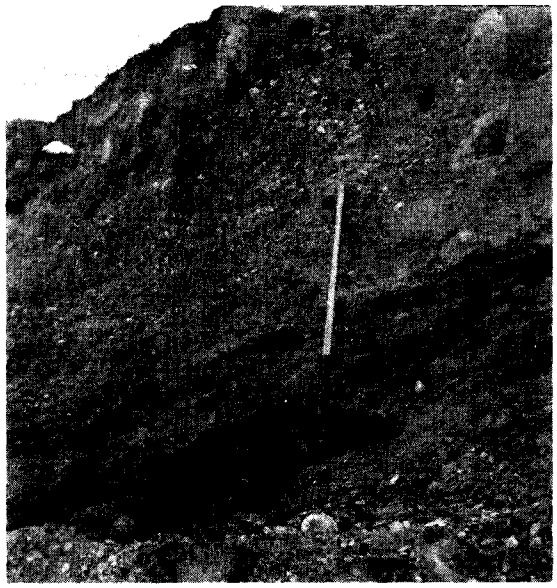

FIGURE 10. Poorly bedded sand and gravel in esker, NE1/4 sec. 17, T. 138 N., R. 54 W. View looking south.

FIGURE 11. Bedded sand and gravel in esker, SE1/4 sec. 28, T. 141 N., R. 55 W. View looking south.

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to 20 feet deep. South of the confluence, the valley is 20 to 40 feet deep.

The valley of the Maple River is mantled with alluvium, which has a maximum known thickness of 6 feet. Test holes drilled in secs. 22 and 27, T. 140 N., R. 55 W., penetrated 1 to 2 feet of alluvium underlain by glacial outwash. The outwash consists of yellow clay, sand, and gravel that has a maximum thickness of about 14 feet. The sand and gravel beds are thin, ranging from 2 to 7 feet in thickness. It is not known if outwash underlies the alluvium in the Maple River valley south of T. 140 N. Several holes were augered to a depth of 6 feet, but none of them completely penetrated the alluvium.

Near the SW cor. T. 137 N., R. 55 W., the bottoms of three "hanging" channels are as much as 20 feet above the bottom of the southeasterly-trending channel to which they are tributary. The tributary channels contain outwash of undetermined thickness that is overlain by 1 to 2 feet of alluvium.

The "hanging" channels probably are diversion channels that were formed during earlier phases of the Maple River. When the ice east of the channels melted, a lower drainageway formed and the channels were abandoned.

Terrace remnants, which are most numerous along the east wall of the Maple River valley, are from 5 to 30 feet above the present flood plain. The terrace remnants range from a few hundred feet in length and width to more than a mile long and half a mile wide. North of the confluence of the Maple River and the outwash channel that extends southeasterly from Tower City, there is only one terrace, but south of the confluence there is evidence of two terraces. Where there are two terraces, the lower one is generally well defined, having a relatively flat surface and an abrupt scarp (fig. 12). The higher terrace remnants, which stand 10 to 20 feet above the lower terrace, generally are mantled by deposits of collu-

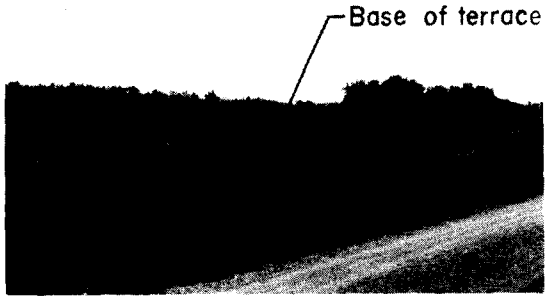

FIGURE 12. Lower terrace, east side of Maple River in NW1/4 sec. 3, T. 138 N., R. 55 W. View looking east.

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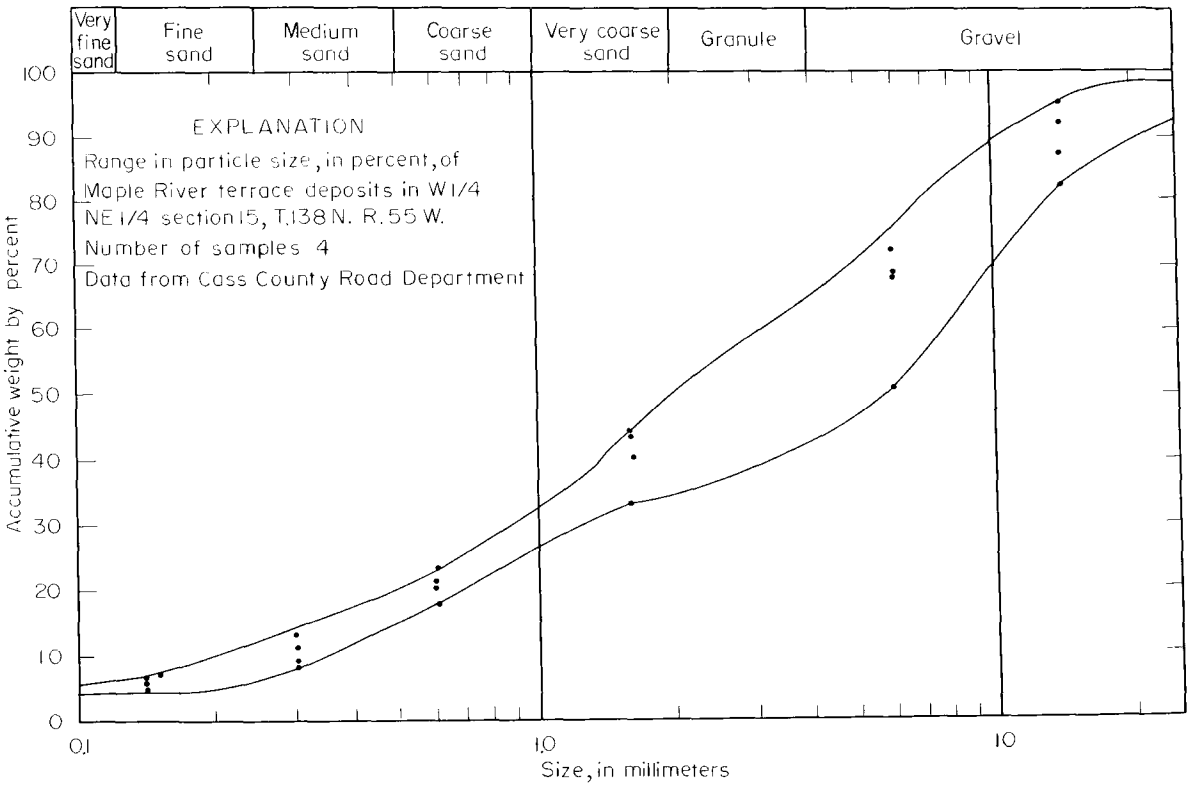

FIGURE 13. Particle size distribution of samples from terrace remnant (W1/2NE1/4 sec. 15, T. 138 N., R. 55 W.).

vium, and are less distinct.

The terrace deposits are composed of silt, sand, gravel, and boulders, but sand and gravel are the dominant size fractions (fig. 13). The deposits generally are poorly bedded, but well-stratified beds of sand and gravel are not uncommon (fig. 14). The deposits range in thickness from 0 to 20 feet.

The Maple River terraces are erosional remnants of an early period of valley development that occurred during the retreat of the ice from the area. The terraces probably were formed during the early stages of glacial Lake Agassiz; however, correlation of the terraces with separate stages of the lake cannot be made.

During the formation of the Maple River valley south of the north edge of T. 140 N., glacial ice apparently occupied the area to the north. This is evidenced by the absence of outwash or terrace deposits along the river north of T. 140 N. Also, there is no distinguishable valley associated with this part of the river, indicating that the Maple River north of T. 140 N. is of postglacial origin.

Ice-marginal outwash channels and associated deposits.--During melting of the last ice sheet, several outwash channels were eroded along successive margins of the northeasterly receding ice sheet. T. E. Kelly (written communication) mapped seven such outwash channels in eastern Barnes County. Six of the channels were reported to trend southeastward from Barnes County and into Cass County, but only three could be identified as outwash channels in Cass County. The other three channels are represented in the county by small, linear bodies of stratified

FIGURE 14. Stratified sand and gravel in terrace deposit, east side of Maple River in NW1/4 sec. 15, T. 138 N., R. 55 W.

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drift that were laid down on or adjacent to stagnant ice. A brief discussion of each of the outwash channels and stratified drift bodies follows.

The outwash channel extending southeasterly across the northwestern part of T. 137 N., R. 55 W., ranges in width from one-tenth to a quarter of a mile. It has a gently concave bottom and steep-sided walls that rise as much as 40 feet above the channel floor. Locally, terrace remnants flank the walls of the channel, but most of the terraces are of minor extent and are not differentiated from the channel deposits in plate 3. The channel deposits are composed of sand and gravel and have a known maximum thickness of 6 feet. The thickness of the terrace deposits is not known, but is probably less than 6 feet. The channel deposits are overlain by 2 to 3 feet of alluvium and, in places, the terraces are covered with a thin veneer of slope wash.

The outwash channel extending southeasterly across the southwestern part of T. 140 N. and the northwest part of T. 139 N., R. 55 W., ranges in width from one-tenth to half a mile. This channel has a relatively flat floor and gently sloping walls that rise 20 to 30 feet above the channel floor. The channel deposits are composed of sand and gravel that are as much as 22 feet thick. The sand and gravel deposits are overlain by 1 to 2 feet of alluvium and are underlain by till. The sand and gravel deposits in this channel are saturated, and serve as a water-supply source for Tower City.

The outwash channel in the NW cor. T. 141 N., R. 55 W., ranges in width from one-tenth to half a mile. The channel has a flat floor bordered by gently sloping walls 5 to 10 feet high. The western part of the channel contains no outwash, but the eastern part contains fine to coarse sand of unknown thickness.

The outwash deposit in the SW cor. T. 142 N., R. 55 W., is topographically higher than the floor of the intermittent stream channel with which it seems to be associated, and lies at about the same level as the adjacent ground moraine. Local relief generally is less than 5 feet. The deposit is known to be as much as 6 feet thick, and is composed chiefly of sand and fine gravel. The topographic position and the linear form of the deposit suggest that it was laid down in a channel that was at least in part floored on stagnant ice and was subsequently lowered unto the underlying till when the ice melted.

The western part of the small outwash body in the SW cor. T. 143 N., R. 55 W., is confined to a shallow channel, but the eastern part is unconfined and lies on nearly flat ground moraine. Local relief is generally less than 5 feet. The outwash is composed of sand and gravel, and is overlain by 1 to 2 feet of alluvium. The outwash is known to be at least 6 feet thick, but the maximum thickness is unknown. The eastern part of the outwash body probably was laid down in water that was ponded in front of stagnant ice.

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The outwash body in the NW cor. T. 143 N., R. 55 W., occupies an area of about 3 square miles. The deposits in the western part of the body have no definite topographic expression, but the deposits in the eastern part stand 5 to 10 feet above the surrounding terrain. There is a gradual increase in altitude from west to east and the eastern part generally is 15 to 20 feet higher than the western part. The deposits are composed chiefly of sand and gravel, but boulders as much as 2 feet in diameter are intermixed with the sand and gravel in a gravel pit located in the SW cor. sec. 6. The deposits are as much as 25 feet thick in the aforementioned gravel pit. Most of these deposits were laid down on or adjacent to stagnant ice by melt water discharging from an outwash channel in adjacent Barnes County (Kelly, 1967, pl. 1). Some of the sand and gravel deposits probably are collapsed outwash.

LAKE AGASSIZ DEPOSITS

Most of Cass County, about 1,270 square miles, lies below the highest shoreline and within the area covered by glacial Lake Agassiz. The Lake Agassiz deposits in Cass County can be divided into the Sheyenne delta, Maple delta, shore deposits, and lake-plain deposits. The locations of these deposits are shown on plate 3.

Sheyenne delta

The Sheyenne delta was named and described by Upham (1895, p. 315-317). Leverett (1912, 1932) and Elson (1957) believed that the feature was a deposit of ice contact stratified drift. Later studies made in Cass County (Dennis and others, 1950) and in Richland County (Baker, 1967) support Upham's theory of deltaic origin. Data collected from test holes and surface exposures during the present study also indicate that the feature is of deltaic origin.

The Sheyenne delta occupies an area of about 60 square miles in the south-central part of Cass County. Northeast of Leonard, the edge of the delta is marked by a rather steep northeastward-facing escarpment that rises 75 to 100 feet above the lake plain. To the west, the deposits merge with the smaller Maple delta, and to the northwest, with the littoral deposits of glacial Lake Agassiz. The northeast-facing escarpment of the Sheyenne delta is continuous with the Campbell beach and is believed to be a wave-cut slope formed during the Campbell stage of the lake.

The Sheyenne delta deposits in Cass County consist chiefly of finely laminated silt and very fine to medium sand. In some exposures along the face of the delta, the deposits consist of silt and very fine sand interbedded with thin layers of dark-gray clay.

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The exact thickness of the deposits at any given location is difficult to determine. The lower beds of the delta have essentially the same texture and composition as the lake-floor deposits. Therefore, no definite boundary can be drawn between the delta and lake-floor deposits. The greatest thickness of silt and sand penetrated during test drilling on the Sheyenne delta was 121 feet in test hole 137-52-31bbb.

If the escarpment of the Sheyenne delta was formed during the Campbell stage of glacial Lake Agassiz, the time of formation of the delta is fixed. Most of the delta probably was formed before the lake declined to the Campbell level.

Maple delta

The Maple delta is located in the southwest part of T. 137 N., R. 54 W. It is a small northeast-southwest-trending deposit bordered on the northwest by the littoral deposits of glacial Lake Agassiz, and on the southeast by the Sheyenne delta. The Maple delta is deeply entrenched along its long axis by the northeastward-flowing Maple River. The boundaries of the delta, as shown on plate 3, enclose only the sand and gravel facies of the deposit. The complete extent of the delta deposits is unknown because the finer sediments cannot be differentiated from the adjacent littoral deposits of Lake Agassiz and deltaic deposits of the Sheyenne River.

The Maple delta deposits are composed of silt, sand, gravel, and a few boulders. The predominant lithology is fine to coarse sand. The boulders are probably ice-rafted erratics.

Little is known concerning the thickness of deposits in the Maple delta. The only test hole (137-54-32ddd) drilled in the delta penetrated 49 feet of sand and gravel and 10 feet of silt before reaching the underlying till. It is not known if the silt is deltaic or lacustrine in origin.

The time of formation of the Maple delta is not definitely known, except that it probably was contemporaneous with the Sheyenne delta.

Shore deposits

A 4- to 10-mile wide belt of stratified gravel, sand, silt, and clay, which was formed along the western shore of Lake Agassiz, extends from the Maple River in southern Cass County northward to the northern edge of the county (pl. 3). The shore deposits were formed on a wave-eroded till surface; they are poorly sorted to well sorted and range in thickness from 0 to as much as 15 feet (fig. 15).

In most places, the deposits have little surface expression except a gentle eastward slope. However, in places well-defined beach ridges are discernible on the ground and in aerial photographs, and the crests of these ridges are shown in

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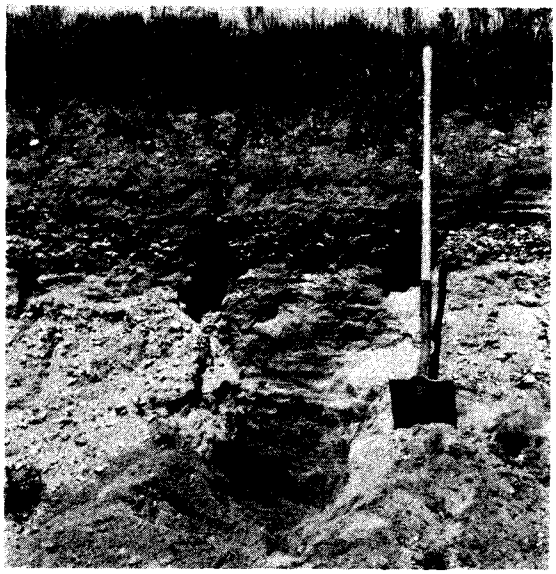

FIGURE 15. Typical beach deposit in SW1/4 sec. 1, T. 141 N., R. 53 W. View of Tintah beach looking west.

plate 3. Upham (1895) described eight beaches that cross Cass County. These he named from oldest to youngest: Herman, Norcross, Tintah, Campbell, McCauleyville, Blanchard, Hillsboro, and Emerado. However, work done during this study revealed no evidence of the Blanchard and Emerado beaches in Cass County, and the McCauleyville and Hillsboro beaches are not as extensive as Upham indicated. Upham (1895, p. 221) believed that the five upper beaches (Herman through McCauleyville) were formed during the time Lake Agassiz drained southward through the Minnesota River. The lower beaches, according to Upham, were formed during the time that the lake drained to the northeast. Leverett (1932, p. 139) disagreed with Upham's interpretation of the time of formation of the McCauleyville beach, and concluded that Lake Agassiz had no connection with the southern outlet during the McCauleyville stage.

The four upper beaches extend in a southwesterly direction from the north edge of the county and merge with the Sheyenne and Maple deltas southeast of Alice. Of the lower beaches, only the McCauleyville and Hillsboro, which are prominent east of Hunter, extend into the county (pl. 3).

Herman beach.--The highest continuous shoreline of Lake Agassiz was named the Herman beach by Upham (1895, p. 317). The beach enters the north end of the county in sec. 6, T. 143 N., R. 53 W., and extends in a southerly direction almost the entire length of the county to the north edge of sec. 31, T. 137 N., R. 54 W. where it becomes indistinct.

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The Herman shoreline is represented both by beach ridges and wave-cut slopes. In the northwestern part of T. 143 N., R. 54 W., the shoreline is a wave-cut escarpment in the till. A short distance to the east the escarpment is paralleled by a low ridge of sand and gravel that probably formed as an offshore bar. From Erie southward to the north edge of T. 138 N., R. 54 W., the Herman beach consists of sand and gravel and has the appearance of a wave-cut slope. South of T. 138 N., R. 54 W., to its terminus at the north edge of sec. 31, T. 137 N., R. 54 W., the beach is a low ridge of sand and gravel.

Norcross and Tintah beaches.--The Norcross and Tintah beaches parallel the Herman beach on the east. Generally they are low discontinuous ridge segments, but in a few places they appear to be wave-cut slopes. Generally the beach deposits consist of sand and gravel. In the western part of T. 143 N., R. 52 W., the Tintah beach is a broad prominent ridge consisting chiefly of sand.

Campbell beach.--The Campbell beach is a prominent wave-cut slope that enters the county about 2-1/2 miles north of Hunter. It extends in a south to southwesterly direction to the north edge of sec. 5, T. 138 N., R. 53 W. From this point the beach extends in a southeasterly direction and leaves the county about 6 miles southeast of Leonard. Southeast of the Maple River, the Campbell beach has been eroded into the northeast-facing slope of the Sheyenne delta. The exact location of the beach is not definitely known because there are no prominent erosional features with which the beach can be correlated; however, the beach probably corresponds to the 1,000-foot contour.

The Campbell beach rises 5 to 25 feet above the adjacent lake floor and consists for the most part of silt and sand.

Lower beaches.--The two beaches below the Campbell are the McCauleyville and Hillsboro. The McCauleyville is a low wave-cut slope eroded in clay. The east-facing slope is fairly prominent where it crosses the section line road between secs. 24 and 25, T. 143 N., R. 52 W.

The Hillsboro beach, which is the more prominent of the two lower beaches, enters the county at the north edge of sec. 6, T. 143 N., R. 50 W., and extends southwesterly for a distance of about 12 miles to the south edge of T. 142 N., R. 51 W. The beach is composed chiefly of silt and very fine sand. Upham (1895, p. 450) correlated the Hillsboro beach with the Maple ridge; however, the features are unrelated in origin.

Lake-plain deposits

The Lake Agassiz plain occupies approximately the eastern half of the county and lies, for the most part, between the altitudes of 895 and 1,000 feet above sea level. The plain is flat and featureless except for a few low ridges. The lake-plain

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deposits consist almost entirely of silt and clay.

Dennis and others (1949, p. 18,20) divided the lake-plain deposits into two units, an upper "silt" unit and lower "clay" unit. They concluded that the lake had been drained and refilled at least once, and that the silt unit had been laid down in shallow water during the later lake stage. Brophy (1963, p. 23A) provided additional evidence of two lake intervals when he reported the presence of plant remains and a dessication zone at the contact between the silt and clay units. Radiocarbon dates reported by Brophy indicate that deposition of the silt unit began about 9,900 years ago. Test-hole data collected during the present investigation verify the existence of two lake deposits throughout most of the county east of the Campbell shoreline.

Differentiation of the silt and clay units is generally based on changes in texture; however, in many places it is extremely difficult to differentiate the two units from drill cuttings. In such cases, color is used as a criterion for distinguishing the two units. The silt unit is generally yellowish brown to yellowish gray, whereas the clay unit is almost always olive gray to dark greenish gray.

Silt unit.--In Cass County, the silt unit is the predominant lake-floor deposit. It rests disconformably upon the clay unit and is composed chiefly of yellowish-brown to yellowish-gray silt. Locally the "silt" unit may consist entirely of clay or sand. It ranges in thickness from 0 to as much as 54 feet in test hole 143-52-36ddd.

In many places deposits of sand underlie or are associated with the silt unit. The presence of these deposits at the base of the silt suggests that a fluvial environment existed prior to deposition of the silt unit. In the vicinity of Kindred, the silt unit, locally, is underlain by very fine to coarse sand that is as much as 50 feet thick. Dennis and others (1949, p. 25) concluded that part of this sand body had been eroded from the face of the Sheyenne delta and redistributed lakeward by wave action during the Campbell stage of Lake Agassiz, and that the rest was deposited by the Sheyenne River during the interlake period preceding deposition of the silt. Dennis and others (1949, p. 25) believed also that the sand thickened toward the delta. The available data, however, indicate that the sand does not thicken toward the delta (pl. 1, section C-C'). The proximity of the shallow sand deposits to the Sheyenne River, and the apparent absence of sand in the area between Kindred and the Sheyenne delta, suggest that the sand deposits at Kindred are fluvial in origin.

Clay unit.--The clay unit underlies the silt unit and rests unconformably upon the till and associated deposits. This unit consists of olive-gray to dark-greenish-gray plastic clay. Locally it is silty, and, occasionally ice-rafted sand, gravel and boulders are found in the clay. Test drilling and well records indicate that the clay unit ranges in thickness from 0 to as much as 82 feet in test hole 140-49-36aaa.

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Maple and Sheyenne ridges.--Two long ridges, which rise 5 to 20 feet above the surrounding lake plain, are the most prominent features in the southeastern part of the county (pl. 3). The ridges consist of silt, sand, and gravel. The upper 10 to 25 feet consists of silt; it is underlain by sand and gravel that may be as much as 25 feet thick. The sand and gravel deposits, in turn, are underlain by lake clay.

The westernmost ridge, called the Maple ridge by Upham (1895, p. 450), lies northwest of the Maple River, and parallels the river for a distance of about 15 miles. The Sheyenne ridge lies east of the Sheyenne River, and parallels the river for a distance of about 12 miles. It stands 5 to 10 feet above the lake plain and extends northward from the NW cor. T. 137 N., R. 49 W. to the SW part of T. 139 N., R. 40 W. At this point, the ridge bifurcates and forms the Fargo and West Fargo ridges (Dennis and others, 1949, p. 11). This ridge has a lithologic sequence similar to that of the Maple ridge, and is believed to have had a similar origin.

Upham (1895, p. 450) suggested that the Maple ridge was part of the Hillsboro beach. He believed that it had formed as a result of deposition of material eroded from the margin of the Sheyenne delta and from the adjacent lakebed. Dennis and others (1949, p. 37) proposed that the sand and gravel deposits underlying the Maple River, Fargo, and West Fargo ridges could have originated either as near-shore deposits in a transgressing lake, or as fluvial deposits laid down during an inter-lake period. They further postulated (p. 37-38) that after recession of lake waters from the area, the ridges were formed as a result of differential compaction of the sediments. The sand and gravel deposits underlying the ridges were compacted less than the silt and clay deposits adjacent to the ridge.

The origin of the sand and gravel deposits underlying the ridges is questionable; however, the proximity and similarity of the trends of the ridges and the present streams, and the fact that the sand and gravel deposits extend down into the lake clay, suggest that the deposits were laid down by streams flowing across the lakebed during the inter-lake period. The main objection to a near-shore lacustrine origin is that there would be no source for coarse clastic material in a lake transgressing across a thick deposit of plastic lake clay. If the sand and gravel deposits extended farther south than the present limits of the ridges, they probably were redistributed by currents or wave action during the second stage of the lake.

Intersecting minor ridges.--Numerous intersecting lineations are present in the lowest and flattest part of the Lake Agassiz plain along the Red River. These features, which are apparent only on aerial photographs, extend northward from Fargo, N. Dak. into Canada. Horberg (1951) described the features as northwest-southeast-trending ridges that are 3 to 10 feet high, 75 to 100 feet wide, and as much as 6 miles long. According to Clayton and others (1965, p. 655) the lineations in Walsh and Pembina Counties, N. Dak. are predominantly ridges; but in

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Cass County, the lineations are predominantly grooves. Horberg (1951, p. 15-16) concluded that the lineations are an unusual type of tundra or permafrost patterned ground. As an alternate theory, he proposed that the ridges are fracture fillings formed in lake ice. Colton (1958, p. 76) agreed with Horberg's alternate theory and suggested that the ridges probably were formed by squeezing up of the soft lake sediment into cracks in thick lake ice when the level of Lake Agassiz was at a low stage. Other workers (Nikiforoff, 1952, p. 99-103; and Elson, 1961, p. 70) proposed different origins for the linear features. Clayton and others (1965, p. 655) concluded that most of the intersecting ridges and grooves on the Lake Agassiz plain were formed by the dragging of thick sheets and blocks of wind-driven lake ice across the nearly flat bottom of glacial Lake Agassiz. According to them, this is the only theory that explains the pattern, orientation, and curvature of the ridges and grooves. They do not imply, however, that all the linear features in the Lake Agassiz basin were formed by the above mentioned process.

This writer agrees with Clayton and others in that most of the linear features were caused by dragging of wind-driven ice blocks across the lakebed.

RECENT DEPOSITS

Alluvium and dune sand are grouped under deposits of Recent age; however, these deposits probably range in age from late Pleistocene to Recent.

Alluvium

The alluvium consists of clay, silt, sand, and fine gravel that was deposited by postglacial streams. Only the alluvial deposits that form the flood plains of the larger streams were mapped. Thin deposits, laid down by the smaller intermittent postglacial streams, were not mapped. Likewise, thin deposits of clay and silt in undrained depressions in the ground moraine, as well as deposits of colluvium along the valley walls of some of the streams, were not differentiated from the underlying unit.

It is difficult to determine the thickness of the alluvium because of the lack of exposures. Augering in stream valleys and examination of exposures in undercut banks indicate that the alluvium is as much as 15 feet thick in places.

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Dune sand

Mappable areas of dune sand are present on the Sheyenne delta in the vicinity of Leonard (pl. 3). The sand areas are characterized by hummocky topography, rather than distinct dunes, and the local relief is less than 10 feet. The dune sand was derived from the delta; consequently, the grain sizes (silt to fine sand) are about the same as those of the deltaic deposits. The surficial sand is usually grayish brown in color because of the presence of decayed organic matter. The color becomes brown to yellowish brown with depth as the dune sand grades imperceptibly into the underlying deltaic deposits.

PLEISTOCENE AND RECENT HISTORY

During Pleistocene time, Cass County probably was covered several times by continental glaciers. Drift of pre-Wisconsin age has not been recognized in eastern North Dakota, but Flint (1955, p. 30-41) identified drift of Nebraskan, Kansan, and Illinoian age in South Dakota. The distribution of pre-Wisconsin drift in South Dakota indicates that the glaciers advanced southward via the James River and Red River lowlands. During Wisconsin time, Cass County probably was covered by glacial ice three and possibly five times (Lemke and others, 1965, p. 13-26).

Each of the advancing ice sheets that crossed the county left deposits of drift, and each succeeding ice sheet removed and redistributed these deposits. The deposits left by the various ice sheets are so similar in lithology that they cannot be easily differentiated. Evidence of more than one drift sheet in the county can be found only in a few places.

Great thicknesses of glacial drift were deposited in the county and by the time of the last glacial recession, the pre-Pleistocene topography was completely buried. The northwest-southeast-trending washboard moraines and ice-marginal outwash channels located in the western part of the county indicate that the last ice sheet receded in a northeasterly direction. As the ice receded from the northward-sloping Red River Valley, a large proglacial lake, called Lake Agassiz, was formed in eastern North Dakota and western Minnesota. About three-fourths of Cass County was covered by the lake waters.

At its maximum, Lake Agassiz extended from northeastern South Dakota into Canada, where its area exceeded that in the United States. According to Upham (1895, p. 215), the average width of the lake was about 150 miles. The greatest depth of Lake Agassiz in Cass County during its maximum (Herman) stage was

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about 150 feet. The lake had an outlet to the south through a valley now occupied by the Bois de Sioux River and a chain of lakes and marshes. Differential erosion of the bottom of the channel was accompanied by rapid declines of the lake level and resulted in the formation of well-defined shorelines. As the ice continued to recede, outlets were uncovered to the northeast, and Lake Agassiz gradually receded from Cass County.

Some of the more prominent features in Cass County were formed during the time glacial Lake Agassiz I occupied the Red River Valley. During the highest stage of Lake Agassiz, a well-defined shoreline (Herman shoreline) was formed, and an extensive delta, which extended into Cass County was formed at the mouth of the Sheyenne River. Another prominent shoreline (Campbell shoreline) probably was formed before Lake Agassiz I drained. The prominence of the Herman and Campbell beaches indicates that the lake stood at these levels longer than at any other.

After Lake Agassiz I receded from Cass County, the lake plain was subjected to subaerial erosion and, in places, there was abundant plant growth. During this interlake period, two streams, probably predecessors of the Sheyenne and Maple Rivers, deposited sand and gravel in shallow channels eroded into the lake plain.

The interlake period terminated about 9,900 years ago when a readvance of glacial ice blocked the northern outlets and caused the basin to be refilled to about the level of the Campbell beach.

When the glacial ice again receded sufficiently to uncover the northeastern outlets, the lake level lowered and gradually receded from Cass County. The lake must have been relatively shallow and of short duration because the shoreline features that were formed during this stage of the lake are not conspicuous. During this last stage of Lake Agassiz, wave action smoothed the lake floor and a blanket of silt was laid down on top of the existing lake clays.

After Lake Agassiz II had receded from Cass County, the lake plain had essentially the same form that is seen today. Recent erosion has produced no prominent changes in the late Pleistocene landscape.

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GUIDELINE 32 - COMPOSTING POULTRY AND OTHER DEAD ANIMALS

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I. Introduction

The North Dakota Department of Health (NDDH) generally regulates composting of solid waste, as specified in North Dakota Century Code Chapter 23-29 and North Dakota Administrative Code (NDAC) Article 33-20. Under the definitions included in Section 33-20-01.1-03 NDAC, composting is defined as, "the controlled biological decomposition of organic solid wastes under aerobic conditions." Additional information on the regulation of solid waste, including composting activities, as well as water protection under the North Dakota Solid Waste Management Rules includes the following:

- Chapter 33-20-02.1 Permit Provisions and Procedures;
- Chapter 33-20-03.1 Permit Application Provisions;
- Chapter 33-20-04.1 General Performance Standards; and
- Chapter 33-20-13 Water Protection Provisions.

To meet the requirements for the NDDH's compost standards, a compost pile must be carefully managed to maintain proper nutrient balance, oxygen content, temperature, and moisture. Vector control must be addressed. Since some concern may arise due to leachate (water contaminated by waste products) migration as well as by odors and vectors, the Department generally requires that someone proposing a waste management facility submit a preapplication to determine the general suitability of the site for the proposed facility.

II. Alternatives

Composting problem wastes such as animal carcasses is difficult, as proper management takes careful planning, construction, operation, and resources. Wintertime compost operations may not be feasible. For many operators, it is probably cheaper and easier to try to reduce mortality (reduce the waste) and, as necessary, arrange for dead animals to be rendered (a list of grease renderers is available on the Department's website). Local municipal solid waste landfills permitted by the Department are also available to handle dead animals (a list is available from the Department).

III. Section 33-20-03.1-01: Preapplication Procedures

A preapplication, submitted to the Department for review before the onset of any extensive facility design, normally consists of a preliminary facility description and a site assessment as follows:

1. The preliminary facility description must include, at a minimum, the location of the facility, a projection of capacity, size, daily waste receipts, type of waste accepted, years of operation, description of operation and costs, and a discussion of the proposed facility's compliance with local zoning requirements; and

2. The preliminary site assessment must include available information about the site's geology, hydrogeology, topography, soils, and hydrology, based on existing information.

The information provided in the preapplication should evaluate the appropriateness of the site, in view of the general location standards detailed in Section 33-20-04.1-01 of the solid waste management rules. In addition, the preapplication submitted to the Department should be aware of the requirements of Chapter 33-20-13 "Water Protection Provisions," however, exact details on the measures necessary for water protection would be discussed as part of the facility's preapplication review. The preapplication procedure allows the Department to interact with the proposed facility's owner/operator to provide guidance on site selection, facility construction, operation, etc., before extensive amounts of time and money are expended in the facility's planning.

IV. Section 33-20-04.1-01: General Location Standards

Discuss site selection for solid waste facilities. Site selection for an animal carcass composting facility should be carefully considered to prevent or reduce potential contamination of surface water or groundwater resources. Leachate (contaminated water) generated from the waste decomposition process typically is contaminated with nitrogen, phosphorous, or microorganisms. Leachate may contaminate surface or groundwater resources. Site selection should involve an assessment of the proposed site's soil types, depth to groundwater, and distance to surface water. Compost facility site selection usually dictates the facility design necessary to protect surface water and groundwater from potential contamination. The Department may restrict establishment of animal composting facilities at some sites, based on potential impact of water resources. Approval of the site will help ensure that the composting facility operation maintains compliance with water protection provisions. Overall, the Department recommends the following criteria for siting an animal carcass composting facility:

1. Avoid sites underlain by sandy or gravelly (coarse textured) soils. These soils possess relatively large pore spaces that allow rapid water infiltration and movement. In the event that contaminated leachate is released during the composting operation, coarse textured soils act do not prevent transport of contaminants to groundwater resources. In many locations of the state, coarse textured soils are underlain by a water table or near-surface groundwater aquifer. These aquifers are particularly vulnerable to contamination from surface or near-surface activities because the aquifer is "exposed" to the surface via coarse textured soils.

2. Avoid sites within a 100-year floodplain, within 200 feet of any surface water or wetland, or sites that are near or in ravines, channels, or woody draws.

Once a preapplication has been approved, the proposed facility's owner/operator may submit the additional details necessary to address any concerns arising due to the state solid waste management rules and the concerns expressed in the preapplication review.

In addition to the General Location Standards detailed above, Chapter 33-20-04.1 includes the general performance standards for solid waste management facilities. These additional sections in this chapter that are pertinent to composting activities include:

- Section 33-20-04.1-02 General Facility Standards;
- Section 33-20-04.1-03 Plan of Operation;
- Section 33-20-04.1-04 Record keeping and Reporting;
- Section 33-20-04.1-05 General Closure Standards; and
- Section 33-20-04.1-07 Piles Used for Storage and Treatment - Standards.

These sections should be reviewed in detail by any proposer wishing to develop an animal waste composting facility. Some requirements may need more explanation than others. Some of the specific requirements may be applicable to other types of facilities such as a landfill (not applicable or NA) or may be simply answered in a one or two sentence statements. Some requirements will need careful explanation. To help the proposer for a facility, the following discussion is intended to help guide them through the various sections and requirements. Any proposer is also advised to work closely with the North Dakota Department of Agriculture, the National Resources Conservation Service (formerly the Soil Conservation Service) who has publications pertinent to animal waste composting and other technical resources.

V. Section 33-20-04.1-07: Piles Used for Storage and Treatment

Detail some specific design and operating standards for compost systems. Design of the animal carcass composting facility will depend on the facility's size and method of operation. Careful facility design such as constructing a sturdy enclosure with a roof, rot-resistant walls and supports, screening, and an impervious floor can control moisture in the compost (thus preventing leachate generation and soil infiltration) as well as controlling vectors (flies, rats, skunks, snakes, etc.). Similarly, in-vessel composting systems can help ensure control of all parameters. Issues to be considered include:

1. Vector control.

2. Comply with the general facility standards of Section 33-20-04.1-02 (partially discussed below).

3. Maintain the site including the removal of all solid waste, as necessary, and at closure to a permitted facility, or otherwise manage the waste that is in keeping with the purpose of this article. This part of the application should detail what will be done with the end product (compost) and what will be done in the event of system disruption and at closure.

4. Requirements for waste piles likely to produce a leachate, such as animal waste compost systems include:

    a. Depending on the site and the facility design and operation, the base of the compost operating area must be adequately lined with concrete, asphalt, specification-compacted clay, or an artificial liner to control or restrict downward migration of leachate. A liner thickness may be reduced if moisture can be carefully controlled and at sites that are underlain by thick deposits of clay-rich soil and a relatively deep water table. The liner or pad must be durable and large enough to allow the equipment to maneuver.

    b. Waste piles likely to produce a leachate must establish structures adequate to control run-on and runoff from a 24-hour, 25-year storm to prevent potential surface water or groundwater contamination. Permanently constructed and well maintained earthen berms of adequate design should be sufficient to control surface water run-on and runoff. The Department also recommends that the composting facility describe methods to manage contaminated runoff ponded within berms.

Based on site and waste characteristics, the Department may require other environmental measures as listed.

VI. Section 33-20-04.1-02: General Facility Standards

Requires a facility owner/operator to provide for the training of facility personnel in procedures necessary for the specific facility and to provide for routine inspections of the facility.

In addition, the standards stipulate that all facilities shall comply with the water protection provisions, not cause a discharge of pollutants into the waters of the state, and not cause a violation of the ambient air quality standards or odor rules, Article 33-15, at the facility boundary.

A description of the equipment necessary for composting operations to meet the environmental standards described in subsections 2 through 5 and may vary with the method used. For any system other than an in-vessel system, a loader or similar equipment will be necessary to create and turn the pile and to remove finished compost. Systems using active ventilation or piping in the pile will need piping and probably a blower. To monitor temperature, a compost thermometer with a long probe is necessary. Systems may need a meter to monitor pH levels. If large particles and resistant bones are a problem, compost grinding or classification may be necessary. Spreading equipment may also be necessary.

Some specific requirements such as for a sign at the facility can be adapted, as necessary, for a composting facility. A facility not taking a wide variety of wastes, and not open for public use, would only need to indicate the name of the facility, the name and telephone number of the owner and operator, specify on the sign that the facility is only for the animal wastes specified for the facility, and have a statement restricting trespassing.

The general facility standards provide general requirements for routine inspection (subs. 8.) and (subs. 9.) control of spillage and windblown waste materials, rubbish, trash or garbage. If animal waste is spilled or scattered, cleanup must be undertaken promptly.

VII. 33-20-04.1-03: Plan of Operation

All facilities shall have a plan of operation specific to their facility as follows:

1. The owner or operator must prepare and implement a plan of operation approved by the Department that describes the facility's operation to operating personnel and the facility must be operated in accordance with the plan. The operation plan should address the rule requirements and the items generally discussed in this guide for the operation of a nuisance-free composting facility. It is advised that the operation of an animal composting facility will need to be monitored and records kept (see subsection 2, 33-20-04.1-04) on a daily basis to ensure the following:

    a. The waste is limited to only dead birds and any bulking agents or admixtures necessary to promote controlled composting. The operation must screen waste and train employees to ensure that no garbage, trash, etc., is mixed with the compost.

    b. A description of waste handling procedures such as:

        (1) Waste should be segregated at collection points and carefully transported. Mortality should be processed daily;

        (2) A base of litter must be provided. Dead birds and litter plus a carbon-rich bulking agent (such as wood chips, straw, corn cobs, etc.) should be added in

layers so that aeration and a carbon to nitrogen ratio is in the range of 15:1 to 35:1 (optimum 23:1) is maintained. Dead birds should be kept six inches from the edges and sealed with litter each day;

(3) Moisture content of the blended compost material should be maintained between 40 and 60 percent (wet weight basis). Biological activity in the compost pile may become inhibited if the pile is too dry. Too wet a pile may cause anaerobic (lack of air) conditions, resulting in strong odors, a slower composting rate, and possible leachate generation. A good source of clean water should be available for makeup in case of dry conditions;

(4) The temperature must reach a minimum of 130°F for at least 7 to 10 days in each heat cycle to process the carcasses and kill the pathogens. A temperature drop or an increase above 140°F indicates it is time to aerate or mix and move the compost. A minimum of two heat cycles are necessary. Adequate temperatures may not be reached during wintertime, thus affecting the viability of the process. The plan should address wintertime waste management;

(5) Maintenance of adequate oxygen levels is necessary to ensure proper aerobic biological activity, control temperatures, and control odors. Measures to maintain oxygen levels in the compost include turning the pile as necessary, providing bulking agents, and providing piping into and under the compost to add air; and

(6) Control of odors, flies, or vermin resulting from animal waste composting must be addressed. Serious complaints can be expected as a result of a poorly managed animal carcass composting operation. Enclosing the facility with a roof and screen or using an In-Vessel system, as well as adhering to a detailed operation plan to minimize development of potential nuisances or health and safety threats is prudent. Use of odor or vector control measures, as necessary, should be employed.

c. The facility must be inspected as required by subsection 2 of 33-20-04.1-03. It is advised that the facility be inspected daily when it is in active use for the measures described above and any other measures necessary to provide for controlled composting in accordance with the state rules.

d. Contingencies must be addressed in the event of a fire, leaks, groundwater contamination, other releases (odors, dust, vectors, surface water releases, etc.) or other issues pertinent to the facility. The contingency action procedures should provide details (names, addresses, phone numbers) as to who will respond and what timely measures will be undertaken to address noncompliant conditions. For example, if vectors are noted on a daily inspection, the contingency action identified in the plan might be to call an exterminator that day and have him eradicate the vector problem. During successive days, remedial measures such as turning the compost and installing a screen over and around the pile could be completed. The problem and corrective measures will need to be described in the daily log will be described in the annual report to the Department.

e. Leachate removal and management must be addressed. If the system is covered with a

roof and no run-on or runoff is feasible, no leachate should migrate from the pile. If a system is to be open to the air, liners, berms, lined ponds, leachate testing and leachate transport to a disposal facility (such as a nearby Publicly Owned Treatment Works (POTW) should be addressed.

f. Safety procedures and health considerations should be addressed. Composting promotes the growth of the fungus Aspergillus fumigatus which can affect the lungs of compost workers. Other diseases and pathogens are possible if the compost operation is not adequately maintained. The risk of infection to healthy individuals working at compost facilities is relatively low. Individuals who have asthma, diabetes, or suppressed immune systems, however, should not work at a compost facility. The following measures are appropriate:

(1) Workers should be aware that disease-producing microorganisms may be in the work environment. Protective clothing or coveralls should be worn, and employees should wash up before breaks and lunch and at the end of the work period. Contaminated clothing should not be worn home by employees;

(2) Workers must maintain high standards of hygiene such as washing hands before meals, breaks, and before going home;

(3) During dry weather the composting area should be sprinkled with water to prevent dust;

(4) To reduce dust inhalation, workers should wear adequate dust respirators;

(5) Safety shoes and glasses should be worn where necessary; and

(6) The compost facility should not be located near any residences, businesses, or public facilities.

g. Sequential partial closure for landfills - Not Applicable (NA) for compost facilities.

h. Industrial waste procedures for on-site compost facilities only receiving dead animal carcasses need only provide assurances that people handling, transporting, and managing the waste will be trained to ensure that unallowed waste will not be managed by the compost facility. A list of unallowed waste might be helpful for training and operation.

2. The owner or operator shall inspect the facility to ensure compliance with the rules and shall keep an inspection log including information such as the date of inspection, the name of the inspector, a notation of observations made, and the date and nature of any repairs or corrective action taken.

VIII. Section 33-20-04.1-04: Recordkeeping and Reporting

This section states:

1. The facility may not receive waste until the construction has been approved;
2. The owner or operator must keep appropriate records at or near the facility that are available for

inspection; and

3. The owner or operator must submit an annual report by March first of each year.

IX. Section 33-20-04.1-05: General Closure Standards

A compost facility that is well operated will only need to complete the compost operation and land spread the compost as detailed in the plans. The owner/operator should detail what will be done in the eventuality that the facility goes out of business or the process is disrupted. In such a case, the owner/ operator should describe how he will remove the waste, transport it, and what facility will handle the waste (such as a local municipal solid waste landfill). As part of the contingency plan, the owner/operator must state what arrangements are made for this eventuality (what landfill, equipment, etc.). A written closure plan and closure documentation is required (see rules).

X. Chapter 33-20-13: Water Protection Provisions

This Chapter describes the site characterization procedures and, if necessary, the groundwater monitoring provisions. Well sited, designed, and operated facilities probably do not need groundwater monitoring. Site with course, sandy soils and a high water table might need monitoring. The water quality standards referenced in this Chapter refer to the North Dakota Century Code Chapter 61-28. State law does not allow pollution of waters of the state.

XI. Conclusion

We hope that these guidelines are useful to anyone considering animal carcass composting facilities. Please contact the Division of Waste Management at 701.328.5166 with questions or comments concerning this guideline or any alternative waste management methods.

Related documents: (available from the Department's website): www.ndhealth.gov/wm

1. Grease Renderers List.
2. ND Solid Waste Management Rules, Chapter 33-20-04.1, General Performance Standards.

NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

ANIMAL MORTALITY FACILITY

(No.)

CODE 316

DEFINITION

An on-farm facility for the treatment or disposal of livestock and poultry carcasses.

PURPOSES

This practice may be applied as part of a conservation management system to support one or more of the following purposes:

- Decrease non-point source pollution of surface and groundwater resources
- Reduce the impact of odors that result from improperly handled animal mortality
- Decrease the likelihood of the spread of disease or other pathogens that result from the interaction of animal mortality and predators
- To provide contingencies for normal and catastrophic mortality events

CONDITIONS WHERE PRACTICE APPLIES

This practice applies where animal carcass treatment or disposal must be considered as a component of a waste management system for livestock or poultry operations. It applies where on-farm carcass treatment and disposal are permitted by federal, State, and local laws, rules, and regulations. It also applies where a waste management system plan as described in the National Engineering Handbook (NEH), Part 651, Agricultural Waste Management Field Handbook (AWMFH) has been developed that accounts for the end use of the product from the mortality facility. This practice includes disposal of both normal and catastrophic animal mortality; however, it does not apply to catastrophic mortality resulting from disease.

CRITERIA

General Criteria Applicable to All Purposes

The facility shall be designed to handle normal mortality and/or catastrophic mortality.

The planning and design of animal mortality facilities or processes must conform to all federal, State and local laws, rules and regulations. This includes provisions for closing and/or removing the facility where required.

All structural components integral to animal mortality management shall meet the structural loads and design criteria as described in NRCS conservation practice standard 313, Waste Storage Facility, unless otherwise designated.

Where an animal mortality facility can be damaged by surface runoff, the runoff shall be diverted away from the facility.

Location. The location shall minimize the impact of the facility on odor and other air quality issues affecting neighboring residences, as well as minimizing the impact of the facility on surface and ground water resources. In addition, the facility, where practical, shall be generally down gradient from a spring or well.

The animal mortality facility shall be located outside the 100 year floodplain; however if site restrictions require location within a floodplain, they shall be protected from inundation or damage.

The location of the animal mortality facility shall be consistent with the overall site plan for the livestock or poultry operation.

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, download it from the electronic Field Office Technical Guide or contact your local NRCS office.

Seepage Control. Where seepage from mortality facilities will create a potential water quality problem and it is deemed necessary to reduce seepage, use AWMFH, Appendix 10D, for clay liner design criteria, or other acceptable liner technology.

Criteria Applicable to All Purposes – Normal Mortality

The facility shall be located as close to the source of mortality as practical, considering bio-security issues and the need to keep the facility out of sight of the general public.

Composters.

General. Design of facilities for composting animal mortality shall conform to conservation practice standard 317, Composting Facility, or the guidance in National Engineering Handbook Part 637, Chapter 2 – Composting (NEH 637.0211, Dead Animal Composting).

Freezers.

General. Freezer units shall be of the chest type with a construction compatible with the mechanism to be used to empty the freezer. Provisions for protecting the freezer unit from precipitation and direct sun shall be made as deemed appropriate.

The freezer unit design, construction, power source, and unit installation shall be in accordance with manufacturer's recommendations. Freezers shall be constructed of durable material with a life expectancy compatible with other aspects of the waste management system. The freezer container shall be leakproof to minimize odor and leachate pollution.

Where needed, the freezer will be placed on a pad of suitable strength to withstand loads imposed with vehicular traffic consistent with equipment used to load or remove the box or tray.

Temperature. The freezers shall be self-contained units designed to freeze animal carcasses before decomposition occurs. For best results, the temperature of the carcasses shall be maintained between 22^0 and 26^0 F.

Capacity. Freezer units shall be sized to accommodate the normal maximum volume of mortality to be expected in the interval between emptying. Volume calculations shall include the expected mortality rate of the animal, the period of time between emptying where mortality is given on a per day basis, the average weight of the animal between emptying, and a conversion factor for weight to volume. For broiler operations use a weight to volume conversion of a minimum of 45 pounds per cubic foot. Capacity calculations shall be supported by a removal schedule supplied by an integrator or approved vendor.

Power Source. An alternative source of power, where available, shall be used to maintain the integrity of the freezing process during power outages. Where an alternative power source will not be available, the operation and maintenance plan shall contain contingencies for disposal of the poultry mortality.

Disposal Pit.

General. Disposal pits shall not be located on sites with:

1) highly permeable soils or over fractured or cavernous bedrock within two feet of the bottom of the pit unless an approved liner is used, or
2) soils with a seasonal high water table less than two feet from the bottom of the pit.

Size and Capacity. Pits shall be sized to accommodate the normal mortality in accordance with criteria acceptable to state and local regulatory agencies. The disposal pit shall be a minimum of 4 feet wide and 4 feet long. No minimum depth is required, but the selected depth shall accommodate 2 feet of cover over the mortality. Multiple pits shall be separated by a minimum of three feet of undisturbed or compacted soil.

Structural Loading and Design. Vehicular traffic shall not be allowed within four feet of the pit structure. Fences or other barriers shall be used to exclude vehicles where necessary.

The disposal pit shall be cased with masonry blocks, treated timber, or a pre-cast concrete septic tank conforming to American Society of Testing Materials (ASTM) C1227-00b Standard Specification for Pre-cast Septic Tanks. In all cases, the bottom of the pit shall remain exposed to the soil. If the pre-cast septic tank is used, it shall be fabricated with three 6-inch openings in each end, and five six

inch openings in each side. When masonry block are used, every fourth block in each course shall be laid sideways (openings toward the outside) except the top and bottom courses. The bottom course shall be on a reinforced concrete footing of at least one foot wide and six inches thick. When treated timbers are used for walls, a one-inch spacing shall be left between timbers.

For pits that are four to five feet deep, a step or bench 18 inches wide and one-foot deep shall be dug around the perimeter of the main pit so the remaining vertical wall shall not exceed four feet. For pits greater than five feet deep, the earthen wall shall be sloped back at 1 1/2 horizontal and 1 vertical or flatter.

The top of a disposal pit shall be covered with a slab constructed of reinforced concrete or treated timber having an appropriately sized hole for a drop chute. A pit over eight feet long shall have drop chutes every five feet and a minimum of two drop chutes. The drop chutes shall be appropriately covered and made of drainage tile, or concrete, clay, or polyvinyl chloride (PVC) pipe. A ten-inch opening is recommended for chickens, and a twelve-inch opening for turkeys and suckling pigs.

Incinerators.

General. Incinerators shall be dual burning Type 4 (human and animal remains) approved for use within the state.

Capacity. Minimum incinerator capacity shall be based on the average daily weight of animal mortality and the length of time the incinerator will be operated each day.

Location. The incinerator shall be located a minimum of 20 feet from any structure. The incinerator shall be placed on a concrete pad with the fuel source as distant as practical. If the incinerator is covered with a roof, at least six inches are required between the incinerator chimney and any combustible roof parts.

Criteria Applicable to All Purposes – Catastrophic Mortality

General. Processes addressed by this standard shall be limited to burial and composting. Catastrophic mortality shall be collected as soon as practical and moved away from the production facility.

Location. The facility shall be located as far away from neighboring dwellings and the poultry or livestock operation as site conditions permit. Locate on sites with restricted percolation and a minimum of two feet between the bottom of the facility and the seasonal high water table unless special design features are incorporated that address seepage rates and non-encroachment of contaminants into the water table. Use AWMFH Appendix 10D for selection of sites where seepage will be restricted with normal construction techniques.

Burial Pit

General. Catastrophic mortality resulting from natural conditions such as temperature extremes shall be buried on-site or as otherwise directed by state and local regulatory agencies. Burial of catastrophic mortality shall be timed to minimize the effects of mortality expansion during early stages of the decay process. Where possible and permitted by state law, mortality shall remain uncovered or lightly covered until bloating has occurred, or methods employed to reduce or eliminate bloating. Topsoil shall be retained to re-grade the disposal site after the ground has settled as the decay process is completed. Stockpiled soil shall be no closer than 20 feet from the edge of the burial pit.

Size and Capacity. Pits shall be sized to accommodate catastrophic mortality using appropriate weight to volume conversions. Capacity shall be in accordance with criteria acceptable to state and local regulatory agencies. The burial pit shall be a minimum of 4 feet wide with length necessary to accommodate mortality. Depth shall accommodate a minimum of 2 feet of cover over the mortality. Pit bottoms shall be relatively level. Lengths may be limited by soil suitability and slope. If more than one pit is required, they shall be separated by a minimum of three feet of undisturbed or compacted soil. The burial site shall be of sufficient volume to contain the mortality with a minimum of two feet of soil cover. The burial site shall be finish graded to slightly above natural ground elevation to accommodate settling.

Structural Loading and Design. Vehicular traffic shall not be allowed within four feet of the pit edge.

For pits that are four to five feet deep, a step or bench 18 inches wide and one foot deep will be dug around the perimeter of the main pit so the remaining vertical wall will not exceed four feet. For pits greater than five feet deep, the earthen wall shall be sloped back at 1 1/2 horizontal and 1 vertical or flatter.

Composting

General. Catastrophic mortality composting shall be in either passive piles or windrows as described in National Engineering Handbook Part 637, Chapter 2 – Composting (NEH 637.0210 and NEH 637.0211).

Composting mortality shall be protected from precipitation as necessary, or provisions made for collecting contaminated runoff. Static piles or windrows covered with sawdust, finished compost, or other benign material will not need further protection.

CONSIDERATIONS

Major considerations in planning animal mortality management are:

- Available equipment at the operation,
- The management capabilities of the operator,
- The degree of pollution control required by state and local agencies,
- The economics of the available alternatives, and
- Effect on neighbors.

Consideration should be given to prevailing wind direction and neighbors when siting animal mortality disposal facilities. A minimum of 900 feet should separate the facility from the nearest neighboring residence, and the facility should be 200 feet from a well, spring, or water course.

Runoff from the livestock or poultry facility, or from outside areas should be diverted away from the animal mortality disposal facility.

Composting of poultry mortality will be hindered if the bird carcasses are allowed to freeze. Birds should be kept in a dry, non-freezing environment until added to the compost mix.

Facility sizes for composting large animal carcasses should reflect the longer compost periods required.

The following table lists factors that could be used in determining minimum daily weight of animal mortality when sizing incinerators:

TYPE OF ANIMAL	DAILY LOSS FACTOR (pounds/day/animal)
Chicken:	
Broilers	0.0024
Laying hens	0.0014
Breeding hens	0.0019
Breeder, male	0.0082
Turkeys:	
Hen	0.0081
Tom, light	0.0193
Tom, feather production	0.0286
Swine:	
Suckling pigs (per sow)	0.0400

Poultry operations often experience higher rates of mortality as the birds reach maturity. The capacity of incinerators should be sized to insure the mortality of the large birds can be handled within the time frame allowed for incineration.

An alternative to prevent bloating of catastrophic mortality die off could include opening animal thoracic and abdominal cavities and viscera prior to placing required cover.

Incineration produces varying quantities of ash that will need to be properly handled.

Vegetative screens and topography can be used to shield the animal disposal facility from public view, and to minimize visual impact.

State requirements for record keeping vary. Items such as burial site location, type and quantity of mortality, burial date, and other pertinent details should be noted at the time of burial.

Operators should maintain a list of current phone numbers for state and local officials to aid in notification if disease-related catastrophic mortality occurs.

Safety devices such as fencing, warning signs, and freezer locks may be necessary at certain sites.

Bio-security concerns should be addressed in all aspects of planning, installation, and operation and maintenance of an Animal Mortality Facility.

Ground disturbing activities such as excavation and site preparation for disposal facilities have the potential to affect significant cultural resources.

OPERATION AND MAINTENANCE

An operation and maintenance plan applicable to this practice that includes, but is not limited to, the items listed below will be developed with the operator, and will become a part of the overall waste management system plan. The requirements in the individual operation and maintenance plan shall be consistent with the practice purposes, intended life, and design criteria. Safety considerations shall be prominently displayed in the plan.

Normal Mortality

Animal mortality facilities will normally be operated or used on a daily basis. At each operation or use, the facility shall be inspected to note any maintenance needs or indicators of operation problems.

Catastrophic Mortality

Possible locations for catastrophic animal mortality facilities shall be located during the planning process to be operated as needed.

Burial of catastrophic mortality shall be timed to minimize the effects of mortality expansion during early stages of the decay process. Where possible and permitted by state law, mortality shall remain uncovered or lightly covered until bloating has occurred. Some topsoil shall be retained to re-grade the disposal site after the ground has settled as the decay process is largely completed.

Where composting is used for catastrophic mortality disposal, the operation and maintenance plan shall identify the most likely compost medium, possible compost recipes, operational information, and equipment that will need to be readily available.

PLANS AND SPECIFICATIONS

Plans and specifications for animal mortality facilities shall be in keeping with this standard and shall describe the requirements for applying this practice to achieve its intended purpose.

REFERENCES

Agricultural Waste Management Field Handbook (AWMFH)

National Engineering Handbook, Part 637, Chapter 2, Composting

NRCS GM 420 Part 401 – Cultural Resources

NRCS National Handbook of Conservation Practices

ASTM C1227-00b Standard Specification for Pre-cast Septic Tanks

United States
Department of
Agriculture

**Natural
Resources
Conservation
Service**

Part 637 Environmental Engineering
National Engineering Handbook

Chapter 2 Composting

637.0211 Dead animal composting

(a) General

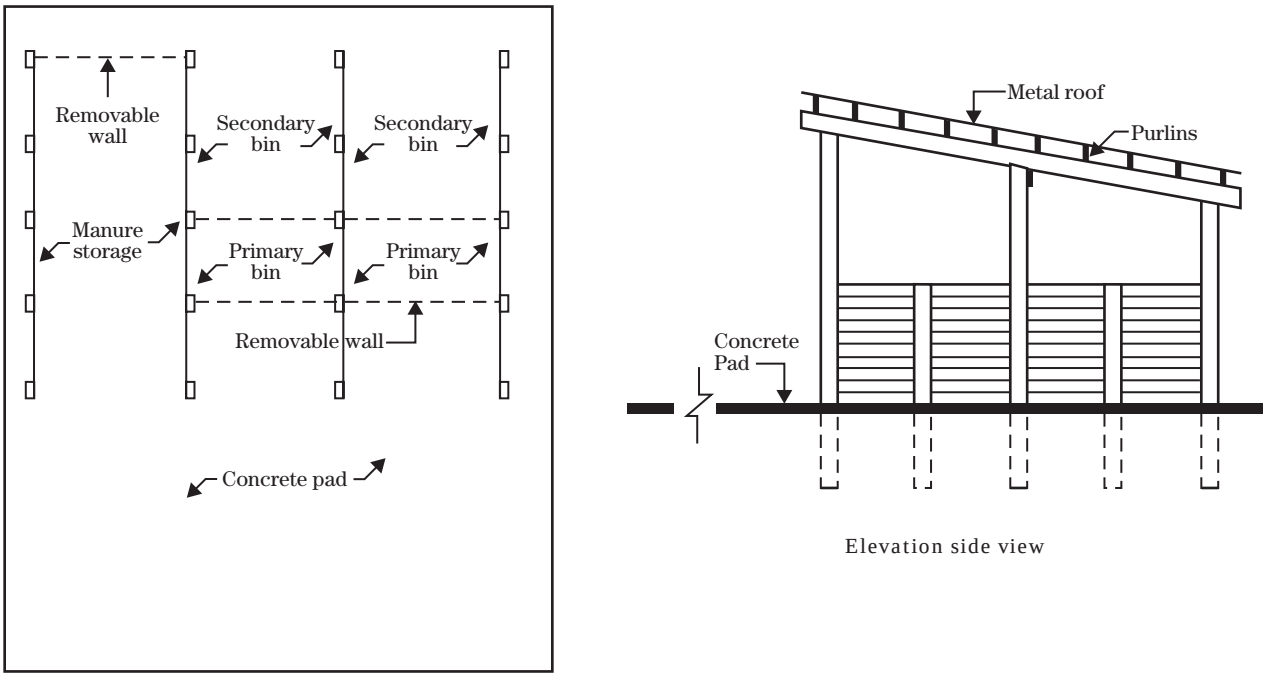
Composting dead animals is an excellent alternative to the traditional methods of their disposal, particularly burning and burying. It provides an environmentally safe and relatively inexpensive method of converting the carcasses into a useful and often marketable product. The composting system for this purpose is easy to implement and requires minimal labor, time, and capital investment.

Dead animal composting has mostly been directed toward broiler mortality, but has also been used to successfully manage swine, turkey, and even bovine mortality. To ensure complete decomposition of larger animals requires a longer composting period. A way to shorten the time required is to make cuts in the larger muscles and open the gut to increase the surface area exposed to biological activity.

The most used method for dead animal composting is the bin method. It can be either a single stage or two-stage method that uses primary and secondary bins. The single stage method is recommended for smaller operations that do not have the necessary equipment, such as front-end loaders available. The two-stage method is recommended for those operations that have a high mortality and the necessary equipment for the composting operations. A third stage may be necessary for larger animals, such as turkeys and mature swine.

Material is loaded into the primary bin (fig. 2–14) in layers (fig. 2–15). The temperature rises to highs between 135 and 150 degrees Fahrenheit within 2 to 4 days and remains elevated for several days. Once the temperature begins to cool from the peak temperature, usually within 7 to 10 days, the material is unloaded from the primary bins. The material from the primary bins is then either loaded into the secondary bins or,

Figure 2–14 Dead bird composter

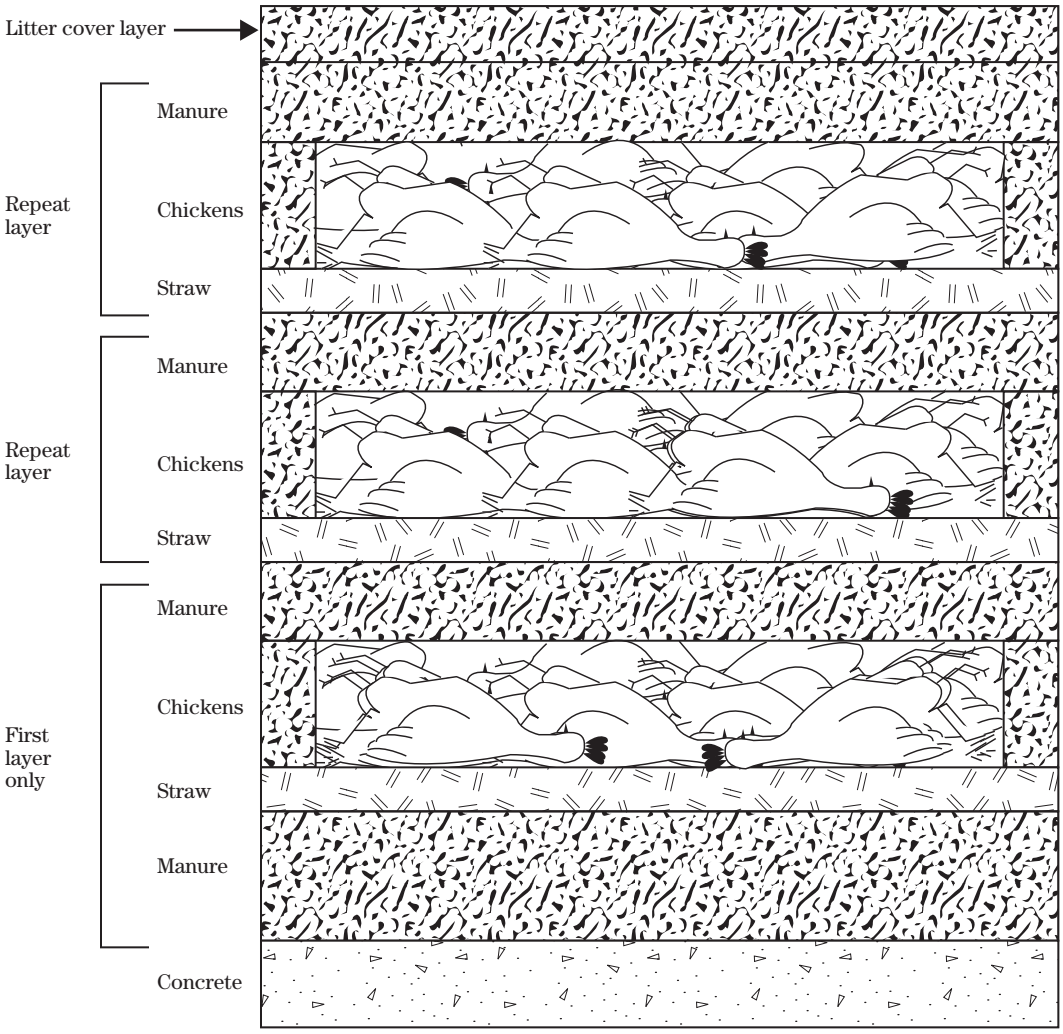


for single-stage operations, placed in curing piles. The material in the secondary bins reheats and cools after 7 to 10 days. Curing is generally done in an enclosed storage area or outside under a protective tarp. This allows new material to be loaded into the secondary bins. The finished compost can be sold or applied to the land.

The recipe for dead animal composting should be formulated so that a C:N ratio between 13:1 and 15:1 and a moisture content of 40 to 60 percent are obtained. Dead animal bodies have a low C:N ratio. Poultry manure, often used in the recipe for dead animal composting, also has a low C:N ratio unless it contains a significant amount of bedding material. To achieve a recipe having the recommended C:N ratio, a carbon amendment must be added to the mix. Straw or sawdust is generally used.

The carbon amendment can be omitted from the mix to reduce costs. Without it, however, the mix has a reduced C:N ratio with decreased aeration, and the ammonia odor increases upon mixing. As such, composting without the carbon amendment results in a tradeoff of decreased expenses for increased odors as well as the risk of incomplete composting. This

Figure 2–15 Dead bird bin composting schematic



incomplete stabilization also results in decreased compost quality and possibly inadequate pathogen destruction if the temperature is not maintained above 130 degrees Fahrenheit for 15 to 20 days.

Dead animal composting facilities should be sited where drainage and ingress and egress are good. For bin composting, a permanent structure, such as bins constructed of treated lumber or concrete, within a pole-frame building with concrete floors is the most desirable. This type facility offers easier overall operation and management, especially during inclement weather, and is more aesthetic (fig. 2–15). Bins can also be constructed of bales of low-quality hay. This type of construction is less expensive and provides flexibility that a permanent structure would not have, such as the number of bins and their location. Bale bins can also be used along with a permanent structure facility to provide additional composting capacity when the need arises. These bins are constructed with large round bales (5 to 6 feet in diameter placed end-to-end to form walls for three-sided enclosures). Some states may require that composters be roofed.

Compost produced from dead poultry or other animals is generally lower in nitrogen than broiler litter because of losses through denitrification and volatilization. It is higher in P_2O_5 and K_2O than broiler litter because of the reduction in volume that is typically 25 to 30 percent and a mass reduction of about 15 percent.

(b) Dead poultry and small animal composting

The following guidelines for composting dead poultry are adapted from those developed by Auburn University for the NRCS based on their study (McCaskey 1993):

- Use only approved plans for construction of compost facilities.
- Provide 200 cubic feet of primary bin capacity per 20,000 birds on hand and an equal amount of secondary bin capacity. For example, a poultry producer with a flock of 40,000 birds per brood would need 400 cubic feet of primary bin and 400 cubic feet of secondary bin capacity.
- Remove poultry mortalities daily from poultry houses.
- Use one of the following recipes (amounts are expressed as parts per weight basis):
  - With carbon amendment (peanut hulls or chopped hay or straw)
    Litter ..... 3 to 4 parts
    Carbon amendment ... 0.2 to 0.4 parts
    Mortalities ..... 1 part
    Water ..... 0.5 to 1 parts
  - Without carbon amendment
    Litter ..... 4 to 6 parts
    Mortalities ..... 1 part
    Water ..... 0.75 to 1 parts

  Compost ingredients should be added to achieve about 30 to 40 percent moisture in the initial mix regardless of recipe used.
- Monitor compost to see that a temperature greater than 122 degrees F for at least 5 days as an average throughout the composting mass is achieved. This temperature and time criterion can be achieved during either the primary or secondary composting stages or as the cumulative time of greater than 122 degrees Fahrenheit in both stages.
- Leave primary compost in the bin until the temperature reaches its maximum and then shows a steady decline for 1 week. If the maximum temperature during primary composting is less than 122 degrees Fahrenheit, the compost should be mixed and aerated to encourage heating. This is accomplished by moving the compost to the secondary bin. This step, mixing and aeration, should be repeated until the compost has achieved at least 5 days of temperatures greater than 122 degrees Fahrenheit. Generally, heating during primary and secondary composting is adequate. When the compost has achieved a temperature greater 122 degrees Fahrenheit for at least 5 days, the composting process is adequate to eliminate the bacterial pathogens *Listeria monocytogenes, Escherichia coli* 0157:H7, and *Salmonella typhimurium*.
- Store stabilized compost until it is convenient to land apply it or prepare it for sale to others. Use the secondary bin for stabilized compost storage or remove the compost from the secondary bin and place it in a facility where it is protected from the weather. Compost to be land applied should be tested for N-P-K and applied at rates appropriate for the type of crop grown.

(c) Dead swine and large animal composting

Determining the size of a dead swine composting facility is similar to sizing a poultry composting facility. The method is given in a step-by-step fashion below and is illustrated in example 2–1. The best data for herd mortality can be obtained from the swine producer. If information from the producer is not available, the mortality rate and carcass design weight values in table 2–5 should be used.

(1) Method to determine the size of a dead swine composting facility

Step 1. Determine the weight (lb) of dead animals per year for each size of animal using the following equations.

Baby pigs:

$$S \times LPS \times PPL \times MR \times DW = PDA$$

where:
S = number of sows
LPS = number of litters per sow
PPL = pigs per litter
MR = mortality rate (% expressed as decimal)
DW = design weight (lb)
PDA = weight of dead animals (lb/yr)

Sows nursery pigs, boars and finishing hogs:

$$S \times MR \times DW = PDA$$

Table 2–5 Mortality rates and design carcass weights for determining the size of a dead swine composting facility

Animal type	Mortality rate (%)	Design weight (lb)
Baby pigs 2 litters/sow/year 10 piglets/litter	20	5
nursery pigs	2-3	50
sows	6	400
boars		550
finishing hogs	2	220

Step 2. Determine the average weight of dead animals per day (AWDAD):

$$\frac{TPDA}{365 \text{ days}} = AWDAD$$

Step 3. Determine the primary bin size for the composting facility. Primary bin size for composting dead swine can be determined using one of two volume factors (VF).

- When sawdust is used as the composting carbon source with no added nitrogen source, VF = 20 cubic feet per pound of dead animal per day (Fulhage 1992).
- When sawdust is used as composting carbon source and poultry litter, swine manure, or other nitrogen source is added to adjust the carbon-to-nitrogen (C:N) ratio, VF = 10 cubic feet per pound of dead animal (Henry 1995).

Sample using sawdust as a carbon source with no nitrogen source added:

$$AWDAD \times VF = TPV$$

where:
AWDAD = average weight of dead animals per day (lb/d)
VF = volume factor
TPV = total primary bin volume required

The typical height of a compost pile when in an open (hay bale) facility is 4.5 feet, thus the floor area of a single primary bin is:

$$\frac{TPV}{CH} = PBFA$$

where:
TPV = total primary bin volume required
CH = height of compost pile
PBFA = primary bin floor area (for a single bin)

The second and third stage bins require the same volume as the first stage bin.

(2) Loading the first stage bin

A typical stage one composting bin is loaded using the following sequences according to type of facility and the materials used for composting.

Composting with no nitrogen adjustment:
Sawdust is layered with the dead animals for composting according to the recipe in table 2–6. The first layer is 1 foot of sawdust. To speed composting and prevent excess bloating, an incision should be made into the abdomen of any pig larger than 50 pounds. After each pig is placed in the composter, it is covered with 6 inches of sawdust. The sawdust is sloped so that runoff will be directed from the facility. When the bin reaches a height of 4.5 feet, a 6-inch minimum layer of sawdust is placed on top and sloped to shed water.

The C:N ratio of the mixture in table 2–6 is approximately the carbon source with a minimum of 6 inches of 300:1, which is the C:N ratio for sawdust (Henry, 1990). This is much higher than that desired for dead animal composting because no outside nitrogen source is used.

Composting with a nitrogen adjustment
The composting process will be more efficient if the nitrogen concentration in the mixture is adjusted. Table 2–7 shows the recipe for composting dead swine when poultry litter is used to adjust the carbon-to-nitrogen ratio.

The C:N ratios of two mixtures above are 15:1 for sawdust and 17:1 for straw. These ratios are lower than typical composting C:N ratios of 25:1. However, they correspond with values for dead animal composting in the NRCS, Agricultural Waste Management Field Handbook (NRCS, 1992).

Loading sequence when composting with litter
A typical stage one composting bin is loaded using the following sequence and according to the prescribed mix in table 2–7:

1. 1 foot of dry litter is placed on the floor of the bin to soak up excess moisture. This is not part of the recipe in table 2–6.

2. A 6-inch layer of carbon source/bulking agent is placed on top of the manure to aid aeration under the carcasses.

3. A uniform layer of carcasses is added on top of the carbon source with a minimum of 6 inches of litter added next to the sidewalls to keep the carcasses away from the sidewalls.

4. A minimum of 6 inches of litter is immediately added to cover the top of the carcasses.

5. The second and each subsequent combination of carbon source, carcasses, and liner (batch) starts with a layer of carbon source, then a layer of carcasses, and then a layer of litter added in proportion required in the prescribed mix (table 2–5). A minimum of four bins should be planned for proper sequencing of the composting process.

6. When the loading of the primary bin is completed an additional 6-inch cap of litter is added to the top of the compost mix. This 6 inches of litter is in addition to the litter that was added to the top of the last batch.

Table 2–6 Mix for composting dead swine with sawdust

	Weight ratio	Volume ratio
Sawdust	1.5	5.5
Carcasses	1.0	1.0
Water 1/		

1/ Water is added as needed to maintain a damp sponge consistency.

Table 2–7 Mix for composting dead swine with broiler litter using sawdust/straw as a carbon source and bulking agent

	Weight ratio	Volume ratio
Sawdust/straw	1.0/0 3	3.0/1.0
Litter	2.0	4.0
Water	0.7	0.5
Carcasses	1.0	1.0

Example 2–2 Determining the size of a dead swine composting facility

Given: A hog operation having 300 sows. Sows have 2 litters per year with 10 pigs in each litter.

Required: Determine the bin size for a dead swine composting facility using sawdust as carbon source. Additional nitrogen from another source will not be added to compost mix..

Solution:

1. Determine total weight of dead animals per year using data from table 2–5:
   Baby pig mortality
   PDA = S x LPS x PPL x MR x DW
   = 300 sows x 2 litters/sow x 10 pigs/litter x 0.20 x 5 lb/pig
   = 6,000 lb

   Sow mortality
   PDA = S x MR x DW
   = 300 sows x 0.06 x 400 lb/sow
   = 7,200 lb

   TPDA = Baby PDA + Sow PDA
   = 6,000 lb + 7,200 lb
   = 13,200 lb

2. Determine the average weight of dead animals per day:
   AWDAD = TPDA/365
   = 13,200 lb/365 days
   = 36.2 lb/day

3. Determine primary bin size for composting facility
   TPV = AWDAD x VF
   = 36.2 lb/day x 20 ft^3/lb
   = 724 ft^3

The second and third stage bins require the same volume as the primary bin. The third stage volume could possibly be reduced by 15 percent. However, this would limit use of this bin for the third stage only.

Using a compost pile height of 4.5 feet, the floor area of the bin would be:
Floor Area = 724 ft^3/ 4.5 ft =161 ft^2

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Sulfide and Sulfate Attack on Reinforced Concrete of Livestock Buildings

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Abstract

Although reinforced concrete is one of the most durable construction materials, in farm buildings it is subjected to high levels of hydrogen sulfide and sulfate that result in corrosion. This leads to premature deterioration of slatted floors and other concrete components of liquid manure storages. The rehabilitation of reinforced concrete structures due to corrosion is expensive and impractical. Prevention is the better approach. Hazardous gases are released from stored manure. Of these, hydrogen sulfide is the most corrosive. Sulfate-reducing bacteria generate sulfuric acid as the end of their metabolism

48 concrete cylinders, 100mm diameter and 100mm high, were made with Portland cement, and various combinations of slag, fly ash and silica fume. Each has a reinforcing steel bar embedded in it. 24 cylinders are half immersed in sodium sulfate (20,000ppm SO_4^{2-}) and also subjected to hydrogen sulfide gas (1,000ppm H_2S). The second set of 24 is subjected only to hydrogen sulfide gas. In each set, there are 8 different treatments.

Initial results indicate that after 11 cycles of testing over about 22 months that the PC concrete with 0.5 W/C ratio is the least corrosion resistant. All treatments containing silica fume, fly ash or slag, except the fly ash/silica fume combination, performed better thus far than PC concrete with 0.4 W/C ratio. Also, there is an indication that concrete with sulfate resistant cement is more resistant than type I Portland cement. Indeed, sulfate resistant cement concrete was one of the best performers in both sets of tests.

Keywords: Corrosion, concrete, fly ash, manure storage, silica fume, slag

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Introduction

The liquid manure storage facilities of a swine or dairy operation constitute a significant part of the agricultural building infrastructure investment. It is important that these facilities perform as expected and that they do so for the expected life of the operation. However, concrete in farm buildings are subjected to severe hydrogen sulfide and sulfate concentrations that result in the corrosion of reinforced concrete. This leads to premature deterioration of walls and floors, especially slatted floors, to the point of requiring replacement.

The Ontario Farmer of Sept. 11, 2001 reported the collapse of a hog barn in Innerkip, Ontario, on a calm August day, presumably as a result of corrosion of the supporting concrete piers inside the liquid manure tank. The upper parts of the piers, above the normal manure level, were so badly corroded to expose the bars. The 12-year old structure collapsed killing 200 hogs and causing damage in excess of CAN$ 0.7M. In some swine barns in Ontario a 50% loss of expected service life was reported, when regular concrete mixes were used. It is estimated that an average annual cost of depreciation on all structures is about $250 million and about $100 to 150 million is spent on repairs.

In order to improve the durability of concrete and the environmental protection under such severe agricultural aggressive conditions, some recent investigations have been made in an attempt to reduce the rate of deterioration by changing the concrete composition (De Belie *et al.* 1997; Idriss 2000; Jiang 2002).

In this study concrete made with various combinations of Portland cement, slag, fly ash and silica fume is subjected to hydrogen sulfide gas and sulfate solution. The overall objective of this study is to provide the technology to design and construct reinforced concrete liquid manure tanks that will be able to withstand the corrosive environment created by the manure, and to provide structures with a reasonable service life (25 to 30 years). The results of this research will help finding the most cost-effective solution for reducing concrete corrosion to a minimum and enhance the service life of reinforced concrete in livestock buildings, thus making better recommendations for durable structures in contact with manure. This paper reports on the progress in the present study in which various combinations of Portland cement, slag, fly ash and silica fume are subjected to hydrogen sulfide gas and sulfate solution.

Background

The reason for the deterioration of concrete, even of high quality concrete, is the specific aggressive environmental conditions often occurring on and below floors in animal houses where manure is collected and stored below the floor. Chemical components from feed residues and manure may attack the concrete floor surface. Different authors have mentioned the presence of large amounts of lactic and acidic acid and the aggressive ions Cl^-, SO_4^{2-}, Mg^{2+}, and NH_4^+. The pH and concentrations of aggressive substances in some samples taken from barns with slatted floors for fattening pigs are presented in Table 1. Table 2 shows the chemical composition of liquid, slurry and solid manure of fattening pigs (Svennerstedt *et al.*1999).

Table 1. Analysis of samples taken in barns for fattening pigs

Location	pH	Lactic acid (mg/g)	Acetic acid (mg/g)	NH_3-N (mg/g)	Cl^- (mg/g)	SO_4^{2-} (mg/g)	Mg^{2+} (mg/g)	NO_3^- (mg/g)
In drinking bowl	7.3	0.02	0.40	0.01	0.21	0.00	0.02	0.00
In wet feeder	5.2-5.9	0.12	0.17	0.09	0.94	0.40	0.66	0.00
In front of wet feeder	5.05	22.00	5.43	1.6	0.87	0.67	1.20	0.00
In front of dry feeder	6.69	5.12	6.63	2.10	2.62	0.87	2.44	0.00

Table 2. Chemical composition of fattening pig manure, in g/L

Chemical Composition	Liquid manure	Slurry	Solid Manure
Ammonium (NH_4-N)	6.5	1.3 – 5.5	1.9
Phosphate (P_2O_5)	0.9	3.6 – 6.6	9.0
K_2O	4.5	2.0 – 6.1	3.5
CaO	0.6	2.4 – 4.4	9.0
MgO	0.2	0.6 – 2.0	2.5
Cl^-	4.0	0.6 – 3.3	2.0
SO_4^{2-}	1.8	1.0 – 2.0	-
Acetic Acid	-	3.2 – 11.0	-

Comparison of the concentration in samples taken from floors in pig houses with those in pig manure reveals that most of the aggressive ions and of the acetic acid comes from the manure. However, the lactic acid originates from acidified meal/water mixtures, and is therefore the main source of severe concrete degradation near or in between the feed and water supply (Svennerstedt *et al.*1999). As well, milking parlor floors suffer from lactic acid corrosion. CSA A 23.1 (1994) specifies the requirements for concretes subjected to high concentrations of SO_4^{2-}. They are shown in Table 3.

Table 3. Aggressiveness of solution to concrete, in mg/L

Exposure Class	Degree of exposure	SO_4^{2-} concentration (mg/L)	Max. water-cementing material ratio	Portland cement type to be used
S-1	very severe	>10,000	0.40	type V
S-2	severe	1,500 – 10,000	0.45	type V
S-3	moderate	150 – 1500	0.50	type II, IV or V
	negligible	<150		type I

Hazardous gases on farms are found in silos, manure storages, grain bins, and barns. These structures provide confined spaces in which corrosive gases may accumulate to dangerous levels. When manure is stored for long periods without agitation, it undergoes anaerobic decomposition during which manure gases are produced. Warm weather and poor ventilation can increase production of these gases. Liquid manure tanks therefore can hold toxic levels of gases, or lack of oxygen. Intermittent agitation of manure in a liquid storage results in a rapid increase in the release of manure gases (Brunet 2002).

Decay of organic matter in manure pits leads to formation of H_2S, which can be transformed into sulfuric acid by bacterial action. Mehta (1986) reported that calcium hydroxide and alumina-bearing phases of hydrated Portland cement are more vulnerable to attack by sulfate ions. On hydration, Portland cement with more than 5 percent potential C_3A will contain most of the alumina in the form of monosulfate hydrate, $C_3A.CS.H_{18}$. If the C_3A content of the cement is more than 8 percent, the hydration products will also contain $C_3A.CH.H_{18}$. In the presence of calcium hydroxide in Portland cement pastes both alumina-containing hydrates are converted to the high-sulfate form (ettringite, $C_3A.3CS.H_{32}$) when they come in contact with sulfate ions (Mehta 1986).

$$C_3A.CS.H_{18} + 2CH + 2S + 12H \rightarrow C_3A.3CS.H_{32}$$

$$C_3A.CH.H_{18} + 2CH + 3S + 11H \rightarrow C_3A.3CS.H_{32}$$

De Belie *et al.* (2002) support the argument that the sulfuric acid first reacts with the calcium hydroxide in the concrete to form gypsum. Gypsum is the primary reaction product of sulfate attack at high sulfate-ion concentrations (>8000 ppm SO_4^{2-}) (Santhanam *el at.* 2001).

$$Ca(OH)_2 + H_2SO_4 \rightarrow CaSO_4.2H_2O \text{ (gypsum)}$$

Although gypsum is associated with an increase in volume by a factor of 1.2 to 2.2, the reaction between gypsum and tricalcium aluminate hydrate (C_3A) to form ettringite is much more detrimental.

$$(CaO)_3.Al_2O_3.12H_2O + 3(CaSO_4.2H_2O) + 14\ H_2O \rightarrow (CaO)_3.Al_2O_3.(CaSO_4)_3.32H_2O \text{ (ettringite)}$$

The volume of ettringite mineral is much larger than the volume of the initial compounds. Thus the formation of ettringite is mainly responsible for the large volume expansion, which leads to increase in internal tensile stress and deterioration of the concrete matrix (De Belie *et al.* 2002).

Santhanam *el al.* (2001), reported that ettringite is not stable in low-lime environments when the pH falls below 11.5 – 12. At this low pH ettringite could decompose to form gypsum. Gypsum, which is a result of cation-exchange reactions, reduces the concrete stiffness and strength, followed by expansion, cracking, and eventual transformation of the material into a mushy or non-cohesive mass (De Belie *et al.* 2002). Vincke and Verstraete (2002) are of the opinion that due to these reactions, the solubility of the calcium compound changes from low to moderately or fairly soluble.

According to Svennersted *et al.* (1999), very high concentration of sulfate may build up within concrete structures which are only partially immersed, or are in contact on only one side, with sulfate water or soils. This is due to the continuing evaporation that will occur under such conditions. Thus, severe attack may occur even where the sulfate content is initially not high. This process is schematically presented in Figure 1. Concrete buried in soil, or completely immersed in water, is under static conditions where sulfate attack is confined to surfaces and therefore often of negligible severity.

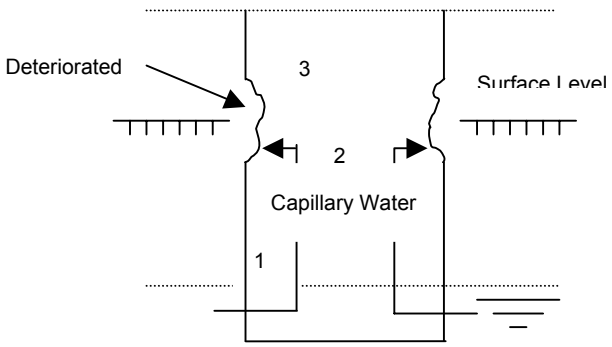


Figure 1. Deterioration of concrete by capillary transport of salts. The process can be illustrated schematically by the following steps: 1. Continuous supply of dissolved salts, 2. Capillary transport, 3. Evaporation and crystallization.

The quality of concrete, especially its low permeability, is the best protection against sulfate attack, as is the case with most corrosive agents. Adequate concrete thickness, high cement content, low water/cement ratio and proper compaction and curing of fresh concrete are among the important factors that contribute to low permeability. Also Portland cement containing less than 5 percent C_3A (Type V) is sufficiently sulfate resisting under moderate conditions of sulfate attack (i.e., when ettringite forming reactions are the only consideration). However, when high sulfate concentrations, of the order of 1500 mg/L or more, are involved, the Type V Portland cement may not be effective against the cation-exchange reactions involving gypsum formation. Under these conditions, experience has shown that cements potentially containing a little or no calcium hydroxide on hydration perform much better: These include high–alumina cements, Portland blast-furnace slag cements with more than 70 percent slag, and Portland pozzolan cements with at least 25 percent pozzolan (natural pozzolan, calcined clay or low-calcium fly ash) (Mehta 1986).

Another effective treatment is the use of silica fume. Due to reduced permeability, silica fume cement concrete provides excellent sulfate resistance. Recent research shows that ternary blends containing slag cement or fly ash, along with silica fume and Portland cement, can be effective for sulfate resistance concrete (Lafarge Canada Inc. 2001).

The broad term objective of this study is to extend the lifespan of concrete farm infrastructure, which is now drastically affected by corrosive environments and to understand the mechanisms that are involved in this corrosion. The short-term specific objectives are:

1. To compare the corrosion resistance of eight different concrete treatments, which could be reasonably be used in the construction of animal housing, under long-term exposure to hydrogen sulfide gas and sulfate solution.
2. To understand the mineralogy of the different concrete treatments.
3. To determine the critical sulfur concentration on the onset of corrosion in the reinforcement bars and the diffusion rates into the eight different treatments, this could be used for determining the diffusion coefficient of sulfur in concrete.

Experimental design

It is intended that the objectives of the research be attained by accelerated corrosion testing in the laboratory using concrete specimens subjected to hydrogen sulfide and sodium sulfate

solution as the only corrosive agents. Acceleration is achieved by using much higher concentration than those experienced in the field, 1,000 ppm H_2S and 20,000 ppm SO_4^{2-}.

Eight treatments, which could reasonably be used in the construction of liquid manure tanks, floors and slats, are being examined for corrosion resistance. Concrete cylinders (100 mm diameter by 100 mm high) made of Portland cement, limestone, sand and water, each with a 10 mm diameter by 90 mm long reinforcing steel bar embedded in the center. Six replicates for each treatment were made. In all treatments a superplasticizer (CATEXOL 1000 SP-MN) was used (625 ml/100 kg of cementitious material) to reduce the water requirements in concrete and attain the necessary workability without the use of excess water. Also an air-entraining admixture (CATEXOL A.E.260) was used in all treatments (50ml/100 kg of cementitious material) to increase concrete durability, improve workability and reduce bleeding. A further three larger replicates of each treatment, 100 mm diameter and 200 mm height, were cast without a steel bar for compressive strength determination at 28 days after curing in a 100% relative humidity environment. The mix proportions for all eight treatments are shown in Table 4.

The eight treatments are:
1. Portland Cement with water-cement ratio 0.50 (PC50)
2. Portland cement with water-cement ratio 0.4 (PC40)
3. Sulfate resisting cement Type V (SR)
4. Slag cement (SC)
5. Fly ash cement (FAC)
6. Silica fume cement (SFC)
7. Silica fume and slag cement (SSFC)
8. Silica fume and fly ash cement (FASF)

The materials used in each of the eight treatments are shown in Table 4

Table 4. Mix Proportions for all Treatments

	PC50	PC40	SR	SC	SFC	FAC	SSSF	FASF
Cement type	I	I	V	I	I	I	I	I
Cement (kg/m^3 of concrete)	340	425	425	276.3	391	318.8	293.3	293.3
Water (kg/m^3 of concrete)	170	170	170	170	170	170	170	170
w/c	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Fine aggregate (kg/m^3 of concrete)	691	616	616	616	616	616	616	616
Coarse aggregate (kg/m^3 of concrete)	850	850	850	850	850	850	850	850
Additive (% of cementeous material content)	---	---	---	35% slag	8% silica fume	25% fly ash	25% slag 6% silica fume	25% fly ash 6% silica fume

The top of all specimens, except those for the compressive strength tests, and the exposed ends of the steel bars were coated with an epoxy coating (TRU-GLAZE 4508 Chemical Resistant Epoxy Coating 4508-1000A and 4508-9999B with a ratio of 1:1) in order to prevent the diffusion of the corrosive ions through that surface.

For the corrosion study the 48 specimens are divided into two sets, each set having three replicates. Set I (i.e. 24 specimens) is tested partially (50%) immersed in sodium sulfate (20,000 ppm SO_4^{-2}) and at the same time subjected to hydrogen sulfide gas (1,000 ppm H_2S) above the surface of the sodium sulfate solution. Each treatment is submerged in a separate container (Figure 3), and placed in the upper level of a two-storey test chamber. Set II (i.e. the remaining 24 specimens) is subjected to hydrogen sulfide gas and air only in the lower level of the same chamber, (Figures 2). To keep the gas in the sealed Plexiglas test chamber at the required concentration a control circuit consisting of H_2S sensor, solenoid valves, flow meter, control program and a gas cylinder is used. The H_2S sensor is based on a semiconductor sensor manufactured by Gemini Detectors Inc.,Texas. The sensing element is an indium oxide film whose resistance is determined by the reaction of oxygen adsorbed on the film surface and H_2S.

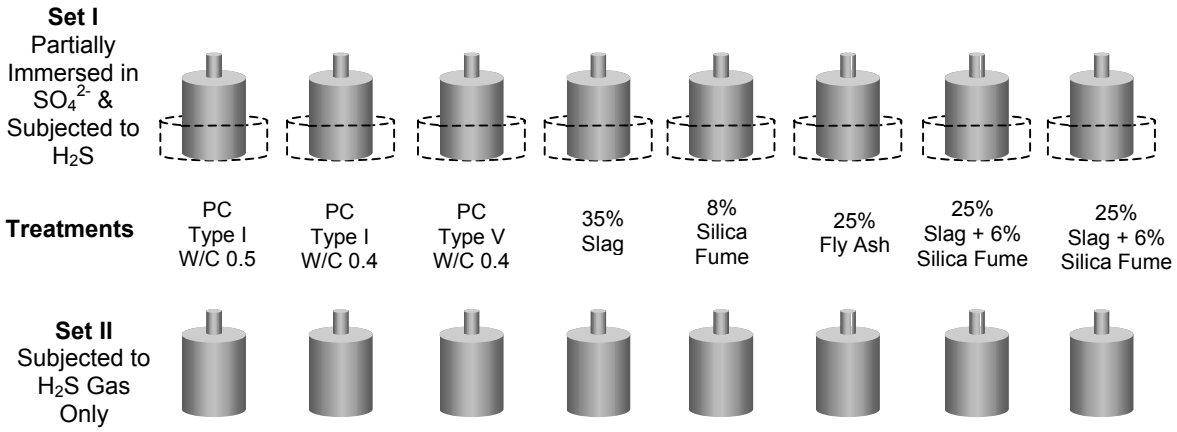
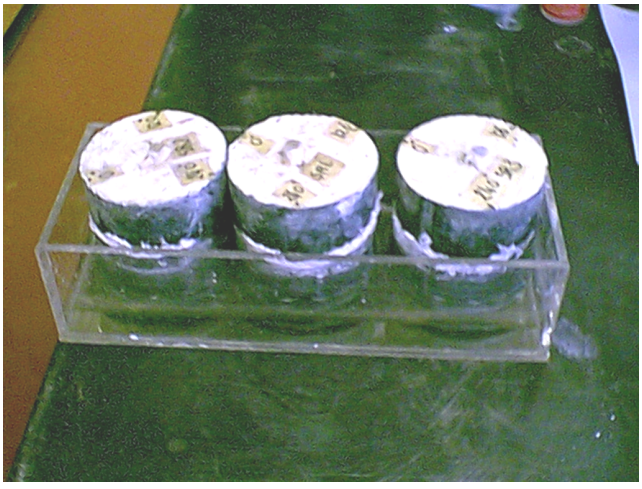


Figure 2 Schematic of test set-up

Figure 3 One Treatment of Set I



The hydrogen gas cylinder used for the test lasts about 3 weeks, keeping the concentration of the gas inside the chamber at 1000 ppm. After this the chamber is left closed for one more week in order to lower the gas concentration back to 0 ppm. Then all the different treatments are taken out of the chamber for the half-cell potential measurement, and thus they are subjected to air for another week. This test cycle is repeated approximately every five weeks.

A number of laboratory tests have been and will be conducted to evaluate the relative merit of each of the eight treatments in resisting corrosion from hydrogen sulfide gas and sulfates in solution.

Compression tests were used to evaluate the strength of the mixes. The results were used also to give an indication of the quality of the concrete. Compressive tests of moist cured specimens were made at 28 days after curing in a 100% moist environment.

The pH of the eight solutions was measured every other test cycle using a potentiometric electrode in order to find out how the H_2S gas affects the acidity of the solutions, and the rate at which the concrete loses its alkalinity. The different solutions in which the test specimens were partially submerged were analyzed after the third cycle of the experiment to find the concentration of the various elements and compounds present (chlorides, sulfate, and sodium).

X-ray powder diffraction (XRD) patterns provide phase, chemical and crystal structure data that may afford greater understanding of cement property / performance relationships. For the XRD test, 50 mg samples were ground (particle size < 10 μm) from the outer surface of the concrete specimen of each treatment to provide a relatively homogeneous material, yet have particles large enough for microscopic analysis. They were well ground to create a uniform particle size and to maximize the number of particles analyzed.

The electrochemical potential of reinforced concrete is a characteristic of the reinforcement steel/concrete interface, which reflects the ionic conduction between the bars and pore fluid of concrete. The half-cell potential, E_{corr}, is used to define the corrosion state of reinforcement bars. A copper-copper sulfate electrode (CSE) and a high impedance voltmeter were used to read E_{corr}. The half-cell potential measurement connection is shown in Figure 4. The E_{corr}, started to be monitored after three cycles of exposure to the corrosive environment. It is intended to continue monitoring it every test cycle of about 5 weeks, until the end of the experiment. 18 readings were taken every 20 mm (at the air end, 20, 40, 60, 80, and 100 mm) along three different angles (0°, 120°, and 240°) for each sample, as shown in Figure 5.

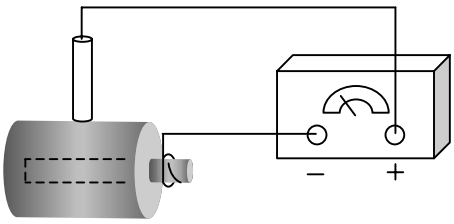


Figure4. Half-Cell Potential Measurement.

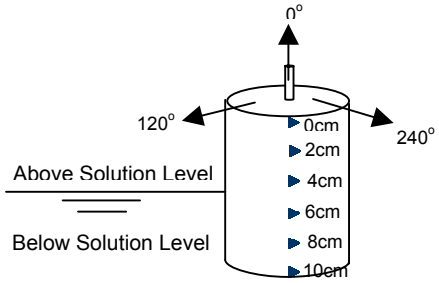


Figure 5. Positions where the potential measurements were taken.

Corrosion potential measurements provide an indication of the oxidizing power of the environment in which a specimen is exposed. It is important to remember, however, that potential is a thermodynamic quantity, and although it can be used to determine whether a reaction can occur spontaneously, it can not be used to provide information about the rate of corrosion reactions.

The splitting tensile strength test (CSA A23.2-13C 1994) was carried out for one set of replicates (16 samples) after 22 months of exposure to the corrosive environment. This allowed the removal of the reinforcing bar for inspection of corrosion and provided a rough indication of the specimen's strength about 26 months after the specimens were cast. The splitting tensile strength was calculated for each sample from

$$T = 2P / (\pi L D)$$

where, T is the splitting tensile strength (MPa), *P* is the maximum applied load (N), *L* is the length (mm), and *D* is the diameter (mm) of the cylindrical specimen.

For the purpose of total sulfur concentration measurements, a 100 mm thick disc was cut at midheight from the samples that were subjected to the H_2S gas only. Three 100 mm thick discs were cut from the samples that were subjected to the H_2S gas and the sulfate solution, one at midheight, a second 10 mm above midheight, and a third 10 mm below midheight. All discs were then cut again to obtain samples approximately 1000 mm^3 in size at different depths (0-0.6, 0.6-1.9, 1.9- 3.2, and 3.2-4.5 cm) as shown in Figure 6. The samples were cut by a low-speed diamond cutter. All samples were pulverized in preparation of a total sulfur analysis (LECO SC444) using dry combustion/infrared analysis.

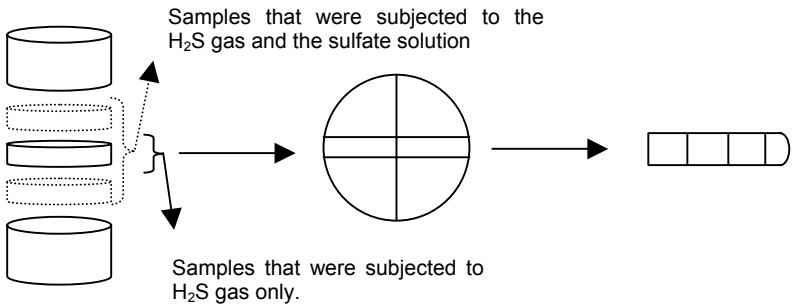


Figure 6. Schematic of the cutting sequence of the samples.

Other tests that are planned to be carried out after completion of the corrosion tests are weight loss of the reinforcing steel, concrete weight loss measurement and microscopic analysis of the specimens. Furthermore, finite element or finite difference method will be used to carry out diffusion analyses in order to predict the length of time to initiate corrosion in the reinforcement steel and to predict the mineralogical structure of the concrete after attack.

Results and Discussion

Compressive Strength Test

The compressive strengths of the specimens are shown in Table 5. The average strength of the PC50 treatment, 34.0 MPa, is considerably lower than that of the other seven. The reason is obvious since this was the only treatment with a W/C ratio of 0.5. The treatments SC and SSFC are both about 10% lower than the other treatments with W/C ratio of 0.4, confirming the well known slowing effect of slag on the strength gain. The balance of the treatments had strengths ranging from 46 to 49 M Pa with the silica fume concrete providing the highest value, indicating excellent quality concrete.

Table 5. 28-day compressive strength for the eight treatments

Treatment	PC50	PC40	SR	SC	SFC	FAC	SSFC	FASF
w/c	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Compressive Strength (MPa)	34.0	48.6	47.4	42.3	49.1	47.0	43.5	46.0

pH Measurement

The pH of the Na_2SO_4 solution before placing the concrete specimens in it (20,000 ppm SO_4^{2-}) was 6.64. The pH was measured at the end of every test cycle for the first three months, then each two cycles when the solution was changed to bring the SO_4^{2-} concentration back up to its original concentration of 20,000 ppm. The different pH measurements are shown in Table 6, the increases in pH from the initial value of 6.64 to the final value are shown in Figure 7. It may be noted that the pH changed rapidly from neutral (~7) to basic (~12) in the first few months due to the leaching of the alkalis from the concrete into the sulfate solution. After the 5th test cycle the pH increased significantly less as the concrete started to lose its alkalinity.

Table 6. pH measurement for the different treatments.

Time	PC50	PC40	SR	SC	SFC	FAC	SSFC	FASF
1st test cycle	12.01	11.87	12.09	11.45	12.09	12.2	11.86	11.85
2nd test cycle	10.99	10.64	11.49	10.64	11.46	11.57	11.27	11.43
3rd test cycle	11.2	11	10.9	10.7	10.7	11	10.4	10.7
5th test cycle	9.02	9.83	9.35	9.05	8.85	9.7	8.95	9.4
7th test cycle	8.75	9.07	8.85	8.5	8.8	9	8.5	8.5
9th test cycle	9.4	9.13	8.99	8.3	8.77	8.7	8.5	8.3

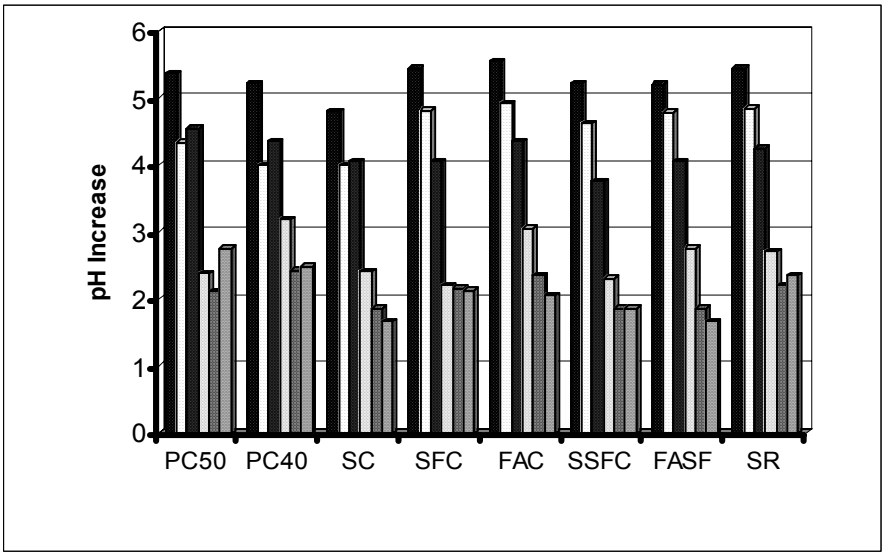


Figure 7. pH increase for the different treatments.

A control solution of Na_2SO_4 solution (20000ppm SO_4^{2-}) having a pH of 6.64, was placed in the experimental box and exposed to 1000ppm H_2S for one cycle (one month). The resulting pH was 5.44. This decrease in the pH is due to the reaction: Hydrogen Sulfide + Oxygen $\rightarrow$ Sulfuric Acid.

Solution Analysis

The solution in which half of the specimens are submerged was analyzed after every two test cycles. The results of the chemical analysis are shown in Table 7. It is evident, that after two test cycles the sulfate concentrations increased up to five times from the initial value of 20,000 ppm and that they varied widely. However, after 6 test cycles the sulfate concentrations are fairly uniform at about twice the initial value. Sodium levels too varied widely in the first few months of testing; after 6 test cycles they varied from 20,000 to 28,000 ppm. Surprisingly high levels of chloride were found, up to 3,000 ppm. The origin of the chlorides is yet to be determined but probably originated in the concrete materials, especially the aggregates (coarse aggregate had 32 ppm chloride, 384 ppm sufate). This is supported by the fact that the most porous concrete, PC50, has the highest chloride concentrations.

Table 7. Solution Analysis (concentrations in ppm).

Treatment		PC50	PC40	SR	SC	SFC	FAC	SSFC	FASF
After 2 test cycles	Chloride	2950	1030	638	454	622	1362	418	774
	Sulfate	58240	107020	13140	68500	41520	11450	77920	83720
	Sodium	9290	15750	18020	12420	18390	27280	14050	15190
After 6 test cycles	Chloride	3140	880	783	912	724	1210	701	950
	Sulfate	42804	38403	39562	41601	37470	35886	43280	38381
	Sodium	27848	24117	25342	22364	23609	22438	19850	22711

Splitting Tensile Strength

The 26-months splitting tensile strengths of the specimens are shown in Table 8. Also the tensile strengths of the different treatments at 28 days calculated from the compressive strength and the relationship $f_t = 0.32(f_c')^{2/3}$ were determined. They are shown in the last column of Table 8. It is obvious there is no clear pattern for the increase or decrease in strength with time for the different treatments. However, it should be borne in mind that the splitting test is not considered a very accurate predictor of tensile strength and that the results are from a single specimen. In three of the eight treatments the strength was lower for those specimens that had been

Table 8. 26-months splitting tensile strength and calculated splitting tensile strength at 28 days.

	Samples subjected to H_2S only		Samples subjected to H_2S and SO_4^{2-}		Calculated tensile strength (Mpa)
Type	Max. Load (kN)	Tensile strength (MPa)	Max. Load (kN)	Tensile strength (MPa)	
PC50	85.5	5.44	69	4.4	3.36
PC40	82	5.22	79.1	5.03	4.26
SR	76.1	4.84	82.1	5.22	4.19
SC	64.4	4.1	100.8	6.4	3.9
SFC	65.5	4.2	91.5	5.8	4.3
FAC	85.5	5.44	70	4.45	4.2
SSFC	85	5.41	72.5	4.6	4.0
FASF	89	5.7	65.7	4.2	4.1

submerged partially in the SO_4^{2-} solution. In all cases the tensile strength increased from that at 28 days. The average increase was about 25%.

Electrochemical Potential Measurement

So far the potential measurements for the different treatments have been taken eleven times since the start of the experiment. They are plotted in Figure 6 for the 8 treatments exposed to hydrogen sulfide and half submerged in sulfate solution. Figure 7 presents the results for the 8 treatments exposed to hydrogen sulfide only.

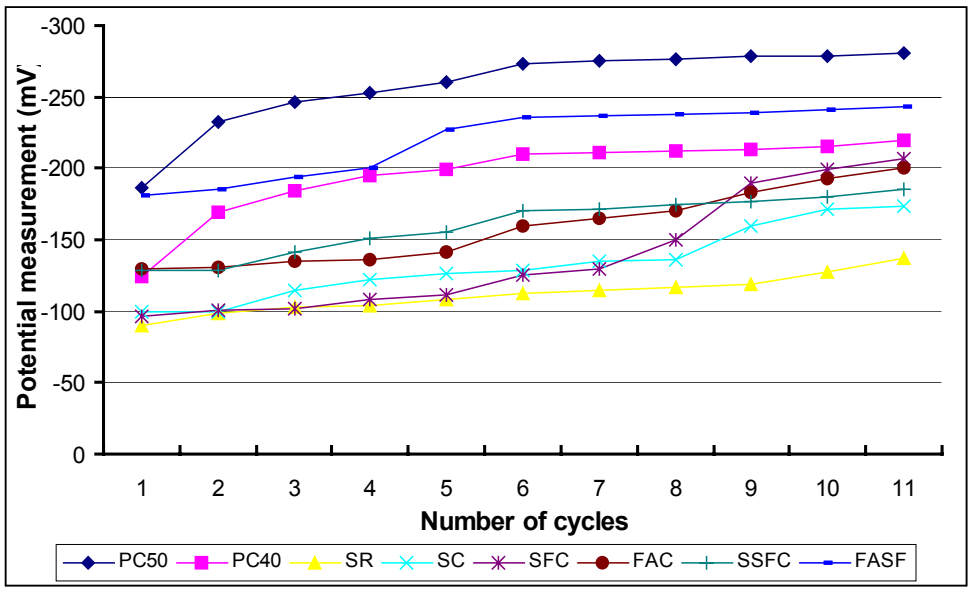


Figure 6. Potential measurement of the samples that are half submerged in sulfate solution and exposed to hydrogen sulfide gas.

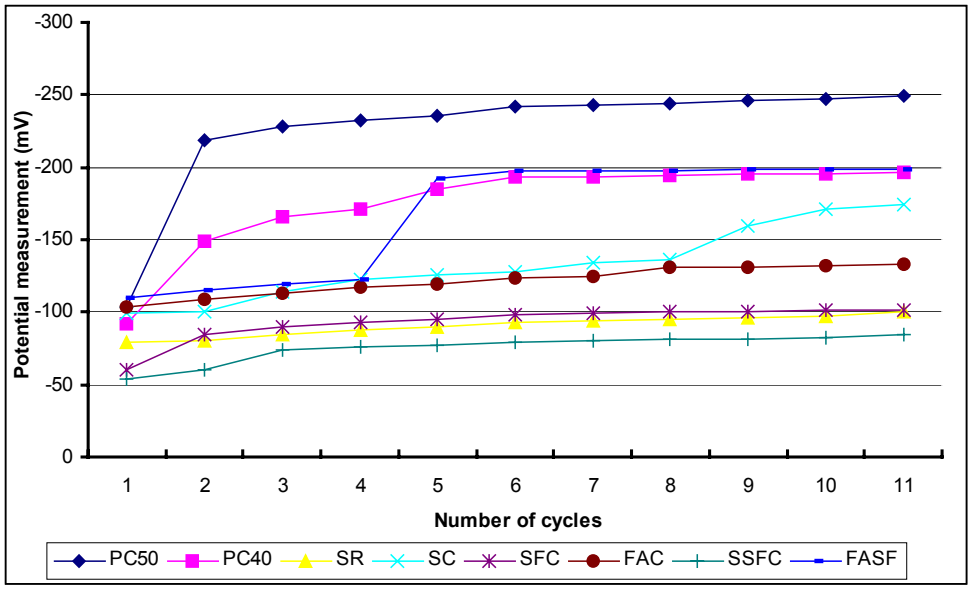


Figure 7. Potential measurement of the samples that are exposed to hydrogen sulfide gas only

Although the results are few and very preliminary, some observations can be made from the results in Figures 6 and 7. In examining the curves it should be noted that the closer potentials are to –350 mV the greater the probability of active steel corrosion is. Treatment PC50 already stands out as the worst performer. After 11 cycles of exposure the risk of corrosion of the steel is in the 50% range. So far all treatments containing silica fume, fly ash or slag, except FASF, perform better than PC40. Also, there is an indication that sulfate resistant cement (SR) is more resistant than type I Portland cement. Treatment FASF, concrete containing both fly ash and silica fume, stands out at this early stage as performing worse than plain PC concrete with the same W/C ratio.

Those specimens that are exposed to SO_4^{2-} as well as H_2S will probably corrode sooner than those exposed to H_2S only. All treatments indicate this consistently through higher negative potentials. In the specimens that were exposed to H_2S only, the potential were fairly uniform over the surface of the cylinders. This was not the case with those half submerged in the Na_2SO_4. The negative potentials above the surface are greater than those below in all treatments.

Total Sulfur Analysis

The total sulfur analysis (LECO SC444) results are presented in Tables 9 and 10. Table 9 has the results for all treatments that were half submerged in the sulfate solution and Table 8 has similar results for those that were exposed to hydrogen sulfide only. The results marked “top” in Table 9 refer to the samples taken from a horizontal slice located about 20 mm above the top of the sulfate solution; “center” samples were cut from a slice at the water line and “bottom” samples were obtained from a slice about 20 mm below the top of the sulfate solution. The results in Table 10 were cut from a slice at midheight of the cylindrical specimens.

Location 1 in Tables 9 and 10 is nearest the outside surface of the cylindrical specimens, location 4 nearest the reinforcing bar at the center of the cylinder. Locations 2 and 3 are two intermediate points.

Table 9. Total sulfur concentration (g sulfur/ kg dry material) for the samples that are half submerged in the sulfate solution and also subjected to the hydrogen sulfide gas.

Type	Top				Center				Bottom			
	1	2	3	4	1	2	3	4	1	2	3	4
PC50	7.6	4.3	4.2	3.7	6.4	3.5	3.6	3.6	4.8	2.6	4.2	3.0
PC40	11.0	3.8	4.0	3.7	8.7	2.7	4.0	3.8	5.2	2.8	2.9	4.0
SR	4.3	2.2	2.1	2.9	6.2	2.5	2.2	2.5	4.3	2.1	2.1	2.6
SC	6.7	4.4	3.8	3.8	7.7	3.6	3.7	3.6	6.8	3.3	3.6	4.2
SFC	6.8	2.8	4.5	3.6	7.2	3.5	3.1	3.6	5.6	3.3	2.9	2.6
FAC	9.1	3.2	1.9	3.9	6.2	2.8	2.4	2.8	5.2	2.9	2.6	3.1
SSFC	6.2	3.3	2.8	3.8	5.0	3.5	3.0	2.8	5.4	3.6	2.8	3.1
FASF	5.1	2.5	2.7	2.6	4.9	2.3	2.2	3.4	5.4	3.1	4.4	3.5

Table 10. Total sulfur concentration (g S/ kg dry material) for samples exposed to the hydrogen sulfide only.

Type	1	2	3	4
PC50	30.7	3.6	2.7	2.9
PC40	13.6	4.1	2.3	3.9
SR	5.4	2.3	2.4	2.4
SC	12.4	3.4	3.0	3.2
SFC	25.2	3.9	3.0	3.6
FAC	12.8	2.7	3.9	3.5
SSFC	14.0	2.7	3.5	3.3
FASF	10.5	2.8	3.5	3.1

In all cases the sulfur concentration is highest near the surface of the cylindrical specimens. The highest concentration occurred in the PC50 treatment subjected to hydrogen sulfide only. The concentrations near the surface of the specimens is higher in all cases for those treatments exposed to hydrogen sulfide only. And in general concentrations are higher above the water level than below for those specimens half submerged in the sulfate solution.

The concentrations inside the specimens are still very small. The highest value of 4.3 and 4.4 occurred at position 2 in the PC50 and SC treatments that were partially submerged.

Powder X-Ray Diffraction Test

Thus far an X-ray analysis for two treatments (PC50 and FASF) has been carried out for the part of the specimens below the sulfate solution level. For corrosion by a sodium sulfate solution at low concentration (<1000ppm SO_4^{2-}), the primary corrosion product is ettringite, while at high concentrations (>8000ppm SO_4^{2-}) gypsum is the main product. The results obtained from the powder x-ray diffraction tests confirmed that the primary corrosion product on the surface of both specimens was indeed gypsum.

Conclusions

Corrosion test of 48 concrete specimens are being carried out using hydrogen sulfide gas and a sodium sulfate solution. One half of the specimens is partially immersed in the sodium sulfate (20,000 ppm SO_4^{2-}) and also subjected to hydrogen sulfide gas (1,000 ppm H_2S). The other is subjected to hydrogen sulfide gas only. Each set consists of 8 different treatments, including Portland cement (PC) concrete with 0.4 and 0.5 W/C ratios, PC concrete with 8% silica fume replacement, 25% fly ash and 35% slag of the total amount of cementitious material, and specimens made of PC concrete with combinations of silica fume and fly ash (6%/25%), and silica fume and slag (6%/25%). Finally one treatment is made with sulfate resistant cement.

After 11 cycles of testing over about 22 months preliminary electrochemical potential results indicate that the PC concrete with 0.5 W/C ratio is the least corrosion resistant, as might be expected. All treatments containing silica fume, fly ash or slag, except FASF, performed better thus far than PC40. Also, there is an indication that sulfate resistant cement (SR) is more resistant than type I Portland cement. Indeed, sulfate resistant cement concrete was one of the best performers in both sets of tests.

The total sulfur measurements support the indication that PC50 does not perform as well as the treatments with a w/c ratio of 0.4. Sulfate resistant cement concrete (SR) stands out again with very low sulfur concentrations, even near the surface of the cylindrical specimens.

The conclusions that are presented must be considered preliminary since they are based on only 11 cycles of testing. Testing is ongoing with the remaining specimens.

Acknowledgement

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Industrialized Farming and Its Relationship to Community Well-Being: An Update of a 2000 Report by Linda Lobao

Prepared for the State of North Dakota, Office of the Attorney General

by

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For Case: State of North Dakota versus Crosslands
North Dakota District Court
September, 2006

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Note: This report is a response to a request from the State of North Dakota to review past social science research on the effects of industrialized farming on community well-being. This review builds upon a similar review conducted by Dr. Linda Lobao in 2000. As author of the book *Locality and Inequality: Farm and Industry Structure and Socioeconomic Conditions* (SUNY Press, 1990), Dr. Lobao is the authoritative source on the relationship between industrialized farming and community well-being She is a professor of rural sociology in the Department of Human and Community Resource Development at The Ohio State University. This update to her 2000 review of the literature since the publication of her book focuses on the consequences of industrialized farming on community well-being irrespective of whether these effects were detrimental, positive or mixed. Thus, a comprehensive review of the literature included all studies in this area, regardless of their conclusions.

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INTRODUCTION

Public concern about the consequences of non-family owned and operated, industrialized farms for communities dates back to the 1920s (Boles and Rupnow 1979).[1] The first published research on the topic appeared in the 1930s. Since then, government and academic researchers have produced numerous studies showing the potential for adverse impacts on community life. The bulk of evidence indicates that public concern about the detrimental community impacts of industrialized farming is warranted This report summarizes results from more than five decades of research that has investigated the relationship between non-family industrialized farming and community well-being. The purposes are: (1) to document the types of studies that have been conducted on the topic; (2) to delineate their results as to whether adverse consequences were found; and (3) to document the aspects of community life that may be jeopardized by industrialized farming.

This report is based on empirical results and observations drawn from Lobao's own research as well as from that of other social scientists. Observations are grounded in her longstanding research on farm change and its impacts on communities and families (Barlett, Lobao, and Meyer 1999; Belyea and Lobao 1990; Kenney, Lobao, Curry, and Goe 1989; Lasely, Leistritz, Lobao, and Meyer 1995; Lobao 1987, 1990; Lobao and Jones 1987; Lobao and Meyer1995a, 1995b, 1997; Lobao and Schulman 1991; Lobao, Swanson, and Schulman 1993; Lobao and Thomas 1988; Lobao and Thomas 1992) as well as her research on the broader topic of community development (Lobao 1993a,b,c, 1996, 1998; Lobao and Rulli 1996; Lobao, Rulli and Brown 1999). The previous research has been funded by major federal competitive grants programs, such as the National Science Foundation and USDA-National Research Initiative Competitive Grants Program, as well as state and regional sources, such as the North Central Regional Center for Rural Development. The previous studies are published in the top-ranked journals in several fields, sociology, rural sociology, geography, family studies, and community development. For specific empirical examples in this report, she draws primarily from her book *Locality and Inequality: Farm Structure and Industry Structure and Socioeconomic Conditions* (State University of New York Press, 1990), the most recent, comprehensive sociological volume published on farm structure and community well-being. Our comments and conclusions also are based on a systematic review of fifty six studies on the topic of industrialized farming and community well-being. For this report, we updated a review (Lobao 2000) which was an update of a previously published review (Lobao 1990) by including studies that were conducted since 2000 on the topic of industrialized farming and community well-being.

The industrialization of farming refers to the transformation whereby farms have become larger-scale, declined in number, and integrated more directly into production and marketing relationships with processors through vertical or contractual integration (Drabenstott and Smith 1996:4). In the past two decades, farms in the farming-dependent Heartland states,[2] which

[1] Boles and Rupnow (1979: 471) state that public concern about corporate influence in farming began in the 1920-30 period when concern about large, publicly held corporations centered on fears about the effect of mechanization, foreclosure of farm land mortgages held by corporations, and corporate monopoly of land.

[2] The states forming the nation's farm heartland extend from the Mississippi River to the Rocky Mountains and from Texas to Canada. These states are Colorado, Iowa, Kansas, Minnesota, Missouri Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, and Wyoming (Barkema and Drabenstott 1996:1). More than two-thirds of the nation's farm-dependent counties are located in these states.

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include North Dakota, declined by roughly one-fourth while average acreage grew by one-fourth to about 750 acres (Barkema and Drabenstott 1996:62). As the number of farms declines, production becomes concentrated on larger farms. Nationally, small farms (defined here as those having annual gross sales less than $50,000) made up nearly three-quarters of the nation's farms in 1995 but they produced only about 8% of sales, while the top two percent of farms (those with sales of over a half million dollars annually) accounted for 44% of all sales (Sommer et al. 1998:10). Half of the nation's agricultural sales are produced by three percent of farms (Sommer et al. 1998:8).

Accompanying the growth of scale of operations are organizational changes in farming. These include an increase in the relative proportion of hired to family labor and greater use of incorporation[3] as a form of legal organization. Another organizational shift is the movement toward a more integrated industry from farm to grocery, whose "hallmark" is "contract production and vertical integration that is linking farmers, food processors, seed companies, and other agribusiness" (Barkema and Drabenstott 1996:64). Vertical integration refers to operation of farms by firms that also operate in at least one other stage of the food chain, such as input supply, processing, and marketing. Examples of vertically integrated firms are large livestock producer/processor enterprises, such as Seaboard Corporation and Tyson. In addition to their direct involvement in farm production, agribusiness firms contract with farmers for goods and services. Two types of contracting arrangements should be distinguished. Marketing contracts are used by independent operators to reduce their exposure to market price swings; these contracts stipulate a commodity price or pricing mechanism for delivered goods and are used mainly for crop and dairy commodities. Production contracts involve cost sharing arrangements and/or payment for operators' services usually for livestock production except for dairying. On farms using production contracts, the largest share of farm sales accrues to the contractor (an agribusiness processor and/or producer), with the operator generally receiving a fixed fee for services (Sommer et al. 1998:16-17). Production contracts extend agribusiness firms into direct farm production using the vehicle of the local farmer. To sociologists, production contract farms are an integral component of the agribusiness chain in which agribusiness firms, depending on corporate strategy, may enter farming through direct operation of their own units and/or through employing local farmers to participate in production home-work. Sociologists are concerned with contract farming because of the risks it poses to agrarian social structure, communities, and families.[4]

[3] In 1995, more than 98% of the nation's 2.07 million farms were classified as family operations. Ninety-one percent were sole proprietorships and five percent were partnerships. Only three percent of all farms were incorporated, and of these, 86% were considered family-held corporations by USDA as they had ten or less stockholders (Sommer et al.1998: iv).

[4] Sociologists are concerned with contract farming insofar that: it alters agrarian social structure by creating a segment of farmers who are the structural equivalent of factory production home-workers; it extends the influence of industrialized farming in a community; and it erodes formally independent operators' autonomy in direct production, farm decision-making and control over assets. Sociologists also are concerned with the general well-being of contractees (operators) and their families given their asymmetrical relationship in bargaining power with agribusiness firms. There is an inherent structural imbalance in contract farming and the degree to which this imbalance is manifest will vary, given specific contract arrangements. In principle, production contracts are used to share risks and costs of production between contractee and contractor. In practice, the bargaining power of external agribusiness is likely to result in a greater of share of risks and costs of production borne by contractees and their families.

In classifying farms as "industrialized" or "family" social scientists distinguish between the construct (an ideal-type concept) and its actual measurement (variables used to define the concept in practice).[5] "Family" farms and "industrialized" farms are constructs at opposite ends of the farm continuum. To sociologists, the construct "family farm," is that where the farm household owns and controls the majority of farm production factors, land, labor, capital, technology, and management. At the other end of the farm continuum, the construct, "industrial farm," refers to a non-household based production unit, with absentee ownership and control over production factors. As with nonfarm firms, industrialized farms have a division of labor among owners, managers, and labor with different groups of people assigned to different positions in the production process. Industrial farms "...are owned by one group of people, managed on a daily basis by another person or group, and worked by yet another group" (Browne et al. 1992:30). Between these "ideal-type" descriptions of family and industrialized farms are other arrangements in organizing farming, such as part-owner farming (a form of family farming where the operator both owns and rents-in land). Again, these are "ideal-type" constructs whose specific definition and measurement must depend upon the time period and public context.

When social scientists refer to "industrialized" farms, they invariably are referring to both scale and organizational characteristics of the farm unit. [6] In general, but not always, scale will

[5] Different classifications of farms have been developed over the years because the structure of agriculture is continually changing. The term "farm structure" or "agricultural structure" "refers to a broad set of characteristics that describe U.S. farms, as well as the distribution of farm production resources and returns to those engaged in farm production activities"(Sommer et al. 1998:6). Sommer et al. (1998:6) provide a useful overview of the criteria used to classify farms:

> Producing units (farms and ranches) may be categorized by farm size (value of sales or number of acres), primary output, and geographic location. Farm businesses may be delineated by form of legal organization, degree of land ownership, marketing or production contractual arrangements, and financial position. Farm operators may be described by age, education, and primary occupation. Finally, farm households may be characterized by features of their associated farm businesses and interaction with the nonfarm sector, such as off-farm employment or income from non-farm sources. Any or all of these elements can be used to construct a structural portrait of farming in the Nation.

For sociologists, family farming is identified by whether the family unit owns a majority of capital resources, such as land, machinery, buildings, makes the majority of managerial decisions, and provides the bulk of labor (Goss et al. 1980). Social scientists often use farm scale as a proxy-measure to classify farms, because it is simple, clear, and often correlated with organizational characteristics of units. A recent USDA report classifies "commercial farms" as those with $50,000 or more in gross sales and "small farms" as those with gross sales less than $250,000 (Sommer et al. 1998:69). Family farms (organized as sole proprietorships, partnerships, or family corporations) with gross sales over $250,00 are classified as "large-family farms," while "non-family farms" are any farms organized as nonfamily corporations, cooperatives, and farms operated by hired managers (Sommer et al. 1998:72).

[6] Social scientists measure industrialized farming by both scale and organizational variables. Scale is usually measured by sales and sometimes by acreage and real estate and for livestock operations, animal inventory. The actual dollar value for scale indicators used by analysts to indicate a "large-scale" farm will obviously vary by the time period of study. In addition, what is considered a "large-scale farm" also varies by regional context and commodity. Organizational measures of industrialized farming include: vertical integration of corporations into farming; production contract farming arrangements; absentee ownership of production factors; dependency on hired labor; operation by farm managers, as opposed to material operation by family members; and legal status as a corporation (family or non-family) or syndicate.

coincide with organization. That is, large-scale farms (relative to smaller farms) are more dependent on hired labor and managers and more likely to have absentee owners, to be incorporated, and to be vertically integrated with agribusiness. For example, in 1995, mean gross sales of corporate farms were $576,925 as compared to $54,287 for sole proprietorship farms and $218,795 for farms organized as partnerships (Sommer et al. 1998:15). Farms with production or marketing contracts also tend to be larger. In 1995, farms with marketing contracts (about 11% of all farms) had mean gross sales of $242,888; while farms with production contracts (2.3% of all farms) had mean gross sales of $617,858 (Sommer et al. 1998: 12). For the purposes of this review, we use the umbrella term "industrialized farm" to refer to both scale and operating characteristics of industrialized farms. We also distinguish between scale and operating characteristics where it is useful and feasible to do so.

The discussion below is organized in four sections. (I) The first section discusses the history of government and academic concern about the risks of industrialized farming for community well-being, from the 1930s to the present. (II) The second section summarizes the findings from Lobao's research and that of colleagues. (III) The third section reviews findings from five decades of social science research. It is divided into several sub-sections discussing, respectively: (A) research issues involved in analyzing industrialized farming and community impacts, focusing on indicators of industrialized farming and types of consequences that a summary evaluation must consider; (B) the various research designs used to assess the consequences of industrialized farming; (C) a summary of the results of past studies as to whether detrimental impacts were found; (D) examples of recent sociological studies conducted on the topic; and (E) the potential for regional imbalances due to industrialized farming. (IV) The final section is a summary and conclusions.

It should be noted that public concern about industrialized farms extends beyond the well-being of states and their communities. Rather, public as well as academic concern extends to national food system issues, such as agribusiness concentration, consumer health, food safety, and sustainability of the national eco-system. The immediate effects of industrialized farms, however, are on the day-to-day lives of people residing in the places where these farms are located. It is also at this level, that social scientists have conducted a great deal of research over a long period of time. For these reasons, this report deals with the consequences of industrialized farming for well-being at the community level.

I. HISTORY OF PUBLIC, GOVERNMENT, AND ACADEMIC CONCERN WITH THE CONSEQUENCES OF INDUSTRIALIZED FARMING

More than a half century of research centers on the potential detrimental social consequences of industrialized farming. Since the 1930s, government and academic researchers have investigated the extent to which large scale, industrialized farms adversely affects the communities in which they are located. One of the first series of studies was conducted by a sociologist, E.D. Tetreau (1938, 1940), who found that large scale, hired-labor dependent farms were associated with poor social and economic well-being in rural Arizona communities.

In the early 1940s, the United States Department of Agriculture sponsored a research project on the effects of industrialized farming using a matched-pair of two California communities, Arvin where large, absentee-owned, non-family operated farms were more numerous, and Dinuba, where locally owned, family operated farms were more numerous. The report on this

project was prepared by Walter Goldschmidt, a USDA anthropologist. The purpose of the study was to assess the consequences of a California law with a provision placing acreage limitations on large farms located in California's Central Valley, so as to support family-size farms in the region. Goldschmidt (1978a: 458) notes that: "Large landholders throughout the state and corporate interests generally opposed this provision while diverse church and other agrarian-oriented interests wanted this law applied to California. The comparative study of Arvin and Dinuba...was designed to determine the social consequences that might be anticipated for rural communities if the established law was applied or rescinded." Goldschmidt later became President of the American Anthropological Association and remains one of our nation's leading anthropologists.

In his report, Goldschmidt (1978a) systematically documented the relationship between large-scale farming and its adverse consequences for a variety of community quality of life indicators. Goldschmidt (1978a) found that, relative to the family farming community, Arvin's population had a small middle class and high proportion of hired workers. Family incomes were lower and poverty was higher. There were poorer quality schools and public services, fewer churches, civic organizations, and retail establishments. Arvin's residents also had less local control over public decisions, or "lack of democratic decision-making," as local government was prone to influence by outside agribusiness interests. By contrast, family farming Dinuba had a larger middle class, better socioeconomic conditions, high community stability and civic participation. Goldschmidt's report was eventually published as Congressional testimony (1968) and as a book (1978a). Goldschmidt's conclusion that large scale industrialized farms create a variety of social problems for communities has been confirmed by a number of subsequent studies. One criticism of Goldschmidt's (1978a) research was published by agricultural economists Hayes and Olmstead (1984). They did not challenge Goldschmidt's (1978a) conclusion that large scale, industrialized farms have adverse community impacts. Rather they argued that Arvin and Dinuba were not as closely matched research sites in the 1930s as Goldschmidt had intended. Nearly four decades after Goldschmidt's study, the state of California, through its Small Farm Viability Project (1977:229-230), affirmed Goldschmidt's conclusions by re-visiting Arvin and Dinuba. They concluded that: "The disparity in local economic activity, civic participation, and quality of life between Arvin and Dinuba...remains today. In fact, the disparity is greater. The economic and social gaps have widened. There can be little doubt about the relative effects of farm size and farm ownership on the communities of Arvin and Dinuba."

As the structure of U.S. agriculture has evolved towards larger and fewer farms, and government and academic researchers have continued to investigate the extent to which large-scale, non-family owned and operated industrialized farms adversely affect communities. Congress has conducted inquiries, such as that by Senate Subcommittee on Monopoly dealing with Corporate Secrecy and Agribusiness, in which rural sociologists and agricultural economists provided testimony in 1973 about the dangers to communities posed by increasing corporate control of agriculture (Boles and Rupnow 1979:468-469). The Office of Technology Assessment (OTA), concerned that the relative growth of large scale industrialized farms might have adverse impacts on communities, commissioned a series of research papers on the topic. The OTA research came as a request from Congress and was published first as a report (U.S. Congress, Office of Technology Assessment 1986) and later as a book (Swanson 1988). Federal and state funding has been directed to at least two Agricultural Experiment Station projects that

assess the community consequences of large scale, non-family farms: Project S-148 "Changing Structure of Agriculture: Causes, Consequences, and Policy Implications" (1982-1986);" and Project S-198 "Socioeconomic Dimensions of Technological Change, Natural Resource Use, and Agricultural Structure" (1986-1990). The later project resulted in a book monograph on the consequences of industrialized farming for communities (Lobao 1990) among other publications.

In the 1990s, public concern with industrialized farming has centered particularly on large integrated livestock producer/processor enterprises. Recent studies supported by the North Central Regional Center for Rural Development (1999), the University of Missouri Agricultural Experiment Station (Seipel, Kleiner, and Rikoon 1998; Seipel, Hamed, Rikoon, and Kleiner 1998), and Duke University Medical School (Schiffman 1998) have documented a variety of adverse impacts of these enterprises on communities, households, and individuals.

In summary, there has been over fifty years of public, academic, and government concern that large-scale, industrialized farms jeopardizes community well-being. This concern has resulted in numerous studies, in government sponsored reports, and in Congressional Hearings. In the 1990s, public concern with industrialized farming has increased due to the problems posed by large-scale animal confinement operations. Social scientists have responded to this increased public concern by initiating a number of recent projects---leading to a new generation of literature on the community consequences of industrialized farming.

II. RESEARCH BY LOBAO AND COLLEAGUES

The most recent, comprehensive sociological study on the effects of industrialized and family farming on communities was conducted by Lobao (1990). This study examined relationships across more than 3,000 U.S. counties. The study used both farm scale and organization to measure farm structure; examined direct and indirect consequences of farming patterns; and examined long-term and immediate relationships for two time periods, 1970-1980. To measure community outcomes, the study focused mainly on socioeconomic well-being indicators (median family income, poverty, and income inequality between families measured by the gini coefficient[7]) but also included of community social disruption (births to teenagers) and health status (infant mortality). The study examined the effects of three different community farm structures: "smaller family farming" (small, part-time family farms); "larger family farming" (moderate-size, capital-intensive, family-operated units using little hired labor), and industrialized farming (large scale, hired-labor dependent farms). The community farming structures were constructed based on research by Wimberley (1987). Each of the measures of farm structure was a composite of scale and organizational indicators, created through a statistical technique called factor analysis. Multivariate statistical methods, regression and discriminant analysis, were used to analyze the effects of the three farm structures net of other community conditions, including non-farm industrial employment, establishment size of local businesses, human capital and demographics characteristics of the population (educational attainments, ethnicity), unemployment, social welfare payments, unionization, and spatial factors, such as region of the country.

[7] The gini coefficient is used by the federal government to document income inequality in the United States and is the measure used most frequently in recent studies of economic development across spatial units such as counties (Lobao et al. 1999).

The findings were the following. There was consistent support that moderate-size family owned and operated farms benefit communities. Counties where these types of farms (i.e., larger family farming) predominated had better socioeconomic well-being (lower family poverty, higher median family income, lower unemployment, and lower infant mortality). The beneficial effects of this family farming were found across the U.S., for two time points, 1970 and 1980. Moreover, this type of farming continued to result in beneficial effects over time. Counties where larger family farming was greater in 1970 continued to have better socioeconomic well-being over time. This study indicates that the "high road" to community development is a farming system based on moderate-size family operations. Such farming not only increases aggregate well-being, as indicated by income levels, but it also sustains a larger middle class, as indicated by lower income inequality and poverty, and thus allows more families to benefit from income produced.

However, where industrialized farming was greater, there were mixed effects on community well-being: either detrimental or no statistically significant impacts. For example, industrialized farming had no relationship with family poverty or median family income at either of two single time points (1970 and 1980). Industrialized farming, however, was related to higher income inequality at both time points, and also to lower family income, higher poverty, and higher income inequality across time, over the decade from 1970-1980 (i.e., counties with greater industrialized farming in 1970 experienced relative declines in socioeconomic well-being over the decade). The finding that industrialized farms are associated with high income inequality indicates that this farming segments social class structure by polarizing families into richer and poorer income groups. Income polarization is related to other social problems, such a crime and other breakdowns in community social fabric. The study also found that where very small farms predominated, well-being was poorer. This indicates that reseachers should distinguish between small and moderate family operated units in assessing consequences for well-being. Smaller family farming tends to predominate more in the South.

As would be expected in a post-industrial society, nonfarm manufacturing and service employment were stronger predictors of community well-being than farming. However, it is important to note the study found that farming, nonfarm industry, and other local characteristics were interrelated, mutually sustaining a population in a locale.[8] Good quality farms and high quality local employment were interrelated, with "larger family farming" associated with greater employment in high wage manufacturing and other beneficial sectors. The study offered consistent support that when farming is an economic development strategy of choice, moderate-size family farms are best for communities.

[8] That farming has a smaller impact on community well-being than does nonfarm industry is expected even for communities highly dependent on farming. Farming is interrelated with local nonfarm industry and other sectors, forming a community livelihood strategy which sustains a population in a locale. Communities where larger family farming predominated had greater high wage, durable manufacturing employment and greater employment in local schools and retail industries. Communities where industrialized farming predominated had greater employment in lower wage manufacturing such as food processing, less employment in education, health, and retail services, a higher minority population, and provided relatively higher per capita benefits to welfare recipients.

This research on farming systems and community and regional well-being has been elaborated in other articles (Kenney, Lobao, Curry, and Goe 1989; Lobao 1987, 1993c, 1996, 1998; Lobao and Jones 1987; Lobao and Schulman 1991; Lobao, Swanson, and Schulman 1993; Lobao and Thomas 1992).

One of the most recent sociological analysis on industrialized farming and inequality is that conducted by one of Lobao's students (Crowley, 1999; Crowley and Roscigno, 2004). This 1999 study is a Masters' thesis in Sociology supervised and reviewed by four faculty members in the Department of Sociology at The Ohio State University, including Lobao. The methodology used in the study is similar to that followed in Lobao (1990), but the indicators of farm structure differ. Crowley's research extends past work by examining the effects of farm sector concentration and by updating research to the 1990 period. It should also be noted that her work is more comprehensive than other recent research (reported below) in that she specifies direct and indirect paths by which farm concentration affect community well-being. By farm concentration, Crowely (1999) means that a few large farms hold a disproportionate share of farm property in a community. Crowley notes that concentration of business property is important to sociologists because they see concentration as conferring both economic and political power to those who control resources in a community. Concentration of farm property also constrains the options of local family farmers to pursue their interests and realize economic gains. Crowley (1999) analyzed the effects of farm concentration using several indicators, (concentration of land, value of land and buildings, and the value of equipment and machinery, indicators measured by the gini coefficient) and data for all (1053) counties in the North Central U.S. (Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, Ohio, North Dakota, South Dakota, and Wisconsin). She analyzed consequences of these dimensions of farm-sector concentration for local levels of family poverty and family income inequality net of other community characteristics. Using multivariate regression analysis, she controlled for the influences of labor market, demographic, spatial, and other farm structure characteristics. In counties where farm sector concentration was higher (i.e., a few large farms held a disproportionate share of local property in land and real estate), there was significantly higher poverty among families and significantly greater income polarization between families. Also, where farm concentration was higher, residents had lower education.

In the 2004 study, Crowley and Roscigno documented how concentration of agricultural resources shapes rural community stratification through the political economic process. In addition to measures of farm sector resource concentration (value of land, real estate, machinery and buildings), measured by the gini coefficient, and labor endowment (percentage of county work force employed in core, extractive, competitive, and state sectors), they included measures of political process (proportion of votes in presidential election for Democratic Party, average household payment rates, average per farm county level spending on agricultural assistance), and worker power attributes (percent of manufacturing employees that are unionized, proportion of population that are minority, percentage of 25+ population with a high school diploma, and proportion of labor force unemployed). Using data for all (1053) counties in the North Central U.S. they found that dimensions of farm sector concentration shape both poverty and inequality. Furthermore, they found that farm sector concentration is explained by political economic processes, and these processes mediate the negative effects of land concentration on economic well-being. In particular, they found that relative to large scale farms, capital concentration promotes government spending that benefits large farms while it blocks government or labor-

market programs that assists farmers whose farms it consumes and farm workers it exploits. These attempts are evident by the increased funding for agricultural research which benefits large farms, decreased redistribution efforts through transfer payments to benefit small farms and workers, decreased political consciousness through lower levels of Democratic party support, and reduced labor power through lower unionization rates and education and higher unemployment and minority representation.

To provide a balanced assessment of the consequences of industrialized farming, it is useful to review the past findings of other investigators, using different methodologies, for different time periods, and from different disciplines. In the following sections, we discuss the types of studies conducted on the relationship between industrialized farming and community well-being and their conclusions. On balance, the social science evidence accumulated from these and other studies supports public, academic, and government concern about the potential risks of industrialized farming. Recent research indicates the public's welfare is at risk in at least four major areas. Industrialized farming: (1) has a detrimental impact on certain aspects of socioeconomic well-being; (2) disrupts the social fabric of communities; (3) poses environmental threats where livestock production is concentrated; and (4) is likely to create a new pattern of "haves and have nots" in terms of agricultural production, whereby some communities gain large, industrialized farms (and attendant social problems) and others lose their farming base as production becomes concentrated elsewhere in the state and regional economy. (Drabenstott and Smith 1996:4)

III. REVIEW OF PAST RESEARCH ON INDUSTRIALIZED FARMING AND WELL-BEING

Over the past half century, numerous studies, spanning different time periods and regions of the county have tended to find that large-scale industrial farming has detrimental community impacts. This does not mean that every study has produced these results--but rather that:(a) empirical evidence accumulated over the years shows a repeated trend that large-scale industrialized farms have adverse impacts on a number of different indicators of community well-being; and (b) that this trend is sufficiently established in the social sciences, to the point that almost all sociological studies begin with the working hypothesis (research expectation) that large scale industrial farms will have adverse community effects. The extent to which past research supports this hypothesis is discussed below. It should be stressed that no single study can provide a definitive answer as to whether large-scale industrialized farming will or will not adversely affect public well-being in any particular region or state. This is due both to the complexity of the research question and to the lack of existing data required to fully analyze it. At best, a single study can assess the extent to which certain indicators of industrialized farming have adverse affects on certain indicators of community well-being in certain places and time periods. Therefore, the most comprehensive answer to the question of whether industrialized farming adversely affects public well-being comes not from a single study but from assessing the conclusions of decades of past research.

A. Research Issues Involved in Analyzing Industrialized Farming and Its Community Impacts

To adequately assess the consequences of large, scale-industrial farming, the following issues about indicators of industrialized farming and types of consequences must be considered.

1. *Industrialized farming should be analyzed using indicators of farm organization and not only scale.*

   Scale is usually measured by sales or sometimes acreage. As a measure of industrialized farming, scale is limited for several reasons:(a) family owned and operated farms may be large scale owing to technology; (b) scale alone does not capture organizational features of industrialized farming, such as absentee ownership and non-family control over production, that are thought to put communities at risk. Organizational measures of industrialized farming include: vertical integration of corporations into farming; contract farming arrangements; absentee ownership of production factors; dependency on hired labor; operation by farm managers, as opposed to material operation by family members; and legal status as a corporation. With regard to legal status, family and non-family-held corporations should be distinguished.[9]

2. *To adequately assess consequences for community well-being, the full array of outcomes should be considered. Research points to three major sets of consequences of industrialized farming in a community: impacts on socioeconomic well-being, community social fabric, and environment*.

   Socioeconomic well-being refers to standard measures of economic performance (essentially employment, income, and business activity) and to a broader range of socioeconomic indicators used by sociologists to tap material conditions of families and populations (family poverty rates, income inequality).

   Community social fabric refers to social organization, the features of a community that reflects its stability and quality of social life. Impacts on community social fabric are seen in social indicators such as: population change; social disruption indicators (crime rates, births-to-teenagers, social-psychological stress, community conflict, interference with enjoyment of property); educational attainments and schooling quality; changes in social class structure (decline of local middle class, in-migration of low wage workers); health status, such as mortality rates; civic participation (e.g., declines in church attendance, voluntary organizational membership, and voting); and changes in local governance, such as loss of local control over community decision-making, and resource/fiscal pressures on local government, such as those due to increased need for social services and diversion of public funds to subsidize agribusiness development.

   Environmental indicators include quality of water, soil, and air, energy usage, and environmentally-related health conditions.

[9] It also should be recognized that farms may be incorporated because of family farmers' interests in estate planning, greater assurance of business continuity, limited liability, and income tax advantages.

3. *Industrialized farming has both direct and indirect consequences for community well -being. Both sets of consequences should be considered.*

Industrialized farms directly influence community well-being: through the quantity of jobs produced and the earnings' quality of those jobs; by the extent to which these farms purchase inputs and sell outputs locally; by affecting the quality of local environmental conditions; and by affecting local decision-making about economic development and other public-interest areas relevant to community quality of life.

First-order, indirect effects on local economic performance and general socioeconomic conditions occur because the quantity and quality of jobs plus purchases affect total community employment, earnings, and income (e.g., economic multiplier effects), the local poverty rate, and income inequality. First order, indirect effects on local social fabric occur because: the quantity of jobs created by industrial farms affects total community population size; the quantity and quality of jobs affects social class composition, such as a when an increase in hired farm workers reduces the proportion of the local middle class; local control over community decision-making may erode or become conflictual, since the interests of industrialized farmers and absentee owners are detached from those of local residents.

Second-order, indirect effects on local social fabric work through first-order effects above. Population size and social class composition are related to: indicators of community social disruption, such as crime, family instability, the high school dropout rate, and conflict resulting in civil suits; local demand for schooling, public assistance, health, and other social services; and the property tax base (Boles and Rupnow 1979; Freudenburg and Jones 1991, Murdock et. al 1988; North Central Center for Regional Development 1999).[10] Decline of local control over community decisions-making creates problems associated with poor governance, such as: the potential for diversion of public resources toward financial incentives supporting the interests of agribusiness developers over the community at large; and the loss of public and private revenues to support local schools, community services, and infrastructure, which contributes to a downward spiral of community social and economic conditions.

The direct and indirect paths by which industrialized farming may affect community well-being are delineated in various studies, including Boles and Rupnow (1979), Lasley et al. (1995), Lobao (1990), MacCannell (1988), and the North Central Regional Center for Rural Development (1999).

4. *Differences in impacts for diverse social groups within the community must be considered*.

Changes in farming affect social groups differently, depending upon their age, class position, and residents' proximity to industrialized farms. The elderly and poor are

[10] Rapid increases in population size and poorer social class composition tend to be related to the indicators of social disruption noted above and also place increased demands on local schooling and other social services. Population decline reduces local demand for services and the property tax base..

affected by rising costs of housing and services whenever large corporations migrate to a rural community (Summers et al. 1976). Within communities with large confined animal feeding operations (CAFOs), residents who live closer to the operation report inability to enjoy their properties and physical and psychological problems associated with odor (Schiffman and others 1998; Wing and Wolf 1999; Reisner et al., 2004; Constance and Tunistra, 2005). Property closer to CAFOs has been found to fail to appreciate in value relative to places further away (Seipel and others 1998). Income generated by industrialized farming (relative to family farming and over time) also appears less likely to filter down to families of different social classes. As noted, Lobao (1990) and Crowley (1999) found that income inequality was higher in communities where industrialized farming was greater.

5. *There are long-term as well as short-term consequences of industrialized farming for communities and for regional development within a state.*

Industrialized farming puts a community on a path of development whose consequences are not fully manifest in the short term of one or two years. Lobao (1990) found that some impacts were manifest a decade later. As noted earlier, counties with greater industrialized farming in 1970 had significantly poorer well-being a decade later: these counties had lower median family income, higher family poverty rates, and higher income inequality relative to other counties and net of past county conditions.

For the heartland states, including North Dakota, economists at the Federal Reserve Board of Kansas City (Drabenstott and Smith 1996:4) indicate that differences in communities will widen over time. According to these economists:

> Industrialized agriculture produces two effects on rural communities. As production increases in some "cluster" communities, it will leave others, lessening agriculture's impacts. Communities that are home to industrialized production and processing may see jobs and income increase. But even there, the economic links will be different than under community production. More production inputs are purchased from nonlocal sources, and more of the profits go to nonlocal owners of the firm.

B. Types of Studies Conducted on the Effects of Industrialized Farming: Research Designs and Methodology

Analysts have used primarily four different types of research designs to assess whether industrialized farms have detrimental impacts on communities. Each design has inherent strengths and limitations in being able to comprehensively analyze industrialized farming and its many potential impacts noted above.[11]

1. *Case-study designs* provide in-depth analysis of the consequences of industrialized farming in a single or multi- community site. Usually, a comparative case-study design is implemented whereby a community or communities characterized by industrialized farming are contrasted with a community or communities with a different farming pattern

[11] We have outlined the strengths and limitations that are intrinsic to each research design. A individual study will vary as to how the analysts have exploited the strengths or overcome the limitations of the design.

(usually moderate-size, family-owned and operated farms). A comparative case-study design allows communities to be matched on similar background characteristics, such as location near cities and dependency on farming as an economic base, which helps to "control" (or exclude) extraneous factors that influence the relationship between farming type and community well-being. Examples of case studies are Goldschmidt (1978a) noted above and the North Central Regional Center for Rural Development (1999). The strengths of case-studies are the following. (a) They provide detailed information about how both scale and organizational aspects of industrialized farming impact community well-being. (b) They provide detailed information about outcomes for a great many community indicators of local socioeconomic well-being, social fabric, and environment. (c) They trace the direct and indirect effects of industrialized farming. (d) They can address short-term as well as long-term outcomes. The inherent limitation of case-studies is that detailed conclusions are produced about the impacts of industrialized farms in specific site communities at the expense of producing less detailed findings but over a greater number of research sites. Case-studies also vary as to how well the analyst is able to partition out extraneous factors that influence the causal relationships of importance.

2. *Macro-social accounting designs* involve statistical analysis of secondary or pre-collected data from government and other sources, such as the Census of Agriculture and Census of Population, to document relationships found in regional social structure (MacCannell 1988). Community units, such as counties and townships, and states are the research focus. To assess the consequences of industrialized farming, analysts usually compare its effects relative to other farming (usually smaller or moderate-size family farm units) and over time, while controlling for other, non-farm factors known to affect community well-being. Multivariate statistical techniques, such as regression procedures and discriminant analysis, are used so that the effects of farm structure are assessed net of other community conditions. Examples are Gilles and Dalecki (1988), Lobao (1990), Crowley (1999), Crowley and Roscigno (2004) and Irwin et al. (1999). The strengths of these studies are the following. (a) They provide conclusions about true (actual empirical) relationships, which are generalizable across many communities, various states, and the nation as a whole. (b) They provide conclusions about industrialized farming using measures of scale and organization. Customary measures of industrialized farming in these studies are: for scale, farm size in sales, such as the percent of farms above some gross annual sales threshold (e.g. above $500,000) or depending upon commodity, acreage above a certain size; for organizational indicators, percent of farms organized as corporations or non-family-held corporations; percent of farms with full-time hired labor; annual costs of hired labor per farm; and non-resident operators. (c) Macro-social accounting designs provide conclusions about a variety of socioeconomic well-being indicators (i.e., unemployment rate, poverty rate, income levels, income inequality), social fabric impacts (i.e., population change, educational attainments, health status, family disruption indicators), and about some environmental indicators (i.e., energy usage). (d) They address short-term and long-term relationships between industrialized farming and community well-being. The inherent limitation of these studies is that they depend on the availability of pre-collected data, which constrains the use of certain measures and time periods of study. Some organizational measures of industrialized farming, contract farm-

ing and vertical integration of farm units are not available over time from the Census of Agriculture or from other secondary sources across communities.

3. *Regional economic impact models* use linear programming methods to estimate impacts on employment and income for regions, states, and smaller units such as counties and cities. These studies focus on the integration of business enterprises in markets and use programs, such as variants of input-output analysis, to model the backward and forward linkages with enterprises in other industries and to estimate resulting local impacts. The costs and benefits of varying different firm-level practices can be estimated. Examples are studies by Heady and Sonka (1974), Marousek (1979), Otto et al. (1998), and Thompson and Haskins (1998). The strengths of regional economic impact models are the following. (a) They provide detail about economic performance, such as the number of jobs and total income produced by firms or industries in a region or community. (b) They can provide projected estimates, so that the potential impacts of not yet existing enterprises can be appraised. Limitations of regional economic impact, input-output models are well-known and documented.[12] In brief, most models involve assumptions about relationships not actually found in the community--that is, models depend on estimates from past years and different places. To the extent to which real (true, empirical) conditions in a particular community vary, these studies will not provide accurate assessment of impacts. Another inherent limitation is the types indicators of industrialized farming and impacts addressed. Farm scale, as indicated by sales and labor force size, is analyzed, not the organization of production. These studies do not examine certain socioeconomic well-being indicators such as family poverty and income inequality (the degree to which economic growth is shared by families throughout the community); nor do they examine social fabric or environmental indicators. Finally, input-output analyses of industrialized farming usually do not address long-term impacts, such as over the course of a decade.

4. *Survey-design studies* use samples of populations from any number of communities. These studies use interviews or questionnaires to document how industrialized farming affects residents or a particular social group exposed to industrialized farming as compared to those who are not (such as those residing in family farming communities). In contrast to macro-social accounting and economic impact models which are based usually on secondary or pre-collected data, the researchers using a survey design collect primary data directly from individuals or families. Multivariate statistical procedures such as regression are used to assess the consequences of farm variables net of other community and individual characteristics. Examples of studies based on survey designs are Heffernan and Lasley (1978), Poole (1981), Wing and Wolf (1999). The strengths of these studies are the following. (a) They provide detailed information about how both scale and organizational aspects of industrialized farming impact individuals or families. (b) They

[12] A good review of input-output analysis is provided by the recent report published by the University of Minnesota (1999) on the impacts of the livestock industry. The authors (pp. F35-F56) note that input-output models, such as IMPLAN, are limited by the quality of data used in the models, the assumptions made about regional purchase coefficients, and how economic shocks are specified. The authors note that for the present period it has become increasingly difficult to obtain data from large farms and therefore more difficult to adequately analyze costs by size of operation.

provide detailed information about outcomes for a great many indicators of personal and family social and economic well-being, including social fabric indicators, such as community participation and stress, health status, all of which allows for a more in-depth analysis of quality of life. Inherent limitations of surveys for addressing the impacts of industrialized farming are that cost considerations often restrict surveys to specific states and communities and to one time point.

C. Conclusions of Studies Examining Industrialized Farming and Community Well-being

As noted, to assess the consequences of industrialized farming, it is useful to examine the body of past work conducted by researchers from various social science disciplines, over time, and using different methodologies. Table 1 reports the conclusions from 56 studies conducted since the 1930s on the effects of industrialized farming on communities to provide the most recent findings for each of the four study designs above. This table has been updated from Lobao (2000) by adding all empirical studies published on the topic in *Rural Sociology* (the major scholarly journal in this field) since 2000. A review of articles in the *American Journal of Agricultural Economics* (the major scholarly journal in this field) over the past five years was undertaken but no empirical studies were found on the topic. In addition, the following journals were surveyed for articles relevant to the topic: *Agriculture, Food and Human Values, Culture and Agriculture, Sociologia Ruralis, Southern Rural Sociology, American Journal of Alternative Agriculture* (now the *Renewable Agriculture and Food Systems* journal*), Journal of Rural Studies* and the *International Journal of the Sociology of Agriculture and Food.* Two scholarly search engines -- *Google Scholar* and *Agricola* – were also used to find relevant articles. Some articles were located serendipitously. The programs and abstracts for the 2000-2005 annual meetings of the Rural Sociological Society also were reviewed.

In Table 1, studies are classified by: (a) methodology, referring to the research designs described above; (b) regions of the country analyzed; (c) the indicators used to measure industrialized farming; (d) types of impacts analyzed; and (e) results of the study as to whether detrimental impacts were found (discussed further below). With regard to the indicators of industrialized farming, most of the studies examine farm scale; organizational characteristics are examined less frequently. The studies examine a wide variety of impacts on community well-being. Community well-being impacts were classified as to whether they were socioeconomic well-being indicators (income levels, poverty, and unemployment); indicators of social fabric (population change, social class, civic involvement, quality and types of community services, population size and composition, and social disruption indicators such as stress and crime); and environmental impacts. In most studies (all of the sociological studies), the authors hypothesize that where farms are larger scale or industrialized in terms of organizational characteristics, they have a detrimental impact on the indicator(s) of community well-being, relative to family-owned and operated farms. These relationships are expected to be found across communities and over time.

Types of Detrimental Impacts Reported by Social Scientists

Social scientists report that industrialized farms are related to relatively worse conditions for the following community impacts:

Socioeconomic Well-being

1. Lower relative incomes for certain segments of the community: greater income inequality (income polarization between affluent and poor), or greater poverty.
   (Tetreau 1940; Goldschmidt 1978a; Heady and Sonka 1974; Rodefeld 1974; Flora et al. 1977; Wheelock 1979; Lobao 1990; Crowley 1999, Deller, 2003; Crowly & Roscigno, 2004: Peters, 2002; Welsch & Lyson, 2001; Durrenberger and Thu, 1996)
2. Higher unemployment rates.
   (Skees and Swanson 1988; Welsch & Lyson, 2001)
3. Lower total community employment generated.
   (Marousek 1979; Thompson and Haskins 1999)

Social Fabric

1. Population: decline in local population size where family farms are replaced by industrialized farms; smaller population sustained by industrialized farms relative to family farms. (Goldschmidt 1978a; Heady and Sonka 1974; Rodefeld 1974; Wheelock 1979; Swanson 1980)
2. Class composition: social class structure becomes poorer (increases in hired labor). (Gilles and Dalecki 1988; Goldschmidt 1978a; Harris and Gilbert 1982)
   Social disruption:
   - increases in crime rates and civil suits (North Central Regional Center for Rural Development 1999);
   - general increase in social conflict (Seipel et al. 1999);
   - greater childbearing among teenagers (Lobao 1990);
   - increased stress, social-psychological problems (Martinson et al. 1976; Schiffman et al. 1998)
   - swine CAFOs located in census blocks with high poverty and minority populations (Wilson, et al., 2002)
   - deterioration of relationships between hog farmers and neighbors (Jackson-Smith & Gillespie, 2005; McMillan and Schulman, 2003)
   - more stressful, less neighborly relations (Constance & Tuinstra, 2004; Smithers, et al., 2004)
4. Civic participation: deterioration in community organizations, less involvement in social life. (Goldschmidt 1978a; Heffernan and Lasley 1978; Poole 1981; Rodefeld 1974; Lyson, et al, 2004; Smithers, 2004)
5. Quality of local governance: less democratic political decision-making, public becomes less involved as outside agribusiness interests increase control over local decision-making.
   (Tetreau 1940; Rodefeld 1974; Goldschmidt 1978a; McMillan and Schulman, 2003)

6. Community services: fewer or poorer quality public services, fewer churches. (Tetreau 1940; Fujimoto 1977; Goldschmidt 1978a; Swanson 1980)
7. Retail trade: decreased retail trade and fewer, less diverse retail firms. (Goldschmidt 1978a; Heady and Sonka 1974; Rodefeld 1974; Fujimoto 1977; Marousek 1979; Swanson 1980; Skees and Swanson 1988; Foltz et al, 2002; Foltz & Zueli, 2005, Smithers, 2004; Gomez & Zhang, 2000)
8. Reduced enjoyment of property: deterioration of landscape, odor in communities with hog CAFOs (Schiffman et al. 1998; Wing and Wolf 1999; Constance & Tuinstra, 2005; Reisner et al., 2004; Wright et al., 2005; Wing and Wolf, 2000; Kleiner, 2003; McMillan and Schulman, 2003)
9. Health: neighbors of hog CAFOs report upper respiratory, digestive tract disorder, eye problems. (Wing and Wolf 1999; Constance & Tuinstra, 2005; Reisner et al., 2004; Wright et al., 2005; Wing and Wolf, 2000; Kleiner, 2003)
10. Real estate values: residences closest to hog CAFOs experience declining values relative to those more distant. (North Central Regional Center for Rural Development (1999:46); Seipel et al. 1998; Constance & Tuinstra, 2005; Reisner et al., 2004; Wright et al., 2005)

Environment

1. Eco-system strains: depletion of water, other energy resources. (Tetreau 1940; Buttel and Larson 1979; North Central Regional Center for Rural Development 1999)
2. Environmental consequences of CAFOs: increase in Safe Drinking Water Act violations, air quality problems, increased risks of nutrient overload in soils. (North Central Regional Center for Rural Development 1999)

Summary of Conclusions Reported by Social Scientists by Study

In addition to showing the types of impacts reported in the social science literature, the studies also provide an overview of the consistency of evidence on the risks of industrialized farming. For each study, a number of different relationships may be tested. Authors invariably provide a summary estimation of each study's conclusion. Whether hypotheses about detrimental effects were largely supported (e.g. the authors report detrimental impacts overall); whether there were mixed findings (authors report only some detrimental impacts were found); and whether authors' report no detrimental effects. The results of the studies were then classified according to findings along those three lines: detrimental, some detrimental, or No Detrimental. Out of the total 56 studies, the researchers report largely detrimental impacts in 32, some detrimental impacts in 14, and no evidence of detrimental impacts in 10. Thus, over 82% (46 out of 56) of the studies report finding some negative impacts of industrialized farming. It is this consistency of past research which leads researchers to hypothesize that industrialized farming will jeopardize communities.

Of the thirty two studies where social scientists found predominantly detrimental impacts, the following points should be noted. First, studies reporting these impacts exist through all time periods, from the 1930s to the present. The studies show detrimental impacts for socioeconomic well-being, social fabric, and environment across communities, for both scale and organizational indicators, and throughout all regions of the country, including the North Central heartland states. These studies use five types of research designs, comparative case study, macro-social

accounting, regional economic impact models and survey. In other words, a great deal of evidence produced over time, for various regions of the country, by different researchers, and by five different research designs shows that industrialized farming has detrimental impacts.

Of the fourteen studies where social scientists report some, but not consistenly negative impacts of industrialized farming, the following points should be noted. These studies provide mixed findings, in that while adverse effects on some community indicators were found, at least one of the following also occurred: (a) industrialized farming had no statistical relationship with other indicators (i.e. there was an absence of any relationship); (b) industrialized farming had a trade-off effect, with beneficial effects on certain indicators; (c) industrialized farming did not consistently produce negative impacts for all time periods or regions; or (d) industrialized farming produced beneficial effects for some groups but Detrimental to other groups. These studies were found principally in the use of four research designs: regional impact studies of economic performance, macro-social accounting, case study, and survey. Regional impact studies (e.g., Heady and Sonka 1974; Marousek 1979) have tended to show costs-benefits for economic performance indicators, with larger farms injecting greater total income into the community, but also producing less employment relative to smaller farms. In the case of macro-social accounting studies reporting mixed effects, Lobao's (1990) study is an example. For counties in the forty-eight contiguous states, industrialized farming had no relationship with family poverty or median family income at either of two single time points (1970 and 1980); however, industrialized farming was related to higher income inequality at both time points and also to lower family income, higher poverty, and higher income inequality over the decade from 1970-1980 (i.e. counties with greater industrialized farming in 1970 experienced relative declines in socioeconomic well-being over the decade).

An example of a case study showing mixed effects is Wright, et al., (2001) conducted in six CAFO counties in Minnesota. This study demonstrated the mixed impacts of CAFOs for residents in these counties. This study found that CAFOs had positive effects for farmers who expanded their operations, detrimental effects for neighbors to CAFOs who saw their ability to enjoy their property deteriorate, detrimental effects for younger and mid-sized producers unable to expand because expansion by others had restricted their access to markets, detrimental effects for older producers who mourned a loss of a way of life, and no effects for those who were not neighbors or who were not expanding. The greatest detrimental effects were the decline in social capital as trust in government agencies declined due to their inability to make decisions in a timely manner, and a decline in cultural capital because of the differing visions of agriculture and of local communities.

A survey study (Jackson-Smith and Gillespie, 2005) also found mixed effects regarding the impact of scale on social relations. When demographic variables were controlled, there was little evidence that size of farm or use of hired workers was related to relationships with neighbors, however, farm size was the strongest predictor of neighbors' complaints about a dairy operation.

The ten studies that found no detrimental impacts of industrialized farming used regional impact models, macro-social accounting, and survey designs. Most of these studies analyzed only indicators of socioeconomic well-being. The regional impact study by Otto et al. (1998) indicated that larger farms are beneficial, both in terms of injecting greater income into a community and in creating more jobs. The results of this study were later challenged by Thompson and Haskins (1998) who argued that Otto et al. (1998) failed to correctly compare

large farms with smaller farms by holding constant total output. Here the point is not to dispute either study but to note that regional impact models because of their assumptions, use of shocks (i.e. disruptions to the regional economy), and focus on scale as opposed to organizational indicators usually find net benefits for specific economic performance indicators. An example of a macro-social accounting study that found no detrimental impacts is Lobao and Schulman (1991). They examined whether industrialized farming was related to higher poverty for the four major agricultural regions in the contiguous states for 1970-1980. They found while moderate-size family farming was related to lower poverty for the North Central states, there was no significant relationship between poverty and industrialized farming in any of the four U.S. regions analyzed. Most of the macro-social accounting studies finding no detrimental impacts of industrialized were conducted using data for 1970-1980. Skees and Swanson (1988) note that the time period may be a factor why detrimental impacts are less likely to be found, because industrialized farming was more regionally confined and of less magnitude in the past than in more recent time periods. A recent survey design study (Foltz and Zueli, 2005) did not find evidence that large farms are unlikely to purchase locally when the presence or absence of local suppliers was taken into consideration, and instead demonstrated that purchasing patterns are commodity specific and are determined by community attachment, and local supply considerations.

D. Examples of Recent Sociological Research on the Consequences of Industrialized Farming

1. Macro-social Accounting: Several macro-social accounting studies provide examples of recent sociological research on industrialized farming. The most recent macro-social accounting studies on the effects of industrialized farming are by Crowley (1999), Crowley and Roscigno (2004), Welsh and Lyson (2001), Lyson et al. (2001), and Peters (2002).

The 1999 study by Crowley analyzed the effects of farm concentration using several indicators: concentration of land, value of land and buildings, and the value of equipment and machinery) and data for counties in the North Central region comprising Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, Ohio, North Dakota, South Dakota, and Wisconsin. She analyzed consequences of these dimensions of farm-sector concentration for local levels of poverty and inequality, controlling for the influences of labor market, demographic, spatial, and other farm structure characteristics. As noted earlier, she found where farm sector concentration is higher (i.e., a few large farms held a large share of local property in land and real estate) both poverty and inequality are higher and education is lower.

In the 2004 study, Crowley and Roscigno documented how concentration of agricultural resources shapes rural community stratification through the political economic process. In addition to measures of farm sector concentration, measured by the gini coefficient and labor endowment, they extended the analysis to include measures of political process, and worker power attributes. Again using data for all (1053) counties in the North Central U.S. they found that dimensions of farm sector concentration shape both poverty and inequality. Furthermore, they found that farm sector concentration is explained by political economic processes, and these processes mediate the negative effects of land concentration on economic well-being. In particular, they found that relative to large scale farms, capital concentration promotes govern

ment spending that benefits large farms while it blocks government or labor-market programs that assist farmers whose farms it consumes and farm workers it exploits.

Whether people in agricultural areas in states with anti-corporate farming laws fare better on measures of economic health than do people in agricultural areas in states without such laws was studied by Welsh and Lyson (2001). In examining states with anti-corporate farming laws (Iowa, Kansas, Minnesota, Missouri, North Dakota, South Dakota, Oklahoma, and Wisconsin), they found that agriculture dependent counties in states with such laws fare better on economic measures, i.e. less families in poverty, lower unemployment, and higher percentages of farms realizing cash gains.

In the first analysis of all agriculture dependent counties, they found that agriculture dependent counties in states with anti-corporate farming laws have lower poverty rates, lower levels of unemployment, and a higher percentage of farms reporting cash gains than agriculture dependent counties in states without anti-corporate farming laws. These results were consistent for both the cross-sectional analysis (across states in same time period) and longitudinal analysis (within states across time periods). In the second analysis of states with more restrictive anti-corporate farming laws compared to states with less restrictive laws, the restrictiveness index had no effect on poverty in the cross sectional analysis (across states at the same time period) but a slight, positive association in the longitudinal analysis (within state, across time periods). That is, states with more restrictive laws have slightly higher poverty rates over time than do states with less restrictive laws. The restrictiveness index had a strong, negative association with unemployment in the cross-sectional analysis, but no association in the longitudinal analysis. That is, states with more restrictive laws have lower poverty rates at the same point in time than do states with less restrictive laws. Finally, the restrictiveness index had a strong positive association with the percentage of farms reporting cash grains in the cross-sectional analysis, but no association in the longitudinal analysis. That is, states with more restrictive laws have higher percentages of farms reporting cash gains at the same point in time than do states with less restrictive laws.

Lyson et al. (2001) found support for Goldschmidt's findings of a negative relationship between farm scale and community well-being, but these negative relationships were mediated by the presence or absence of a civically-engaged middle class. This study examined the agriculture dependent counties in the U.S. for the period 1982 to 1992. In this study, community welfare is measured by percentage of families in poverty, unemployment rates, and percentage of low birth weight babies. Civically-engaged middle class is measured by percentage of workforce that is self-employed, percentage of labor force working at home, and percentage of small commercial establishments. Farm scale is measured by percentage of sales by farms of $500,000 in sales, percentage of farm operators residing on their farms, percentage of tenant farmers in county, and percentage of hired labor on largest farms. They concluded that the presence of a civically-engaged middle class is a more consistent predictor of rural community welfare than was farm scale. More specifically, they found that counties dominated by large scale, absentee owned, agricultural enterprises have less favorable welfare outcomes. However, the presence of a civically-engaged middle class mitigates the negative relationships and enhances positive relationships between farm scale and community welfare. Their findings did not dispute the Goldschmidt hypothesis of a negative relationship between large scale, industrial type farms and community welfare, but they argue that the relationship is not as economistic and deterministic as had been typically hypothesized.

A study of the non-metropolitan counties in Iowa, Kansas, and Missouri by Peters (2002) found support for the argument that the economic structure of the agricultural, industrial and service sectors impacts socioeconomic conditions in non-metropolitan areas. More specifically, he found that areas with greater concentrations of owner-operated farms result in decreased children at risk scores. He argues that this finding supports the Goldschmidt hypothesis that family farming areas are better developed both economically and socially. Because the concentration of non-farm proprietorships did not predict children at risk scores, he suggests that it was not proprietorships in general that mattered as much as the economic nature of farming. He notes two problems with this measure: It does not differentiate between types of farm proprietorships, either by farm size, primary occupation, or management structure, and it does not identify what is unique about farm proprietorships as contrasted to other types of proprietorships that causes improved socioeconomic conditions for children. He also found that areas with greater concentrations of industrial agriculture, characterized by wage labor relations, produce worse socioeconomic conditions for children. This was one of the weakest predictors of children at risk scores, but one of the strongest predictors was percent employed in animal slaughter and meat processing which causes scores to increase. Peters argues that although not considered agricultural production, meat manufacturing is considered part of the agro-food industrial complex. When the measures of both production and of manufacturing of agricultural products are taken together as a measure of industrial agriculture, he argues they support the Goldschmidt hypothesis.

2. Case Studies: Five recent case studies (NCRCRD, 1999, Seipel et al., 1999; Wright et al., 2001; Constance and Tunistra, 2005; McMillan and Schulman, 2003) document the detrimental effects of confined animal feeding operations (CAFOs), a particular kind of industrial agriculture, on community quality of life.

A comprehensive case-study on industrialized farming is that by the North Central Regional Center for Rural Development (NCRCRD, 1999). This study is useful for providing documentation about relationships over time and for assessing impacts on a wide range of socioeconomic, social fabric, and environmental indicators. The study examines the impacts of a large, confined animal feeding operation (CAFO) owned by the Seaboard Corporation, which moved to Texas County, Oklahoma in 1992. Company officials indicated that Seaboard was attracted to Oklahoma because of the state's "relatively lax anti-corporate farm laws, permissive groundwater access laws, and generous public sector incentives" (NCRCRD 1999:1). Public sector incentives given to Seaboard to locate in the county totaled $60.6 million dollars, with the capital coming from publicly repaid bonds, taxes foregone, interest subsidies and grants, an investment of $27,500 per job created. At the time Seaboard moved to Texas County in 1992, the county had an unemployment rate of 3.7% and was among the highest per capita income counties in the state. Seaboard made extensive land purchases in the county to establish corporate-owned swine production facilities as few local cattle ranchers were interested in raising pigs due to the terms of the contracts offered (NCRCRD 1999:16). To analyze the effects of the CAFO, a comparative case-study design was used where changes in Texas County were compared to thirteen other farming dependent counties in Oklahoma. As a strategy of local

economic development, the CAFO performed poorly.[13] The number of jobs, per capita income, poverty rate, number of new businesses, and total bank assets did not change at a rate significantly different from the other, comparison farming dependent counties. Consumer loans increased at a greater rate in Texas County, but increases in commercial and industrial loans were greater in the comparison counties. The economic benefits gained were increases in retail sales and property values. The community costs of the CAFO were experienced largely in social fabric and environment. With regard to social fabric, beneficial impacts were seen in increased population and school enrollment relative to comparison counties. But most other indicators showed rifts in the social fabric. Crime rates increased by 74% in Texas county, compared to a decline of 12.5% in the comparison counties over 1990-1997 (NCRCRD 1999:38). Theft increased 64%, while it decreased 11% in the comparison counties. Violent crimes increased 378%, but decreased by 29% in the comparison counties. Availability of housing declined and rental rates increased to a greater degree than the comparison counties, indicating that crowding is occurring and that the elderly and poor may be priced out of the county. With regard to the environment, water quality violations were much greater in Texas County relative to the comparison counties. Livestock water use increased 66% from 1990 to 1995 in the county. Environmental impacts noted by NCRCRD (1999) were in water depletion and quality, odor, and increased risks of nutrient overload in local soils.

Research by Seipel et al. (1999) elaborate on the NCRCRD (1999) findings by outlining reasons why industrialized farming contributes to breakdowns in social fabric and to environmental degradation. Based on research in four Missouri communities, they note that *CAFOs tend to increase social conflict and personal and community stress for the following reasons:*

1. Some individuals and communities are exposed to the social and environmental harm of CAFOs when other people and communities are not, creating conflict between those residents that pay the costs of industrialized farming and those that do not.
2. The public has often not been involved in decision-making and has not chosen this development as a group.
3. Community residents experience loss of personal control as outsiders, politicians, and corporations are perceived as exercising control over local lives.
4. There is an infusion of new systems and people that communities must now accommodate.
5. While hog farms are a normal part of many rural areas, concentrated operations of thousands of animals confined to one location are not.
6. There is insecurity about health. Residents look to CAFOs and odor to explain personal and family health-related problems. There is increased concern about the health of children and later generations.

[13] The NCRCRD (1999:28-29) study describes how incorrect assumptions in input-output analysis led to misleading results about projected impacts of recruiting the new integrated corporate hog and pork producer to Texas county. Analysts used a figure of $35,137 for average annual income of swine production jobs in input-output models. However, this figure was derived from research in Iowa and was nearly twice the amount earned by swine production workers in Oklahoma. Thus, the input-output analysis severely over-estimated the total income and number of jobs that would be produced in the county by recruiting the corporation.

7. There is "loss of perceived control" (an indicator related to social psychological stress and depression). There is guilt and anxiety over the inability to protect oneself and family, and a feeling of powerlessness concerning resolution of the problems brought on by the industrialized operation.
8. Residents' perceptions about their community changes from a place of security and sense of attachment to a "a degraded space and context of conflict."
9. There is anger and disgust with those who bring CAFOs to the community, which leads to general distrust of government.
10. There is a social stigma attached to living in a CAFO community due to the deterioration of local landscape and to odor problems.

Seipel et al. (1999) note the following general environmental problems related to hog CAFOs:

1. Algae growth and oxygen depletion of surface waters
2. Contamination of wells and groundwaters
3. Contamination of surface water drinking supplies
4. Risk of drinking water contamination due to pathogens such as fecal coliform
5. For workers on CAFOs, the risks of health problems include: asthma, organic dust toxic syndrome, upper airway inflammation, and bronchitis
6. For neighbors of CAFOS, environmental health problem risks include: upper respiratory and digestive track disorders, headaches, nausea, and burning eyes.

Case studies conducted by Wright, et al., (2001) in six CAFO counties in Minnesota demonstrated the mixed impacts of CAFOs for residents in these counties. In these studies they found that CAFOs had positive effects for farmers who expanded their operations, detrimental for neighbors to CAFOs who saw their ability to enjoy their property deteriorate, detrimental for younger and mid-sized producers who were unable to expand because expansion by others has restricted their access to markets, detrimental for older producers who mourned a loss of a way of life, and no effects for those who were not neighbors and who were not expanding. The greatest detrimental effect was the decline in social capital as trust in government agencies declined due to their inability to make decisions in a timely manner, and a decline in cultural capital because of the differing visions of agriculture and of local communities.

A case study by Constance and Tuinstra (2005) found that the quality of life was more stressful and less neighborly in communities with chicken CAFOs. The strain between neighbors and CAFO owners was evident in their perception of the issues. While neighbors focused on substantive concerns of odor nuisances, water pollution, health problems, property values and community disruption, CAFO owners minimized these concerns by saying that it was either neighbors' jealousy or their impractical views of rural land use was the basis for their complaints. Some neighbors had been interested in becoming contract producers, but they had been turned off by Sanderson Farms' hard sell and did not think the contract Sanderson held out was a good business decision. Others realized that once the contract had been signed and chicken houses had been built, growers were locked into long term commitments. Thus, the community was at an impasse over the chicken CAFOs which polarized community relations.

As in the previous example, McMillan and Schulman (2003) also found that CAFOs reduced the quality of life and increased community conflict. Neighbors complained about odor nuisances, voiced concerns about the environmental consequences, worried about health related

concerns, thought they had been betrayed by hog producers, and felt the government had been unresponsive. Producers contended that swine CAFOs provided economic benefits to a depressed community, blamed the media for sensationalizing the concerns about CAFOs, and dismissed neighbors' concerns about quality of life, environmental and health issues as being irrational or overstated. Activists were concerned about the impact of the hog industry on health, the environment, local economic opportunities, community neighborliness and cohesion. They were especially concerned about its effects on the environment and human health through contamination of drinking water.

3. Regional Economic Impact Models: Results of analysis from several recent economic impact models (Gomez and Zhang, 2000; Deller, 2003; Foltz, et al., 2002) indicate that industrial agriculture poses detrimental effects to community well being.

The results of one study in Illinois (Gomez and Zhang, 2000) found that large hog farms actually hinder economic growth in rural communities. In a study of 2240 non-metropolitan US counties, Deller (2003) found that large scale agriculture, measured in sales and value added, and counties' dependence on agriculture, tends to result in lower levels of economic growth. He suggests that as agriculture expands either in terms of farm size or overall share of the economy, it would place downward pressure on regional growth rates. A study of dairy farms in Wisconsin by Foltz, et al. (2002), showed that scale (measured in herd size) had a negative effect on share of input purchases made locally. While one model suggests that community attachment increases local expenditures, another model indicates that that effect is described by distance. Demographic variables did not explain where dairy farmers make their purchases either. Both of the economic models show a significant negative effect for larger farm sizes (herd size) on the share of purchases made locally.

4. Survey Research: Several recent Survey Design Studies demonstrate the effects of industrialized farming on community quality of life. The most recent survey research on the effects of industrialized farming are by Reisner et al., (2004), Smithers et al. (2004), Foltz and Zueli, (2005), and Jackson-Smith and Gillespie (2005). Reisner et al. (2004) focuses on the strain on relations between neighbors and CAFO owners. The remaining three studies focus on how industrial agriculture affects relationships with neighbors or farm purchasing decisions.

The research by Reisner et al., (2004) documented the extent to which CAFOs increase the social tensions between neighbors and owners of swine farms in the community as well as the completely different definitions of the problem by neighbors and swine CAFO owners. While both residents and CAFO owners agreed on the presence, level and length of the controversy, residents were much less satisfied and perceived much less support for CAFOs than did the owners. Additionally, while the owners blamed many groups for the controversy over building or expansion of swine CAFOs, the neighbors identified themselves as the source of the controversy. Neighbors felt that large scale farming was a fait accompli, but they were much less satisfied with the presence of CAFOs than the owners thought they were. The greatest differences between neighbors and owners was about the degree of effect of the large-scale swine farms. Neighbors reported more days with detectable odors than did owners and were more likely to believe that there were problems with water pollution and more likely to report that CAFOs were causing their homes to decline in value.

Three survey design studies also discussed the extent to which industrial agriculture has affected social relationships between large scale farmers and their neighbors, or between large scale farmers and their communities. Smithers et al., (2204) in their survey of Ontario farmers, found that those classified as being in the expansionist mode were constrained in their ability to participate in social activities and organizations, were more likely to not purchase their inputs locally but instead sought the cheapest source, and viewed the community instrumentally in regards as to the goods and services it could provide the farm.

Foltz and Zeuli (2005) did not find that large scale farms (in terms of herd size) purchased less locally than did small farms. They did find that the presence or absence of local marketing or supply outlets and attachment to community influence the decision to purchase locally. Generally, they found that purchasing patterns are commodity specific and not determined by farm size or other farm-level characteristics. Attachment to a community affects purchasing decisions only where there is a choice available to farmers.

Jackson-Smith and Gillespie (2005) were also interested in the relationships between large scale dairy farmers (in terms of herd size) and their neighbors. In the multivariate analysis, demographic variables were associated with knowing neighbors well. When demographic variables (age, children at home, length of time operating the farm) were controlled, there was little evidence that size of farm or use of hired workers was related to relationships with neighbors. Farm size, however, was the strongest predictor that neighbors had complained about a dairy operation. These results, they suggest, indicate that regardless of a dairy farm's household social ties, building a large operation will generate conflicts with neighbors. In regard to community participation, they found that both demographic and farm structural variables determine participation. More specifically, age, education, children at home, use of hired workers, and plans to remain in dairy farming are positively related to involvement in community organizations.

Finally, one study used neighborhood level analysis to test the relationship between exposure to concentrated animal feeding operations and perception of CAFO impacts on rural communities, the economy, and the environment. Kleiner (2003) argues that the neighborhood and not the county is the unit of analysis that is more appropriate for understanding the impacts of industrialization of agriculture. Using GPS technology, she identified households for their actual distance from a swine CAFO in two counties characterized by large-scale, corporate-owned and operated swine CAFOs. She compared responses to rural residents in a control group county without such CAFOs. Her analysis found that proximity to large-scale livestock facilities is associated with people's perceptions of CAFOs impacts, especially environmental impacts. The lower mean scores on overall community impacts and environmental impacts for residents in the neighborhood closest to a CAFO of a county characterized by high concentration of CAFOs were expected when compared to mean scores derived from the combined data from the three counties. Furthernore, attitudes about current regulations for CAFOs were found to be more negative for the residents in the neighborhood in the county characterized by a high concentration of CAFOs compared to the combined scores for the three counties. When the types of impacts were analyzed separately, she found that economic impacts are more obvious to residents than perceived social and environmental impacts. This explains, she contends, why residents of corporate CAFO counties are more likely to perceive CAFO impacts more positively than residents of the non-corporate CAFO county which have less direct experience with them. The findings suggest that negative CAFO impacts perceived by residents in close proximity tend

to impact behavioral patterns in and around the home, especially in the county where CAFOs are most concentrated.

E. Industrialized Farming and Regional Imbalances in Opportunities to Engage in Farming and Well-Being

Thus far this report has focused on impacts occurring in communities. Another way that industrialized farming may adversely affect public well-being is through creating differences within a region. Until recently, the historical predominance of moderate-size family farms in the Heartland helped create a stable region economy with middle class farming communities (Flora and Flora 1988; van Es et al. 1988). This is now changing. For the Heartland states, economists at the Federal Reserve Board of Kansas City indicate that differences in communities within any given state will widen over time with regard to communities' ability to participate in commodity agriculture. It is useful to quote at length from their analysis (Drabenstott and Smith 1996:4).

> Agriculture is a common ingredient to the rural economy throughout the Heartland. The 12 Heartland-states are home to more than two-thirds of the nation's farm-dependent counties. Historically, agriculture has been a primary engine of growth for rural communities. A large number of mid-sized farms have created significant economic multiplier effect for agriculture, enhanced by any local agricultural processing in rural areas.
>
> Today, that picture is changing. Heartland agriculture has moved quite rapidly to fewer, bigger farms. The largest farms in the United States, those with annual sales greater than $500,000 a year are just 2.5% of all farms; yet they account for 40 percent of farm output. A similar pattern is found in Heartland states.
>
> As agricultural production has moved to bigger farms, agriculture's links with local rural communities have weakened. Large farms tend to procure their inputs, including financial capital, from more distant places that can offer more products and lower prices. In addition, large farms often have direct marketing relationships with processors, by-passing local buyers.
>
> More recently, a pickup in the industrialization of agriculture has further weakened linkages to local rural communities. Industrialization refers to the movement toward more direct production and marketing relationships between producers and processors, a trend now symbolized by the broiler industry. Under industrialization, processors attempt to secure a stable supply of consistent product while exploiting the economies of scale in new production and processing methods. The result is a further concentration of production, as production shifts to bigger firms and clusters around processing plants much more than in the past.
>
> Industrialized agriculture produces two effects on rural communities. As production increases in some "cluster" communities, it will leave others, lessening agriculture's impacts. Communities that are home to industrialized production and processing may see jobs and income increase. But even there, the economic links will be different than under community production. More production inputs are purchased from nonlocal sources, and more of the profits go to nonlocal owners of the firm.
>
> Agriculture remains important to the Heartland. But its economic impact is much different than in the past. Commodity agriculture remains, but it is in bigger hands. And the advent of industrialized agriculture creates a new pattern of agricultural haves and have-nots. And even in those communities that have industrialized agriculture, the economic links are different than in the past.

Barkema and Drabenstott (1996:72) note that while some communities in the region will lose farms and farmers due to production concentration in other communities, those gaining new agribusiness, at least in the meat industry, are not likely to realize great economic gains.

> While the region's meat prospects are good, the corresponding economic impact may be low. Wages in the meat industry are relatively low. Moreover, the value added in meat processing is low. The average value added for all food products is 39 percent, for meat products it is just 21 percent. Thus, the region's solid prospects for expanding meat processing are unlikely to provide a wide-spread economic tide for Heartland

Barkema and Drabenstott's (1996:72) conclusion is supported by the NCRCRD (1999) study above that found no appreciable gains in per capita income and employment growth where CAFO recruitment occurred relative to comparison counties in Oklahoma where it did not occur. In the industrial sociology and economic geography literatures, food processing is considered part of the peripheral manufacturing sector (Lobao et al. 1999). Production here is routinized, wages are relatively low-wage compared to durable manufacturing and certain services, and firms tend to be more footloose in seeking out low-costs labor. In sum, reliance on meat processing is not likely to enhance community development over the long-term.

Relatedly, communities that look to industrialized farming to solve economic development problems will not only confront the problems noted above in terms of social fabric and environment but also are pursuing a strategy that may be costly in terms of long-term development. While it is often noted that smaller farms (as all smaller businesses) fail more often than larger farms,[14] analysts rarely consider the opposite side of the coin: when large vertically-integrated farm corporations fail they are likely to do a great deal of community damage, particularly if scarce public resources have been used to attract them. NCRCRD (1999) details the extensive public sector incentives such as tax increment financing, tax exemptions, interest-free loans, and grants given to recruit CAFOs. Public resources and community well-being are at risk should such farms underperform in their agreements with local governments or fail overall.

As vertically integrated production in agriculture is new to many communities, its failure rate is yet to be adequately assessed, particularly over the long-term. Public concern with large confinement operations is demanding that these farms adhere to ever higher standards of social and environmental responsibility. Whether the operators of these farms have the skills and expertise to succeed in a climate demanding increased consumer and public accountability and at the same time remain competitive is unclear. In Ohio, for instance, the German owner of Buckeye Egg Farm (one of the country's largest egg producers with nearly 15 million hens in three Ohio counties) was banned from professional contact with animals in his native Germany. His operations in Ohio have faced a continual series of "serious environmental, regulatory, financial and public- relations problems" in the 1990s (Columbus Dispatch, November 7, 1999: 2g). The Ohio EPA recently filed a lawsuit accusing the company of violations of Ohio's solid-waste, water-pollution-control, safe-drinking-water, air-pollution and nuisance laws (Columbus Dispatch, December 22, 1999:1h-2h).

The diversion of state and local resources toward regulating the operation of large farms confining many animals to a single location must be considered in assessing the impacts of industrialized farming. The problem is compounded in rural areas, because rural local governments are already disadvantaged in staff and fiscal resources needed to adequately serve their

[14] Sociologists again would point out that moderate-size farms are not inherently less efficient producers but that they are disadvantaged in competing with large farms that have transaction costs advantages in terms of buying and selling.

populations. They do not have the resources to engage in endless rounds of litigation to protect the well-being of their residents.

IV. SUMMARY AND CONCLUSIONS

Based on the evidence generated by social science research, we conclude that public concern about the detrimental community impacts of industrialized farming is warranted. In brief, this conclusion rests on five decades of government and academic concern with this topic, a concern that has not abetted but that has grown more intense in recent years, as the social and environmental problems associated with large animal confinement operations have become widely recognized. It rests on the consistency of five decades of social science research which has found detrimental effects of industrialized farming on many indicators of community quality of life, particularly those involving the social fabric of communities. And it rests on the new round of risks posed by industrialized farming to Heartland agriculture, communities, the environment, and regional development as a whole.

In this report, a review by Lobao (2000) was updated to 2006 so that the findings of past and recent research on industrialized farming could be systematically documented. The conclusions from fifty six studies (32 detrimental effects and 14 some detrimental effects) examining the consequences of industrialized farming for communities were evaluated. Approximately 82 percent of these studies found adverse impacts on indicators of community well-being. The types of indicators and the number of studies reporting these are discussed in Table 1 and in the text. Analysts have tended to find the following impacts.

For socioeconomic well-being, researchers noted that industrialized farming was related to higher income inequality and to lower community employment, relative to moderate-size family farming. Higher income inequality indicates that industrialized farming is less likely to sustain middle-class communities. Places with higher income inequality also are prone to other social problems because the gap between affluent and poor is greater. With regard to other socioeconomic impacts, such as total income injected into the community, regional economic impact models were likely to report beneficial impacts. However, the findings for income inequality suggests that income growth is impeded in trickling down to families.

Studies assessing consequences for the social fabric of communities were likely to find detrimental impacts. Industrialized farming affects the social fabric of communities through altering population size and social composition which affect crime, social conflict, family stability, the local class structure, community participation, and local shopping patterns. Case-studies reported the loss of local autonomy, in which communities become increasingly subject to the influence of external business owners who interests may not be compatible with their own. More recent studies reported environment impacts. Because large animal confinement operations house densely concentrated livestock, they are prone to a host of negative environmental impacts on water, air, and human health.

Given the relative consistency of past research, the studies such as Crowley's (1999), Crowley and Roscigno's (2004), and Welsh and Lyson's (2001) which specifically analyzed North Central states, including North Dakota, and research focused on neighboring states in the region, there is every reason to expect that the conclusions drawn here apply to North Dakota. From the social science literature, we can anticipate four sets of impacts of industrialized farming for farming-dependent communities in Heartland states such as North Dakota: impacts

on socioeconomic well-being, social fabric, the environment, and regional imbalances.

Communities that receive industrialized farming are likely to increase population relative to other communities (that is, if local family farmers are not displaced). These communities may increase employment and per capita income but as shown by the NCRCRD (1999) study, this may not be at a rate significantly different from comparison locales.

Communities with industrialized farms are likely to experience greater income inequality; government services for the poor and other disadvantaged groups are likely to be needed in these locales.

Communities that gain new industrialized farming will encounter stresses in the social fabric; community decision-making is likely to be more subject to corporate farm interests; and in the case of large livestock confinement operations, communities will be at risk for environmental and health problems, entailing the need for state and local government intervention.

Communities that lose moderate-size family farms, in part because of transaction cost advantages (e.g., volume buying-selling) and public incentives given to industrialized farms, will lose a base of middle class producers and experience rifts in social fabric, including population decline. These communities are likely to have declines in other businesses and in the local property tax base and may require government aid for social and public services.

Regional clustering of agricultural production is likely to occur (Drabenstott and Smith 1996:4). While some communities will gain industrialized farming (and it attendant costs and benefits) others will continue to lose their family farm base as production clusters closer to large processors. Within states, there is thus likely to be greater inequality between communities over time.

Not discussed in this report are alternative economic development strategies that farming dependent communities can pursue. Notwithstanding arguments that vertical integration into farming and production contracts are the only options left to keep American farmers farming, there are alternatives and some working examples are discussed in NCRCRD (1999).

From a sociological standpoint, government plays a role in the types of consequences that industrialized farming will have for community well-being. It establishes the legal-institutional framework for regulating these farms. It establishes the incentive structure offered to agribusiness firms in their location decisions. It provides the public services needed to mop up the destabilizing impacts of industrialized farming, such as a rising crime rate, increased social conflict, and the need for social services to cope with a changing population. And government will need to provide the social services related to population decline and poverty alleviation in communities which lose family farming.[15]

Prior to Welsh and Lyson's (2001) research, the role that laws regulating corporate farms have in countering detrimental community impacts of industrialized farming had only been alluded to by some researchers. Lobao and Schulman (1991:596) postulated that one of the reasons why a few studies have found that industrialized farming has had less adverse effects in the North Central Heartland region (relative to the South and West) is due to its agrarian history

[15] In non-farm dependent communities, government intervenes in a number of ways when paid employment, such as in manufacturing and mining declines: through programs such as unemployment insurance, various income transfers, such as welfare payments, for which independent farm operators are generally not eligible due to property ownership; through re-training programs, such as for workers who lose jobs because of NAFTA; and through enforcement of community rights in plant closure laws. Because of their farming base, farm-dependent communities usually cannot make as full use of these social safety nets as can other communities.

of protection of family farming and regulation of corporate farming. NCRCRD (1999:1) also indicated that "relatively lax anti-corporate farming laws, weak environmental regulations and permissive groundwater access laws" not surprisingly encouraged large, animal confinement operation to locate in Kansas. When Welsh and Lyson (2001) examined states with anti-corporate farming laws (Iowa, Kansas, Minnesota, Missouri, North Dakota, South Dakota, Oklahoma, and Wisconsin), they found that agriculture dependent counties in states with such laws fare better on economic measures, i.e. less families in poverty, lower unemployment, and higher percentages of farms realizing cash gains. In the comparison of states with less restrictive vs. states with more restrictive laws, they generally found the same results as with the comparison of states with anti-corporate farming laws and states without such laws.

Remote rural counties appear to be targeted as recent operating sites by large animal confinement operations. Research by Wilson et al. (2002) demonstrated that census blocks in Mississippi with high percentages of African Americans or people in poverty were much more likely to be the locations of swine CAFOs. Of all local governments, remote rural counties have the least resources (staff, economic development, and social service budget) to cope with industrialized farming. These governments are in weak positions to bargain successfully with external corporations, to regulate their operations once they are in place, and to protect community social life and environment overall. Remote rural counties are the places where state protection from industrialized farming is most critical due, in part, to the fragility of local government.

From a social science standpoint, the farming system in place today has been created from both market forces and government policy and programs. It is thus logical that government can also be an instrument in transforming this system toward greater public accountability.

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Table 1. Summary of Studies Examining Industrialized Farming and Community Well-Being*

Study	Methodology	Region	Measures of Industrialized Farming	Community Well-Being Indicators	Results
Goldschmidt (1968, 1978a) (1944, original)	Comparative Case Study, two communities	California	scale/ organization	Socioeconomic/Social Fabric (class structure, services, population, politics, retail trade)	Detrimental
Tetreau (1938, 1940) (one study, two articles)	Survey Design Study, 2700 households	Arizona	scale/ organization	General Socioeconomic Indicators/Social Fabric (class structure)	Detrimental
Heffernan (1972)	Survey Design Study, 138 broiler producers	Louisiana	organization	Social Fabric (social psychological indicators, community involvement)	Detrimental
Heady and Sonka (1974)	Regional Economic Impact Model of 150 producing areas	continental U.S.	scale	Socioeconomic: Economic performance (income, employment generation)	Some Detrimental: large farms lower food costs but generate less total community income
Rodefeld (1974)	Survey Design Study, 180 producers from 100 farms	Wisconsin	scale/ organization	Socioeconomic/Social Fabric (class structures, services, population size)	Detrimental
Martinson et al. (1976)	Survey Design Study, 180 producers	Wisconsin	organization	Social Fabric (social psychological indicators)	Detrimental
Fujimoto (1977)	Macro-social Accounting, 130 towns	California	scale	Social Fabric (community services)	Detrimental

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Study	Methodology	Region	Measures of Industrialized Farming	Community Well-Being Indicators	Results
Flora et al. (1977)	Macro-social Accounting, 105 counties	Kansas	scale/ organization	Socioeconomic/Social Fabric (class structure, services)	Some Detrimental: industrialized farming is related to greater income inequality but other relation-ships not clearly supported
Small Farm Viability Project (1977)	Comparative Case Study, reanalysis of Arvin and Dinuba	California	scale/ organization	Socioeconomic/Social Fabric (class structure, services)	Detrimental
Goldschmidt (1978b)	Macro-social Accounting, states	entire U.S. except Alaska	scale	Social Fabric (agrarian class structure)	Detrimental
Heffernan and Lasley (1978)	Survey Design Study, 36 grape producers	Missouri	organization	Social Fabric (community social and economic involvement)	Some Detrimental: operators of nonfamily farms less involved in community activities but little support for other relationships
Wheelock (1979)	Macro-social Accounting, 61 counties	Alabama	scale	Socioeconomic/Social Fabric (class structure, population size)	Some Detrimental: rapid increases in farm scale related to decline of population, income, and white collar labor force; other relation-ships mixed.
Marousek (1979)	Regional Economic Impact, one community	Idaho	scale	Socioeconomic: Economic performance (income, employment generation)	Some Detrimental: large farms result in greater regional income but produce less employment than small farms

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Study	Methodology	Region	Measures of Industrialized Farming	Community Well-Being Indicators	Results
Buttel and Larson (1979)	Macro-social Accounting, state-level data	entire U.S.	scale/ organization	Environment (energy usage)	Detrimental
Heaton and Brown (1982)	Macro-social Accounting, county-level data	continental U.S.	scale/ organization	Environment (energy usage)	No Detrimental
Swanson (1980)	Macro-social Accounting, 27 counties	Nebraska	scale	Socioeconomic/Social Fabric (population size)	Detrimental
Poole (1981)	Survey Design Study, 78 farmers	Maryland	scale	Social Fabric (involvement in community organizations)	Detrimental
Harris and Gilbert (1982)	Macro-social Accounting, state-level data	continental U.S.	scale/ organization	Socioeconomic/Social Fabric (class structure)	Some Detrimental: large farms result in more lower class farm personnel but have positive total effects on rural income
Swanson (1982)	Macro-social Accounting, 520 communities	Pennsylvania	scale/number of farms	Social Fabric (population)	No Detrimental
Green (1985)	Macro-social Accounting, 109 counties	Missouri	scale/ organization	Socioeconomic/Social Fabric (services, population size)	No Detrimental

Study	Methodology	Region	Measures of Industrialized Farming	Community Well-Being Indicators	Results
Skees and Swanson (1988)	Macro-social Accounting, 706 counties	Southern U.S., excluding Florida, Texas	scale/ organization	Socioeconomic/Social Fabric (services)	Some Detrimental: moderate-size farms produce greater employment; large and very small farms related to higher unemployment; some detrimental impacts of large farms over time
MacCannell (1988)	Macro-social Accounting, 98 counties	Arizona, California, Florida, Texas	scale/ organization/ capital intensity	Socioeconomic/Social Fabric (population size, retail trade, local government taxation and expenditures)	Detrimental
Flora and Flora (1988)	Macro-social Accounting, 234 counties	Great Plains and West	scale	Socioeconomic/Social Fabric (retail trade, population size)	Some Detrimental: medium-sized farms relative to large farms enhance community well-being
Buttel et al. (1988)	Macro-social Accounting, 105 counties	Northeast	organization	Socioeconomic/Social Fabric (population, retail trade)	No Detrimental
van Es et al (1988)	Macro-social Accounting, 331 counties	Corn Belt	scale/ organization	Socioeconomic/Social Fabric (population size)	No Detrimental
Gilles and Dalecki (1988)	Macro-social Accounting, 346 counties	Corn Belt and Central Plains	scale/ organization	Socioeconomic	Some Detrimental: counties with greater numbers of hired laborers tend to have lower socio-economic well-being; other relationships for scale not supported

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Study	Methodology	Region	Measures of Industrialized Farming	Community Well-Being Indicators	Results
Lobao (1990)	Macro-social Accounting, 3037 counties	Continental U.S.	scale/ organization	Socioeconomic/Social Fabric (income, poverty, income inequality, teenage fertility, infant mortality)	Some Detrimental: moderate-size family related to better socioeconomic conditions. Industrialized farming related to greater income inequality and births to teenagers, and over time to greater poverty and lower family income, but not to other indicators
Lobao and Schulman (1991)	Macro-social Accounting, 2,349 rural counties	U.S. and four regions	scale/ organization	Socioeconomic (poverty)	No Detrimental: moderate-size family farms related to lower poverty, most regions, industrialized farms have little relationship to poverty in any region
Barnes and Blevins (1993)	Macro-social Accounting, 2,000 rural counties	U.S.	scale/ organization	Socioeconomic (poverty, median income)	No Detrimental

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Study	Methodology	Region	Measures of Industrialized Farming	Community Well-Being Indicators	Results
Durrenberger and Thu, (1996)	Macro-social Accounting	Iowa	Scale: farm size in acres, total county hog inventory, farms with hogs, farms with more than 1000 hogs, net agriculture sales	Socioeconomic (people living in poverty, people receiving food stamps)	Detrimental: The more large scale operations, the fewer small and moderate farms and the more people who use food stamps. Most hogs in Iowa are produced in small and moderate sized integrated operations. Since total hog operations are related to a decline in small and moderate sized operations. The more farms that produce hogs, the fewer people who use food stamps.
Otto, et al. (1998)	Regional Economic Impact Study: pork operations	Iowa	scale	Socioeconomic: economic performance	No Detrimental: larger units create more local jobs and income
Thompson and Haskins (1998)	Regional Economic Impact, pork operations	Iowa	scale	Socioeconomic: economic performance	Some Detrimental: larger units create fewer local jobs than smaller units
Seipel, et al. (1998)	Hedonic Price Analysis, one county	Missouri	concentrated animal feeding operation	Sales prices of farmland parcels with and without houses	Detrimental: reduction in property prices of $144 per hectare within 3.2 km of a CAFO
Schiffman, et al. (1998)	Quasi-experimental Design: 88 matched individuals	North Carolina	concentrated animal feeding operation	Social Fabric (social-psychological distress)	Detrimental: residents living near swine operations are more depressed due to psychological and physical effects of odors, reduced enjoyment of property

Study	Methodology	Region	Measures of Industrialized Farming	Community Well-Being Indicators	Results
Wing and Wolf, One study, (1999, paper) (2000, article)	Survey Design Study: 155 residents, three communities	North Carolina	concentrated animal feeding operation	Social Fabric (quality of life, health status)	Detrimental: residents of CAFO community report greater respiratory and gastrointestinal problems and eye irritations, lower quality of life, reduced enjoyment of property
Seipel et al. (1999)	Survey Design Study: 780 residents in four counties with pork production	Missouri	concentrated animal feeding operation	Social Fabric (attitudes toward increasing government regulation of corporate swine production)	Detrimental: majority of residents support increased regulation, strongest determinants of this position due to perceived detrimental economic, social, environ-mental impacts on community
North Central Regional Center for Rural Development (1999)	Comparative Case Study, 14 farm dependent counties, one of which recruited CAFO	Oklahoma	CAFO county compared to others	Socioeconomic: well-being, social fabric, Environment	Some Detrimental: Detrimental on social fabric and environment (e.g., greater crime), no appreciable gains in per capita income and jobs relative to non-CAFO counties; beneficial effects for a few indicators (increase in population, school enrollment, retail sales and property values)
Irwin et al. (1999)	Macro-social Accounting: 3024 counties	Continental U.S.	organization	Social Fabric (residential stability)	No Detrimental

Study	Methodology	Region	Measures of Industrialized Farming	Community Well-Being Indicators	Results
Crowley (1999)	Macro-social Accounting: 1053 counties in NC states	12 north central states	organization	Socioeconomic (poverty rate, income inequality)	Detrimental
Gomez & Zhang (2000)	Regional Economic Impact Models: (rural hog producing towns located in 76 rural cos. and 26 non-metro urban cos. with < than 50K hogs sold annually)	Illinois	CAFO/Scale	Social Fabric: Annual change in inflation-adjusted "real" retail spending	Detrimental on lower economic growth
Welsh and Lyson (2001)	Macro-social Accounting: 433 agric. dep. cos. in states with anti-corp. farming laws and in states without such laws.	Iowa, Kansas, Minnesota, Missouri, North Dakota, Oklahoma, South Dakota vs. states without anti-corp. farm laws	Scale/ Organization	Socioeconomic: percentage of families in poverty, unemploy-ment rate, farms realizing cash gains	Detrimental on agric. dep. cos. in states without anti-corp. farming laws or in states with weaker anti-corp. farming laws.
Lyson et al., (2001)	Macro-social Accounting: 433 Ag. Dep. Cos. in the U.S	Ag. Dep. Cos. in the U.S.	Scale/Organization	Social Fabric: Civically engaged middle class, participation & involvement in civic affairs, community welfare	Detrimental are mediated by presence of civically engaged middle class. Communities in agric. dep. areas in which a high percentage of persons work for them- selves or operate independent businesses have higher levels of social welfare.

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Study	Methodology	Region	Measures of Industrialized Farming	Community Well-Being Indicators	Results
Wright et al., (2001)	Case Study: Six CAFO counties – Pennington, Clearwater, Rock, Goodhue, Sterns, Morrison	Minnesota	CAFO/Scale	Social Fabric: social & community well-being – quality of life, community interaction, social capital	Some: Detrimental effects for neighbors, younger and mid-sized producers. Positive effects for those who expanded operations; No effects for those not neighbors or not expanding. Detrimental due to lack of trust in gov't. agencies and differences in shared vision of agric. & of local communities.
Foltz, et al., (2002)	Regional Economic Impact Models: 100 dairy farms in three dairy dependent communities – Athens, Chilton, and Richland	Wisconsin	Scale	Social Fabric: Share of local input purchases made locally	Detrimental: Significant negative effect for larger farm sizes (herd size) on share of input purchases made locally.
Peters, (2002)	Macro-social Accounting: All agric. dep. cos.	Iowa, Kansas & Missouri	Organization	Socio-economic: Children at risk -- % of children enrolled in free-reduced price meals, low birth rate infants,	Detrimental: Areas with lower concentrations of farm proprietorships results in increased children at risk scores. Areas with greater concentrations of industrial agriculture production results in increased children at risk scores.
Wilson et al., (2002)	Macro-social Accounting: Census blocks in rural counties with CAFOs	Mississippi	CAFOS (Swine)	Social Fabric: Whether swine CAFOs were located in high poverty/high Black census blocks	Detrimental: Swine CAFOs 2.4-3.6 times more likely to be located census block with poor African Americans.

Study	Methodology	Region	Measures of Industrialized Farming	Community Well-Being Indicators	Results
Deller, (2003)	Regional Economic Impact Models: 2249 non-metro U.S. cos.	Non-metro U.S. cos.	Scale	Socioeconomic: Growth rates in per capita income	Detrimental: Counties dominated by larger-scale agriculture experience slower growth rates in per capita income. As agric expands in terms of farm size or share of local economy, downward pressure is placed on regional growth rates.
Reisner, et al, (2004)	Survey Design Study: 22 newspapers covering 52 cos.	Illinois	CAFOs Swine	Social Fabric: Perceptions of source of controversy over swine CAFOs, of frequency of swine CAFO odors, & problems caused by CAFOs	Detrimental: Residents were far less satisfied with presence of facilities than farmers thought, reported more days with odors, were more likely to believe that CAFOs contributed to water quality problems, and report loss of value of homes near CAFOs
Crowley & Roscigno, (2004)	Macro-social Accounting: All counties in North Central States -- IA, IL, IN, KS, MI, MN,MO, NE, OH, ND, SD	North Central States	Scale/Organization	Socioeconomic: Percent of population living below poverty & inequality of income distribution among families	Detrimental: Dimensions of farm sector concentration shapes both poverty and inequality of income.

Study	Methodology	Region	Measures of Industrialized Farming	Community Well-Being Indicators	Results
Smithers, et al., (2004)	Macro-social Accounting	North Huron County, Ontario	Scale	Social Fabric: Community involvement, purchasing behavior, perception of community support by expanding, stable, and contracting farms	Detrimental: Farmers in the expansionist trajectory were constrained in their ability to participate in social activities & organizations, sought inputs at lowest cost, were less committed to sourcing locally, and saw the community in terms of what it could do for them rather what they could do for it.
Kleiner (2003)	Survey Design Studies: Three counties in MO, two characterized by swine CAFOs & one by independent hog production	Missouri	CAFOs	Social fabric: Effects of CAFOs on rural communities including economic, social and Environmental	Detrimental: Proximity to large-scale livestock facilities is associated with perceptions of CAFO impacts, especially environmental impacts.

Study	Methodology	Region	Measures of Industrialized Farming	Community Well-Being Indicators	Results
Constance and Tuinstra (2005)	Case Study Design; Three rural clusters of communities -- Normangee and Flynn Leon Co. and Midway in Madison Co.	East Texas	CAFOs (chicken broilers)	Social Fabric: Odor, water quality, health, property values, source of conflict, social effects	Detrimental: Quality of life deteriorated as it became more stressful and less neighborly. Neighbors focused on issues of odor nuisances, water pollution, health problems, property values, & community disruption. Growers minimized complaints by saying that neighbors' jealousy was the root cause of discomfort or suggested they were city folks with impractical views of rural areas.
Whittington & Warner (2006)	Case Study Design: Two communities with large-scale dairies (under 700 cows) Jackson Twp. in Wyandot Co. and Liberty Twp. in Wood Co.	Ohio	Scale	Social Fabric: Knowledge of and attitudes towards managers of risk of large scale dairies	Detrimental: Community members unable to identify managers of risk, felt hopeless to act, personal experience in agric. leads to understanding of issues, large-scale animal agric. is a cultural shift, two-way communication is essential, safety precautions by CAFO leads to greater community acceptance.

Study	Methodology	Region	Measures of Industrialized Farming	Community Well-Being Indicators	Results
Jackson-Smith & Gillespie (2005)	Survey Design Studies: Nine dairy farm dependent rural communities in seven states	Dairy dependent areas in NY, WS, MN, TX, UT, ID, & NM	Scale	Social Fabric: Relationships between farmers & neighbors; how well they know their neighbors; if they had ever had complaints about odor, flies, or noise; level of involvement in local community organizations & activities;	Some: Demographic variables are related to knowing neighbors well. When these are variables are controlled, there is little evidence that size of farm or use of hired workers was related to relationships with neighbors. Farm size is strongest predictor of likelihood that neighbors have complained about a dairy operation.
Foltz and Zueli, (2005)	Survey Design Studies: 141 dairy farmers in three dairy dependent WS towns – Athens, Chilton, and Richland	Wisconsin dairy dependent towns	Scale: Farm size measured by size of dairy herd	Social Fabric: Annual quantity of expenditures per unit for various farm inputs and supplies	No Detrimental: Very little evidence that small farms are more likely to buy locally than large farms. Purchasing patterns are commodity specific and not determined by farm size or farm-level characteristics. Presence of local marketing outlets affects decisions to purchase locally. Community attachment affects purchasing decisions when there is a choice available locally.
McMillan and Schulman (2003)	Case Study: Two CAFO counties, four focus groups (Citizens, Leaders, Producers, Activists) and anti-hog informants interviews	No. Carolina	CAFOs	Social Fabric: neighbor relations, environmental concerns, health concerns, enjoyment of property, quality of democratic participation, community cohesiveness	Detrimental: Increased community conflict and tensions between neighbors, reduced quality of life due to CAFO odors, increased worries about health concerns related to CAFO odors, and worries about environmental consequences

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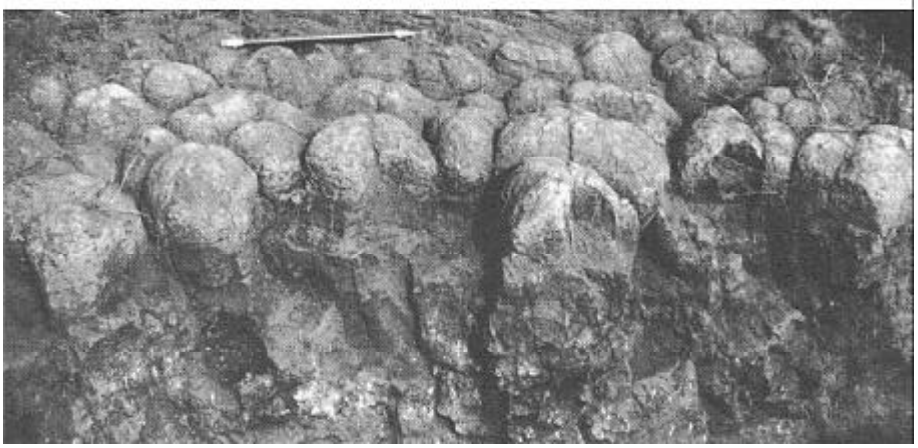
Salinity and Sodicity

IN NORTH DAKOTA SOILS



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NDSU EXTENSION SERVICE

MAY 2000

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WHAT IS SALINITY AND SODICITY?

Soil salinity and sodicity are related problems that are commom in North Dakota. Both eastern and western North Dakota have their share of saline and sodic soils. For example, 24 and 17 percent of the soils in Grand Forks County and Slope County, respectively, are affected by salinity or sodicity (Soil Survey Staff, 1987). Further, soil survey data from 34 of the 52 coun-ties in North Dakota show approximately 1,900,000 acres affected by sodium and 700,000 acres affected by salinity. These problem soils compose about 9 percent of the 34-county area.

Salinity and sodicity are often seen as bare ground with whitish crust that has a scabby appearance. Scab-land, salt-land, alkali, alkaline, and sour-ground are a few of the local terms that describe these areas. Some of these terms are misleading, because they imply problems that are not necessarily related to salinity or sodicity. For instance, alkaline and sour-ground actually refer to soil acidity. Alkaline soils are basic (pH > 7) and sour-ground is acid (pH < 7). Many soils in North Dako-ta are basic in pH but are not affec-ted by salinity or sodicity. On the other hand few soils in North Dako-ta have high enough acidity to reduce crop yields. Acid soils are occasionally found in in in the extreme south-central and southwestern parts of North Dakota. They have formed in acid sediments of the Fox Hills formation and are generally used as rangeland.

We are concerned with salinity and sodicity levels high enough to affect production. Clear definitions of these two problems are necessary for proper identification and management.

SOLUBLE SALTS AND SALINE SOILS

Soils with high amounts of soluble salts are called saline soils. They often exhibit a whitish surface crust when dry. The solubility of calcium sulfate or gypsum ($CaSO_4$) is used as the standard for comparing solubilities of salts (Table 1). Salts more soluble than gypsum are considered to be soluble and cause salinity. Examples are sodium sulfate or Glauber's salt (Na_2SO_4) and sodium chloride, or table-salt (NaCl). Salts less soluble than gypsum are considered insoluble and do not cause salinity. Calcium carbonate ($CaCO_3$) or lime is an example of an insoluble salt com-monly found in North Dakota soils.

Salts found in North Dakota soils are of three types: sulfates (SO_4); carbonates (CO_3); and chlorides (Cl). Most saline soils in North Dakota are composed of sulfate salts (Keller et al., 1984). However, the northern Red River Valley has extensive areas of saline soils that have high amounts of chloride salts. Soils with high amounts of carbonates of sodium occur rarely, and are usually associ-ated with coarse textured materials.

SODIUM AND SODIC SOILS

Soils high in sodium (sodic soils) may present physical restrictions to plant growth. Sodium (Na^+) is a positively charged component, or cation, of many salts. Sodium prob-lems are due to its behavior when attached to clay particles. If 15 per-cent or more of the clay adsorption sites are occupied by sodium (sodium-clay), poor physical condition of the soil often restricts root growth and makes tillage difficult.

The forces that hold clay particles together are greatly weakened when sodium-clay and water come into contact. In this condition clay par-ticles are easily detached from larger aggregates, or dispersed (Figure 1). When dried, however, sodium-clay particles settle out in dense layers

Table 1. Composition and solubility of some common evaporite minerals (salts).

Mineral	Composition	Solubility	Chemical Name
		(moles/liter)	
Calcite (lime)	$CaCO_3$	0.00014	Calcium Carbonate
Gypsum	$CaSO_4 \cdot 2H_2O$	0.0154	Calcium Sulfate
----	$CaCl_2 \cdot 6H_2O$	7.38	Calcium Chloride
Magnesite	$MgCO_3$	0.001	Magnesium Carbonate
Hexahydrite	$MgSO_4 \cdot 6H_2O$	4.15	Magnesium Sulfate
Epsomite	$MgSO_4 \cdot 7H_2O$	3.07	Magnesium Sulfate
Bischofite	$MgCl_2 \cdot 6H_2O$	5.84	Magnesium Chloride
(Washing soda)	$Na_2CO_3 \cdot 10H_2O$	2.77	Sodium Carbonate
(Baking soda)	$NaHCO_3$	1.22	Sodium Bicarbonate
Mirabilite	$Na_2SO_4 \cdot 10H_2O$	1.96	Sodium Sulfate
Thenardite	$NaSO_4$	3.45	Sodium Sulfate
Halite	NaCl	6.15	Sodium Chloride

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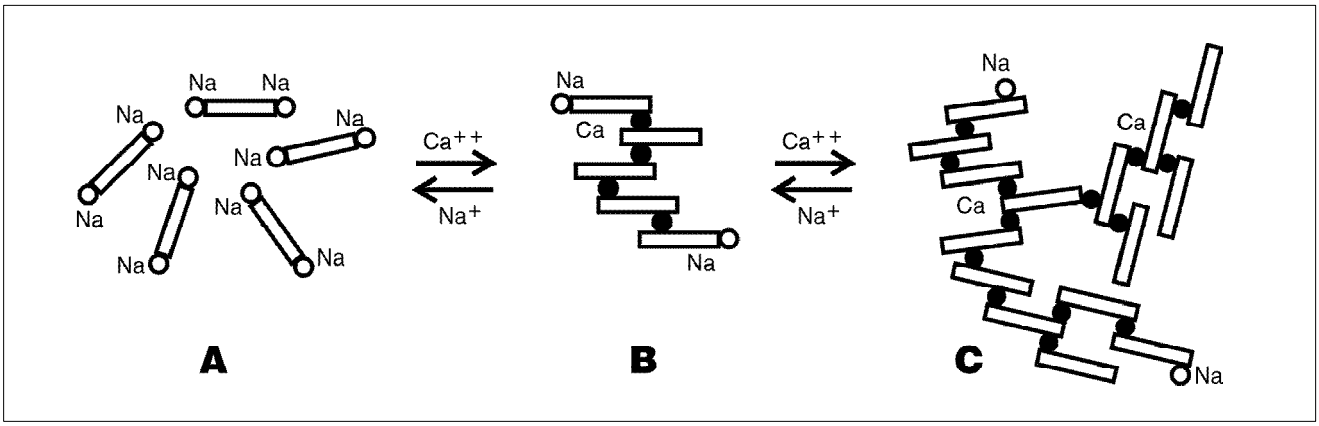

Figure 1. When the exchange complex has greater than 15 % sodium (Na) the clay is dispersed (A) resulting in poor soil structure. When calcium (Ca) replaces enough sodium the clay is flocculated (B); stable soil aggregates are formed that create good soil structure (C). (After Rengasamy, P., et al., 1984.)

that are impenetrable to plant roots and seedling emergence.

SODIUM ADSORPTION RATIO AND SODICITY

Sodicity can be defined in terms of the sodium adsorption ratio (SAR). The SAR is a calculation from laboratory measurements made on a water sample or water extracted from a soil. It is based on the concentration of sodium (Na^+), calcium (Ca^{2+}), and magnesium (Mg^{2+}) in the sample. There is a relationship between the amount of each ion in solution and its relative amount adsorbed on the clay; however, the relationship is not direct. Na^+, Ca^{2+}, and Mg^{2+} are adsorbed to the clay with unequal strength. Na^+ is weakly held compared to Ca^{2+} and Mg^{2+}. The SAR computation (equ. 1) accomodates the difference in adsorption strengths.

The U.S. Salinity Laboratory Staff (1954) determined a SAR of 13 from a saturated soil extract is comparable to 15 percent of the adsorption sites being occupied by Na^+. Because of the difficulty and laboratory expense of analyzing the amount of actual Na^+, Ca^{2+}, and Mg^{2+} adsorbed on the clay, the SAR determination has become the standard measure for sodicity.

To demonstrate the SAR calculation and the importance of the ratio of ions as opposed to the total concentration of sodium, let's look at the following two examples:

Example 1

$[Na^+]$ = 25 meq/l

$[Ca^{2+}]$ = 60 meq/l

$[Mg^{2+}]$ = 30 meq/l

$SAR = 25 / \{(60 + 30) / 2\}^{1/2} = 25 / (45)^{1/2} = 25 / 6.7 = 3.7$

Example 2

$[Na^+]$ = 25 meq/l

$[Ca^{2+}]$ = 4 meq/l

$[Mg^{2+}]$ = 2 meq/l

$SAR = 25 / \{(4 + 2) / 2\}^{1/2} = 25 / (3)^{1/2} = 25 / 1.7 = 14.7$

$$SAR = [Na^+] / \{([Ca^{2+}] + [Mg^{2+}]) / 2\}^{1/2} \quad [1]$$

where: [ ] = concentration in milliequivalents/liter (meq./l)

The extracts from these two samples contain the same amount of sodium. However, because the amount of calcium and magnesium is different, only example 2 is from a soil that would have a sodicity problem. This points out the fact that some soils may have high amounts of sodium but are not sodic. The high amounts of calcium and magnesium counter-balance the sodium.

U.S. SALINITY LABORATORY CLASSIFICATION

The U.S. Salinity Laboratory Staff (1954) established a system for classifying saline and sodic soils in three broad categories.

Saline Soils

Saline soils are defined as having an electrical conductivity (EC) greater than 4 deciSiemens/meter (dS/m) and sodium adsorption ratio (SAR) of less than 13 in their saturation extract.

Saline-Sodic Soils

Saline-sodic soils have an EC greater than 4 dS/m and a SAR greater than 13 in their saturation extract.

Sodic Soils

Sodic soils have an EC of less than 4 dS/m and a SAR greater than 13 in their saturation extract.

NATURAL RESOURCES CONSERVATION SERVICE, USDA CLASSIFICATION

Saline and sodic soils are recognized and shown on soils maps made by the USDA Natural Resources Conservation Service (NRCS). Soils shown on maps are classified using a system that depends on both observable and laboratory properties. Although the NRCS has incorporated much of the U. S. Salinity Laboratory system into its classification scheme (Table 2), it relies heavily upon soil characteristics that can be observed in the field as opposed to laboratory determinations. Field observations of soil properties such as structure and salt crystals are used regularly, but laboratory data is determined on relatively few samples.

Table 2. NRCS classification of saline and sodic soils.
(Soils Survey Staff, 1993)

Saline Soils				
class	Non-saline	Very slightly to moderately saline	Strongly saline	
criteria	^S.E. EC < 2 dS/m	S.E. EC = 2–16 dS/m	S.E. EC > 16 dS/m	
Natric (Sodic) Soils				
class	glossic subgroups	typic or udic subgroups	leptic subgroups	aquoll suborder
subsoil criteria	*SAR > 13 weak claypan	*SAR > 13 strong claypan	*SAR > 13 claypan high salinity	*SAR > 13 claypan poorly drained

*Most natric soils meet this chemical requirement; however, some soils are also considered natric with SAR < 13 under certain conditions.
^Saturated extract (S.E.) electrical conductivity from the topsoil or the average of the soil profile, whichever is greater.

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EFFECTS OF SALINITY AND SODICITY

OSMOTIC EFFECT

High salinity (high EC) causes dehydration of plant cells. Reduced plant growth and often death is the result. Dissolved salts cause plant cell dehydration by decreasing the osmotic potential of soil water. Water flows from high potential (low salts) to a low potential (high salt) (Figure 2). When a soil solution has a lower osmotic potential than plant cells, plants cannot extract water from the soil. The effect on a plant is similar to drought stress.

Crop Yield and Soil EC

Yields of many crops are reduced noticeably when the soil extract EC reaches 4 dS/m (U.S. Salinity Laboratory Staff, 1954). Yields will decline proportionately as EC levels (salinity) increase above 4 dS/m. Some crops, such as sugar beets, are quite tolerant to EC between 4 and 8 dS/m. At an EC of 16 dS/m the growth and yields of nearly all crops are severely affected. The effect of salts on plant growth is the basis for the NRCS soil salinity categories (Table 2).

Crop Symptoms of Salinity

Crop symptoms from high salinity are generally the same as symptoms of moisture stress from dry conditions. Plants are stunted with cupped leaves to reduce water loss through the stomata. Initially some plants take on a deep blue-green color from excessive accumulation of wax as an attempt to reduce water loss. Eventually leaves become brown and brit-tle on the tips and margins as stress continues.

Salinity in the field is usually characterized by broad transitions that run gradually from high to low salinity. The pattern of crop response can also be a gradual change from normal plants to no growth at all. However, in some cultivated species, the plant is most sensitive to damage during germination or early growth stages.

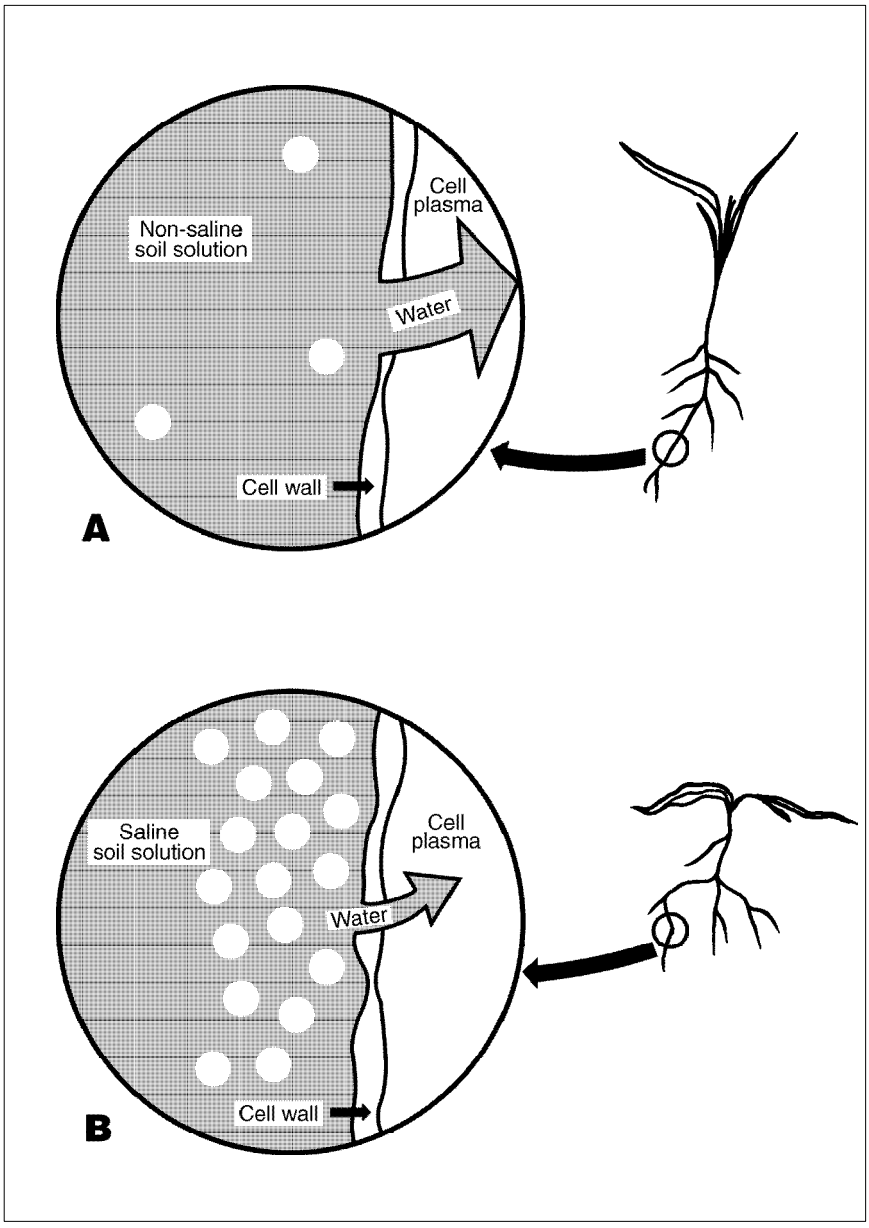

Figure 2. Plants can extract water easily from soils with high total water (A). This is a condition encountered in moist non-saline soils. Dry conditions and dissolved salts decrease the total soil water potential, thus retarding or stopping plant uptake of water (B).

This may result in a pattern of sharp change from normal plants to bare ground where seeds failed to germinate. Often plants are able to flourish during later growth stages at salinity levels that would not have allowed germination or growth during earlier stages.

Plant Indicators

Plants can be used as indicators of saline and sodic conditions, because tolerance varies with plant species. All plants attempt to adjust to osmotic moisture stress caused by salinity. The osmotic adjustment requires energy that would otherwise

be used for growth and production. As a result, when plants attempt to adjust, growth and yields are reduced.

HALOPHYTIC (SALT LOVING) PLANTS

Plants tolerant to salinity are known as halophytes. Technically, plants that can survive in soils that have greater than 0.5 percent (by weight) soluble salts are considered to be halophytes. Some halophytes have developed sophisticated systems of taking in saline water, extracting the salts, and then excreting the salts. Halophytes common to our area that can be used as indicators of high salinity include salt grass (*Distichlis spicata*), alkali grass (*Puccinellia nuttalliana*), cordgrass (*Spartina gracilis*), spearscale (*Atriplex subspicata*), saltwort (*Salicornia rubra*), and sea blite (*Suaeda depressa*). Other less reliable indicator plants are wild barley (*Hordeum jubatum*) and kochia (*Kochia scoparia*). Although they often occur on saline soils, they are also regularly found in non-saline environments.

VEGETATION PATTERNS AND SALINITY

A study of vegetation and saline seeps in northwestern North Dakota showed a consistent pattern of salinity and vegetation (Figure 3). Wild barley was the dominant plant along seep margins with low salinity. Kochia was the dominant plant on the interior of the seep with high salinity. This is a common pattern seen on salt affected soils in North Dakota. Salt grass was the dominant vegetation on sodic soils with high levels of surface salinity on pastureland in central North Dakota (Seelig et al., 1990).

SPECIFIC ION EFFECT – PLANT TOXICITIES AND DEFICIENCIES

Saline soils may also have specific ion effects on plant growth. Higher than normal concentrations of some ions can hinder or block nutrient uptake and certain physiological processes. Few instances of specific ion effects have been reported in North Dakota saline soils. Of the three common cations (Ca^{2+}, Mg^{2+}, and Na^{+}) responsible for saline soils in North Dakota, no toxic ion effects have been reported. Toxic ion effects related to sodium (Na^{+}) have been observed in some plants in other parts of the U.S.

Under rare circumstances, boron has been reported to cause toxic ion effects. Boron toxicity is a potential problem when concentrations in the saturation extract are greater than 1 milligram/liter (mg/l). This level of boron may occur in some saline soils in the northern Red River Valley. However, almost without exception, the osmotic effect plays the most important role in limiting plant growth and yield on saline soils in North Dakota.

Neither cloride (Cl^{-}) nor sulfate (SO_4^{2-}) have been shown to cause plant toxicities in saline soils. Plant toxicities from excessive bicarbonate (HCO_3^{-}) have been reported in other areas; however, few saline soils in North Dakota have high levels of soluble HCO_3^{-}. Many soils in North Dakota do have large accumulations of calcium carbonate ($CaCO_3$) that is quite insoluble. Both phosphorus and micronutrient deficiencies are pos-sible in high lime soils. It may be necessary to increase additions of phosphorus and micronutrients to overcome these problems.

HIGH pH AND SODIC SOILS

High pH (7.8 to 8.5) generally occurs in sodic soils. Extremely high pH (greater than 8.5) occurs in sodic soils when soda ($NaHCO_3$) or sodium carbonate (Na_2CO_3) is present. Sodium-clay, bicarbonate (HCO_3^{-}), and carbonate (CO_3^{2-}) react with water to form hydroxyl (OH^{-}) ions that cause high pH [equations 2, 3,

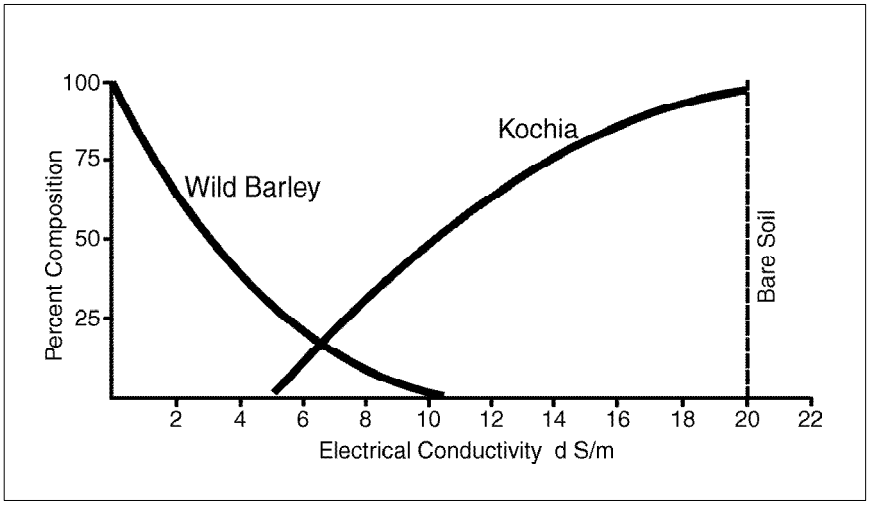

Figure 3. The dominance of plant species in saline seeps is shown by weight % versus EC. (After Worcester and Seelig, 1976.)

and 4]. Soda and sodium carbonate are relatively soluble; therefore, high amounts of soluble carbonate is available to react with water to produce OH^-. For this reason, sodic soils with soda and sodium carbonate are likely to have a pH greater than 8.5.

$$\text{Na-clay} + H_2O \rightarrow \text{H-clay} + Na^+ + OH^- \quad [2]$$

$$HCO_3^- + H_2O \rightarrow H_2CO_3 + OH^- \quad [3]$$

$$CO_3^{2-} + H_2O \rightarrow HCO_3^- + OH^- \quad [4]$$

Extremely high pHs (greater than 8.5) are generally not encountered in sodic soils of North Dakota, because soda and sodium carbonate are rarely present. When soluble carbonate salts are found, the soils generally have coarse textures. When the soil pH is greater than 9.5 live plant roots are vulnerable to deterioration.

Nutrient Availability and High pH

High pH affects plant growth by reducing availability of some plant nutrients. Phosphates are most available to the plant at a pH between 6 and 7. Micronutrients such as iron, manganese, zinc, copper, and cobalt are all much less available at a pH greater than 7.

RESTRICTIVE SUBSOILS AND CRUSTING PROBLEMS

Slowly Permeable Claypans

Soil structure in sodic soils is poor and permeability is low. Permeability is the ease of air and water movement through soils. Good permeability allows water and gasses (oxygen and carbon dioxide) to circulate eas-ily to and from plant roots. This is needed for good plant growth.

A dense layer of clay occurs at or near surface of sodic soils. This natural layer, often called a claypan, is a barrier to roots. Most roots are restricted to the topsoil above the claypan, because movement of water, nutrients, and gases is too slow in the claypan. A dry claypan can be hard enough to physically restrict root penetration. The overall effect on plant growth is one of stress similar to that caused by extremely dry or saline conditions.

UNDULATING OR SPOTTY PLANT GROWTH ON SODIC SOILS

Both claypan depth and root restriction vary considerably within a few feet. Depth to saline material is also highly variable. This variation in soil properties creates extreme differences in plant available water, plant rooting depth, and osmotic potential. Crop response to these extremes is an undulating or spotty pattern of growth that is characteristic of sodic soils.

Soil Crusting

Surface crusting is a common problem with cultivated sodic soils. Plowing mixes sodium-clay from the claypan with topsoil or surface material. Surface material with high amounts of sodium-clay is highly erodible, because it has low aggregate stability and is easily detached by rain drop impact. When dry, the surface forms a hard crust that is a barrier to seedling emergence.

Salinity and Metal Corrosion

Saline soils are corrosive with respect to certain materials commonly used for construction. When metal is placed in the soil, it is exposed to electrochemical reactions that change its physical properties; iron rusting is a good example. Soils high in soluble salts enhance electrochemical corrosion. Electrochemical corrosion can be reduced by coating the metal with organic materials, such as tar or pitch. Metal pipelines are often protected by passing an electrical current through them (cathodic protection) to replace the electrons lost to chemical reactions.

Sulfates and Concrete Corrosion

Soil solutions high in sulfate (SO_4^{2-}) are corrosive to concrete structures. The sulfate solution penetrates concrete and reacts with calcium in the cement to form $CaSO_4$ that precipitates within the pores. This reaction destroys the integrity of concrete in two ways. The cementing agent is changed to a non-cementing material ($CaSO_4$) and large crystals of $CaSO_4$ are formed within voids, causing physical disruption of the concrete.

Much of the damage caused by sulfate solutions can be avoided by using sulfate-resistant concrete. Type I (standard Portland cement) has little resistance to the corrosive action of sulfatic solutions. Type II has medium resistance to sulfates, and Type V has high resistance.

LOCATION AND OCCURRENCE OF SALINE AND SODIC SOILS

NATURALLY OCCURING SALINE SOILS

Saline and sodic soils generally occur on landscape positions where groundwater discharges by evapotranspiration from a shallow water table. In these soils, the water table will flucuate seasonally, but generally will be within 6 feet of the surface for a large part of the growing season. Because soil texture affects the flow of water through soil, it also affects the depth of the water table necessary to cause salinization. Coarse textured soils allow upward capillary movement of water to occur only over a short distance. Therefore a higher water table is required for salinization of coarse textured soils, such as sands or sandy loams, compared to finer textured soils, such as loams or clays. However, because the large pores in coarse textured soils offer much less resistance to water flow compared to the smaller pores in fine textured soils, salinization can occur much quicker in coarse textured soils.

As groundwater is discharged through the soil surface, dissolved salts precipitate and accumulate. Accumulations generally occur near or at the surface of the soil; however, they may occur anywhere in the soil where water is extracted by plant roots.

Discharge as evapotranspiration is only one part of the water balance at a given landscape position. Seasonal rain causes downward percolation of water that leaches salts from the upper parts of the soil.

Salinization occurs in those soils that favor discharge (evapotranspiration loss) over leaching. Not all soils with a water balance favoring discharge are saline. Salinization also depends on groundwater quality. If the groundwater has a only a small amount of soluble salts, salinization is very slow or may not occur at all.

Many combinations of groundwater discharge, water quality, and landscape position exist in North Dakota. As a result, a variety of different types of both saline and sodic soils have developed. Saline and sodic soils with similar properties can often be located by geographical area.

NORTHERN RED RIVER VALLEY

Saline soils in the Grand Forks County area (Figure 4) are the result of regional discharge of artesian groundwater from the Dakota Sandstone formation (Benz et al., 1961). The chemistry of these saline soils is uncommon for the northern Great Plains because of the accumulation of chloride salts. Sulfate salts generally dominate saline soils in North Dakota.

GLACIATED AREAS NORTH AND EAST OF THE MISSOURI RIVER

In glaciated areas, saline soils are associated with the edges of closed depressions or broad swales where discharge of groundwater can occur. Saline soils with most salts at the surface are associated with very shallow water tables. Saline soils with lower water tables may actually have the highest levels of salinity deeper in the soil (Seelig et al., 1987). Leached soils with little salt are often found in depressions within areas of saline soils.

WEST AND SOUTH OF THE MISSOURI RIVER

In nonglaciated areas of North Dakota the water table generally ap-proaches the soil surface on low slopes that gently grade to natural drainageways (streams or rivers). Surface water flow and storage is controlled by the system of interconnected drainageways. This is different than the hydrology in glaciated areas that is controlled by a system of closed depressions (potholes).

Some saline and sodic soils west of the Missouri River are not necessarily related to groundwater discharge. These soils inherited salts from sedimentary material (marine shales, sandstones, etc.) in which they formed. They may be found on landscape positions that have very deep water tables.

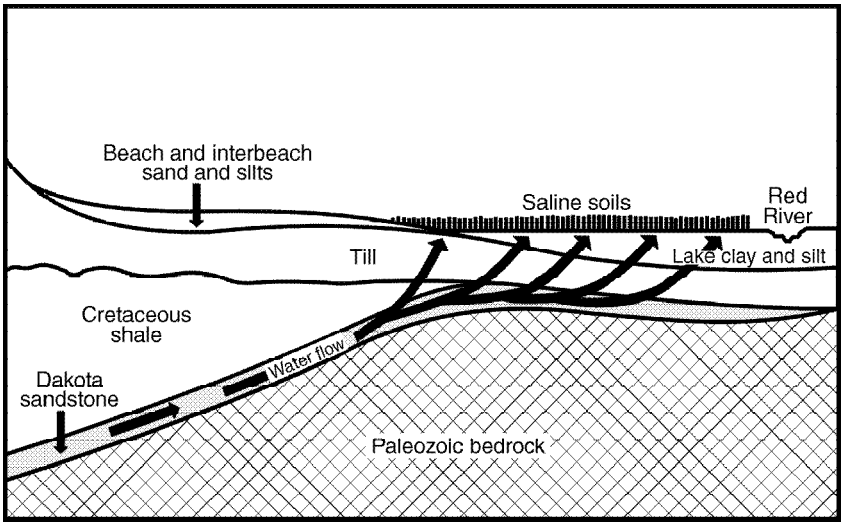

Figure 4. The geologic cross section of Grand Forks County shows the relationship between the Dakota sandstone and the overlying glacial deposits. (After Benz et al., 1961.)

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Naturally Occurring Sodic Soils

Groundwater discharge may lead to the development of sodic soils as sodium salts are concentrated in the soil. During evaporation, sodium salts separate from calcium salts because of different solubilities. The soluble sodium salts concentrate high in the soil profile. As the soil solution becomes more concentrated with sodium, the percentage of sodium on the exchange complex also increases. Eventually there is enough exchangeable sodium to cause dispersion of clay and organic matter.

In the unglaciated parts of western North Dakota, sodium affected soils are quite common and the saline soils are generally also affected by sodium (Figure 5). Sodic soils are also found in the glaciated parts of North Dakota; however, saline soils unaffected by sodium are far more prevalent (Figure 5).

SECONDARY SALINIZATION

Secondary salinization is the term used to describe soils salinized as a consequence of human activities. In North Dakota there are five types of secondary salinization:

1) saline seeps;
2) salinization along road ditches;
3) salinization along lagoon margins;
4) salinization from irrigation;
5) salinization from wetland drainage.

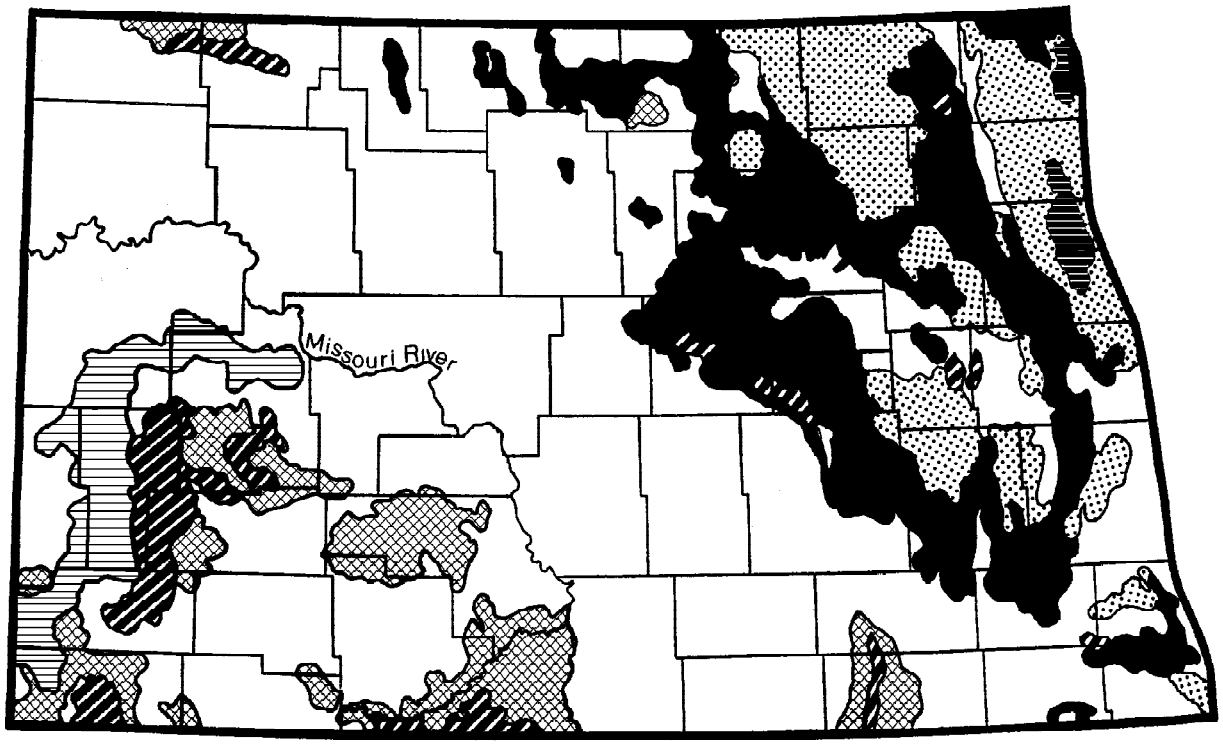

Figure 5. The distribution of saline and sodic soils in North Dakota.
(Adapted by D. D. Patterson, C. Fanning, and B. D. Seelig from the General Soil Map of North Dakota, Soil Survey Staff, 1961).

Saline Seep Formation

Most saline seeps have developed recently (post settlement) in the northern Great Plains. In the last 20 years, investigators have concluded that saline seep formation is closely related to the practice of summer fallow for moisture conservation. Researchers have determined that the soil in the rooting zone under summer fallow reaches its storage capacity long before the end of the fallow period. Deep percolation of additional moisture beyond the rooting zone is likely to occur in this situation.

Rate and amount of downward percolation is controlled by soil tex-ture. Average pore diameter in coarse textured soils is larger than in fine textured soils. Faster rates of water flow and less water storage are directly related to larger pore diameters. As a result, deep percolation is more likely to occur in coarse textured soils. In some places relatively coarse textured soils overlay impermeable material of finer tex-ture. Under these circumstances, deep percolation leads to lateral water flow along the surface of the impermeable material (Deutsch, 1977; Seelig, 1978). If the contact between the two different materials approaches the soil surface along a hill slope, as often happens, the laterally moving water will create a wet spot that eventually becomes saline as the water is evaporated (Figure 6).

LOCATION AND TYPES OF SALINE SEEPS

Saline seeps are most common south and west of the Missouri River and on the Missouri Coteau. Areas most prone to saline seeps have sloping stratified geologic materials. They have been classified into six general groups according to the underlying materials (Figure 7). Doering and Sandoval (1976) estimated that 100,000 acres of western North Dakota cropland are affected by saline seeps. Although this is a small percentage of the total acreage of saline and sodic soils, saline seeps are a serious problem. They are responsible for deterioration of land that was once productive. Efforts to avoid wet saline spots on tracts of cultivated land increases costs of production, especially with today's farm machinery.

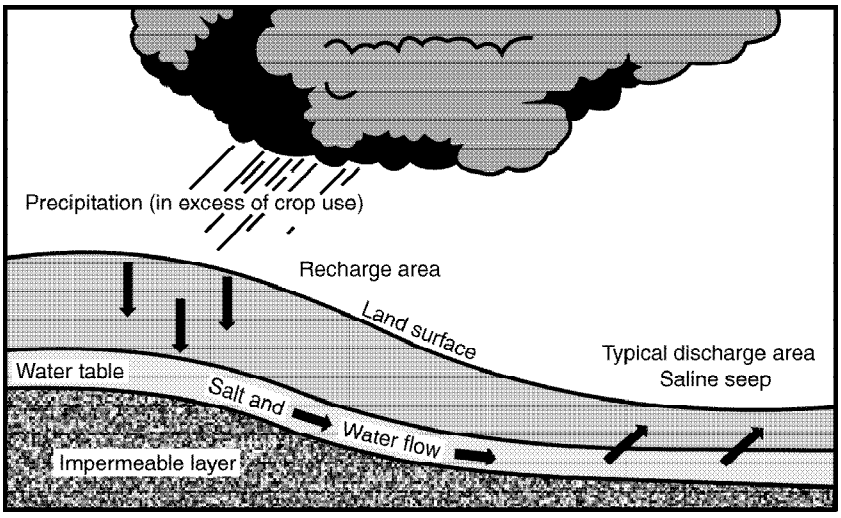

Figure 6. A generalized diagram of a saline seep.

Road Ditch and Lagoon Margin Salinity

Saline soils that have developed around lagoons and drainage ditches are also controlled by the water source. Salinity along drainage ditches is due to lateral movement of water from the ditches to adjacent fields (Figure 8). Extremely flat areas, such as the Red River Valley, are particularly susceptible to this type of secondary salinization. The low grade on most drainage ditches allows water to stand for long periods of time.

Salinity and Irrigation

Under irrigated agriculture, secondary salinization may occur if water is not properly managed. All water from sources other than precipitation contains some dissolved salt. As irrigation water is used by crops, salts are precipitated in the soil. This process may eventually lead to saline conditions that plants cannot tolerate (Figure 9).

The rate at which salinization proceeds depends on the amount and quality of water added. Water with high amounts of dissolved salts will cause rapid salinization. Poorly designed and improperly managed irrigation systems have been responsible for salinization of thousands of acres in the U.S. Before an irrigation system is developed, soil and water compatibility should always be determined by a qualified soil scientist.

Wetland Drainage and Salinity

Drainage of certain types of wetlands in the northern Great Plains may also lead to soil salinization in the wetland interior. Class 3 and 4 wetlands are noted for their non-saline soils but are often surrounded by saline soils on the wetland edge. Hydrologically, many of these wetlands are called flowthrough

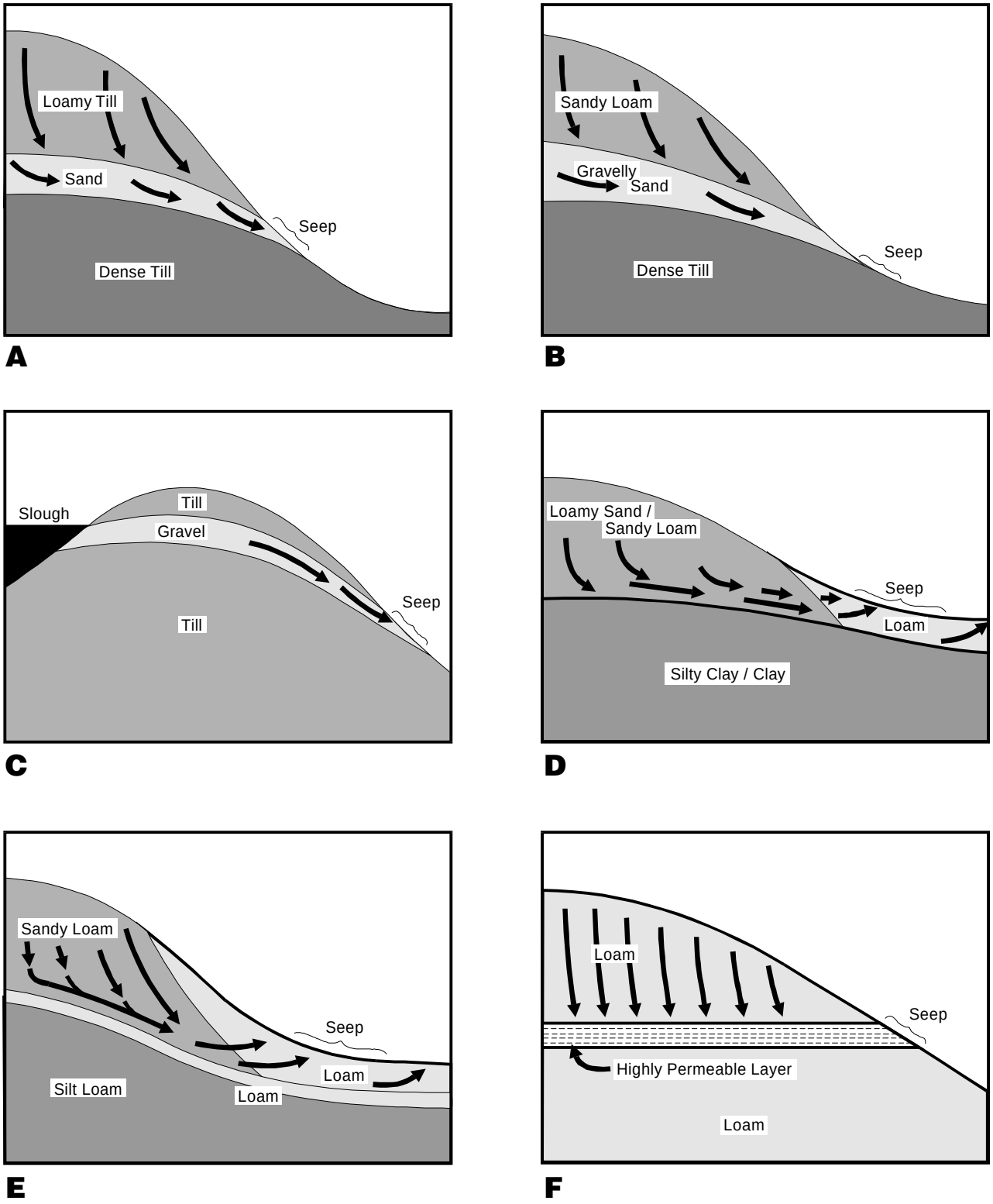

Figure 7. Six classes of saline seeps found in North Dakota. (After Worcester et al., 1975.)

wetlands, because water flows laterally through the wetland soils and does not allow accumulation of salts (Figure 10). When the hydrology of a flowthrough wetland is disrupted by drainage, evaporative discharge can occur through the drained wetland soil. Under the undrained condition, evaporative discharge is confined to the wetland edge; soils may be extremely saline at this location. When the area of evaporative discharge is expanded to the wetland interior, saline conditions may be expanded to the entire wetland (Figure 10). The final result of flowthrough wetland drainage is often no gain in crop production, but a loss of flood protection, groundwater recharge, and wildlife habitat.

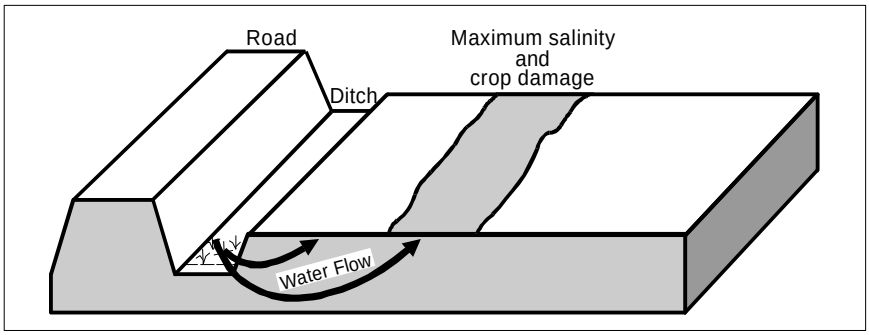

Figure 8. The location of maximum salinity and crop damage along a drainage ditch in the Red River Valley. (After Skarie et al., 1986.)

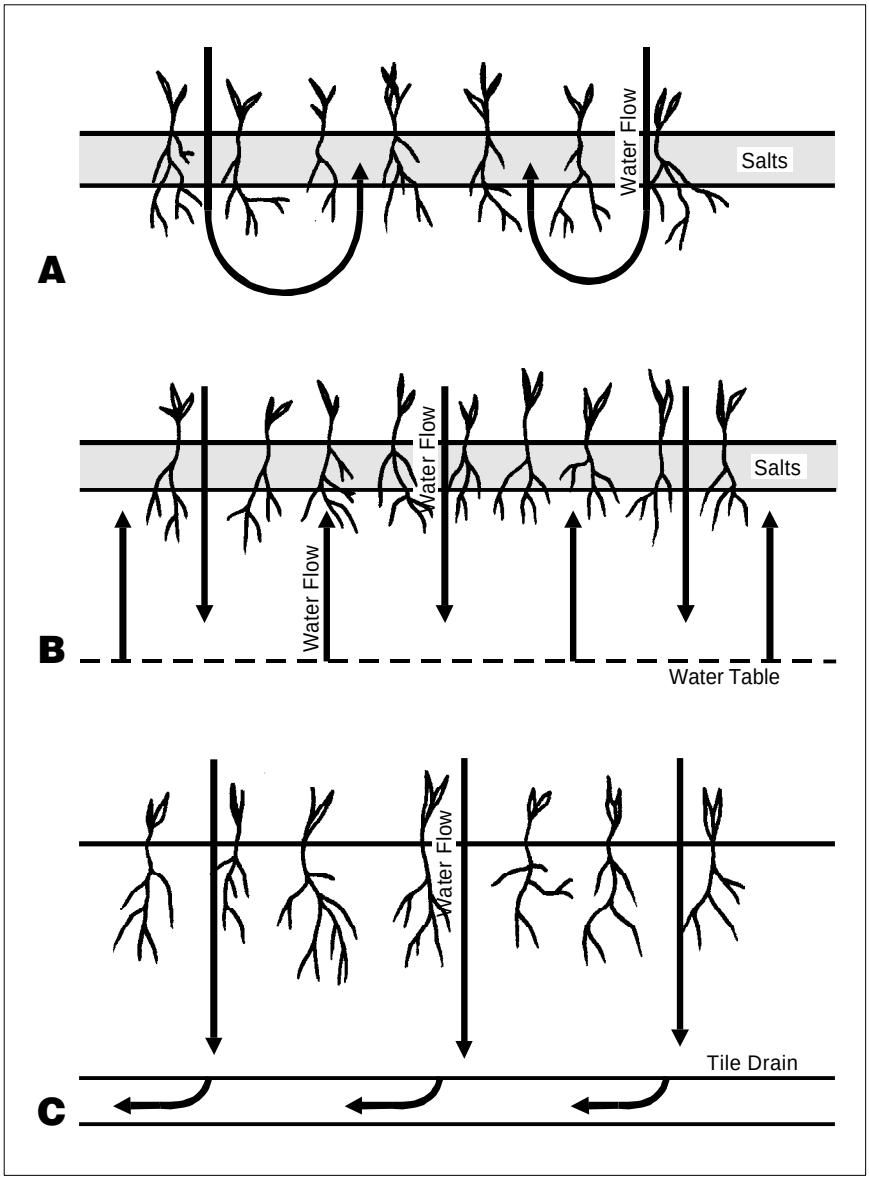

Figure 9. Secondary salinization by irrigation (A) and (B) may be prevented, if the field is adequately drained (C).

SALINE AND SODIC SOIL MANAGEMENT

Management stategies for saline and sodic soils must be designed with processes of salt accumulation in mind. Different management techniques may be necessary for soils with different salt compositions and water regimes.

Most saline and sodic soils are the result of evaporation from a shallow water table. Before effective methods of management can be designed for a specific parcel of land, the water table level must be determined. As long as a shallow water table exists, potential for salinization and sodification exists.

SALINE SOIL MANAGEMENT

The type of ions in the soil solution does not influence the osmotic potential to any large degree; it is the total of all ionic species that controls the osmotic potential. From a practical point of view, management of saline soils with different salt compositions is essentially the same.

Plant Tolerance to Salinity

Salt tolerant plant species should be selected on the basis of salt concentrations found in saline areas. Drought resistant plants such as grasses and small grains are generally more tolerant to salinity than row crops, trees, shrubs, and vegetables (U.S. Salinity Laboratory Staff, 1954). If an accurate estimate of field salinity is known, crop tolerance information can be used to determine the economic feasibility of growing certain crops.

Crop tolerance to salinity has been tested for some of the major crops in North Dakota (Figure 11). It is noteworthy that sunflower is more resistant to salinity than experience from other production areas would indicate.

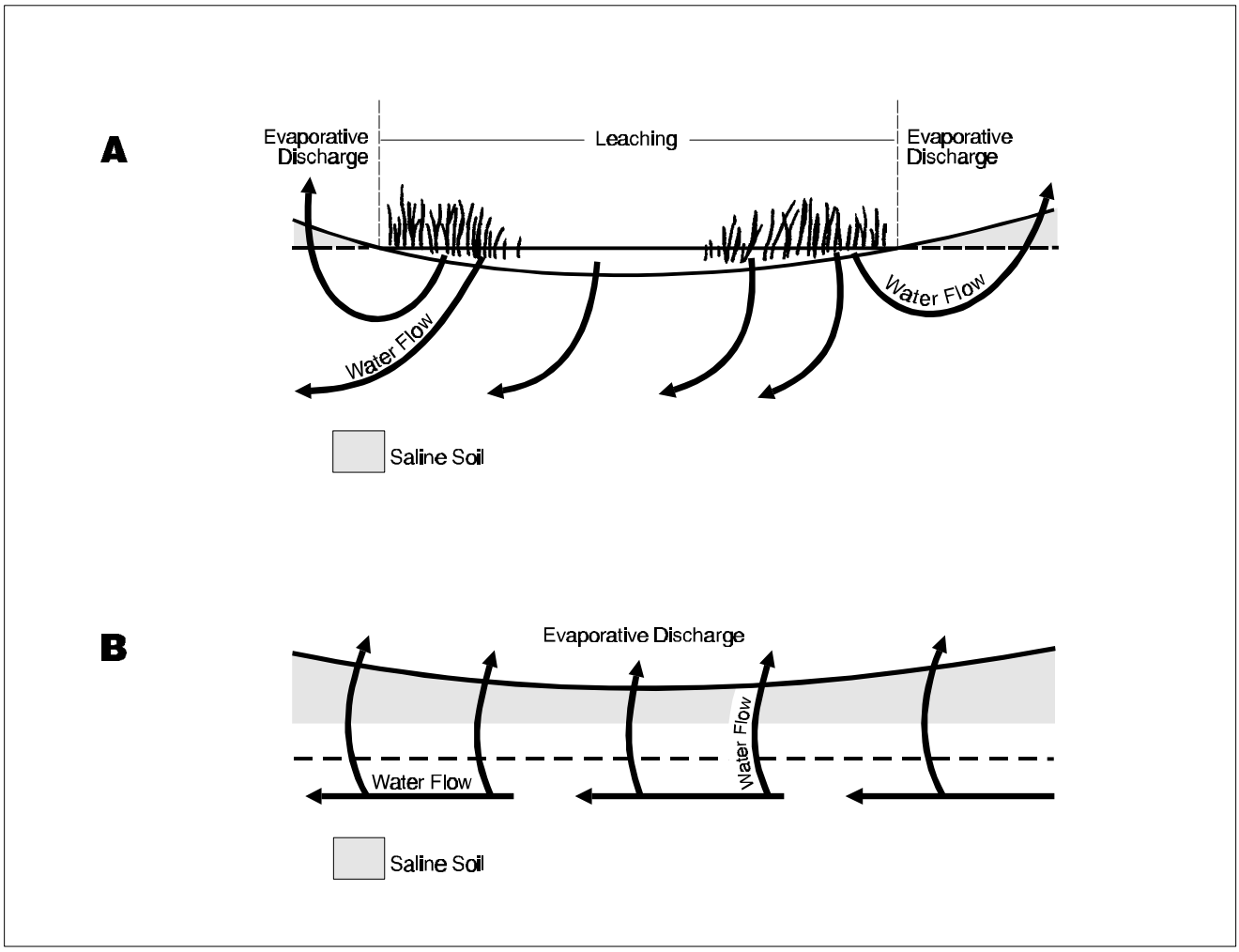

Figure 10. Salinity is confined to the edges of flowthrough wetlands (A), unless the wetlands are drained, and the area of evaporative discharge is expanded to the wetland basin (B).

Many cultivated crops are most susceptible to salinity during germination and early growth stages. If planting coincides with periods shortly after salts have been flushed from the surface, plant germination and seedling survival is more likely to be successful.

Reduction of Evaporative Discharge

Control of salinity must include management practices that reduce evaporative discharge. Subsurface drainage is an effective means of lowering the water table; however, it may not be economically feasible. Evaporative discharge is also affected by the condition of the soil surface and the plants growing on it. Surface mulches can be used to reduce evapotranspiration and salt accumulation.

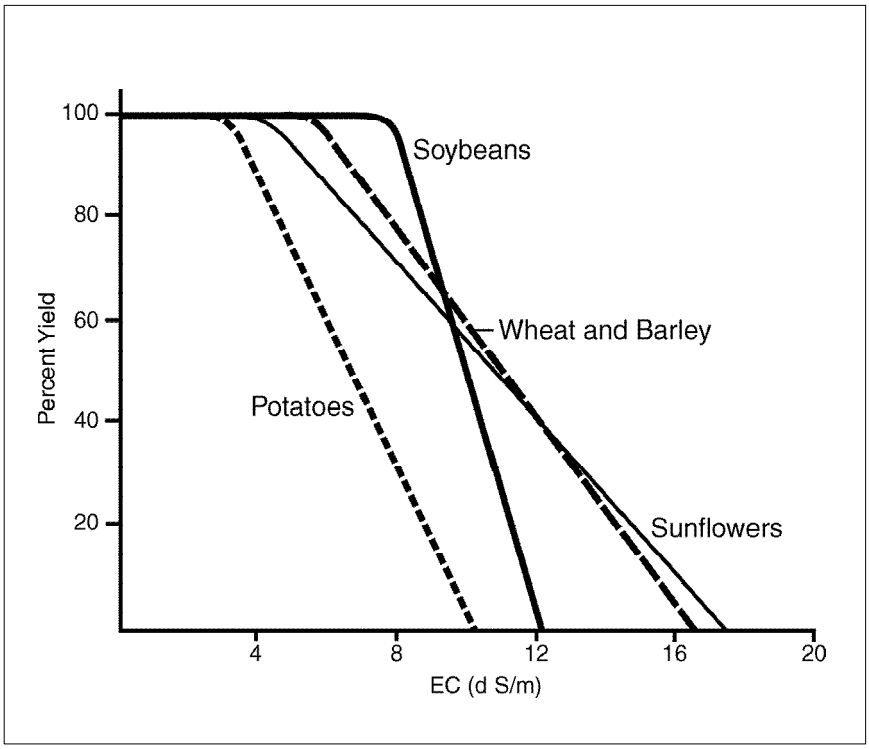

Figure 11. Thresholds of yield reduction due to salinity for some of the major crops in North Dakota. Salinity was expressed as the electrical conductivity (EC) of the saturated soil extract from the plow layer (0 to 6 inch depth). (After Maianu, 1983; 1984; and unpublished data; Maianu and Lukach, 1985; Nelson, unpublished data.)

SODIC SOIL MANAGEMENT

Soils affected by sodium must be managed similarly to saline soils with respect to drainage. Management for these soils includes drought tolerant plant species. Chemical amendments and physical disruption of the claypan may help to reduce the restrictive nature of these soils.

Calcium Amendments for Sodic Soils

Sodic soils may be improved by replacing adsorbed sodium with calcium. A number of amendments have been used with limited success over the years (U.S. Salinity Laboratory Staff, 1954). Amendments that release high amounts of calcium to the soil solution are the most effective. Unfortunately very soluble amendments, such as calcium chloride ($CaCl_2$), are cost prohibitive. Gypsum ($CaSO_4$) is an amendment less effective than calcium chloride but popular in many areas because of cost. Gypsum, however, is often ineffective on sodic soils in North Dakota, because they already have high amounts of gypsum in them. For those sodic soils in North Dakota that do not have gypsum in the upper part of the claypan, $CaSO_4$ may be an effective amendment. Soil inspection and analysis by a qualified soil specialist before calcium amendments are applied to fields with sodic soils is recommended.

Deep Plowing and Sodic Soil Improvement

Deep plowing has improved some sodic soils in western North Dakota (Sandoval, 1978). Deep plowing not only disrupts the restrictive claypan, but may also mix $CaSO_4$ from deeper soil layers into the claypan.

Caution should be taken not to plow too deep or too shallow. Plowing too deep may bring excessive amounts of soluble salts to the surface, creating a salinity problem. Plowing too shallow will not disrupt the lower part of the claypan and will not reach gypsum accumulations below it. The effectiveness of the deep plowing technique depends on the location of the water table and the presence of native gypsum in the soil.

Soil improvement through deep plowing is not expected to be sustained on a sodic soil that has a shallow water table, because sodium salts are continually introduced to the soil through evaporative discharge. If the claypan already has high amounts of

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gypsum, mixing of gypsum from deeper substrata will have no effect on replacement of adsorbed sodium. Consultation with a qualified soil specialist is recommended before deep-plowing is attempted to improve fields with sodic soils.

SALINE-SODIC SOIL MANAGEMENT

Saline-sodic soils have unique problems with respect to management, because they have both high salinity and sodicity. Some saline-sodic soils have well aggregated structure, although high amounts of sodium are present. The SAR ranged from 18 to 30 and EC ranged from 10 to 20 dS/m in a typical saline-sodic soil from northeastern North Dakota. High salinity counteracts the dispersive effect of sodium. Attempts to leach the salts will likely result in a puddled soil, because the counteractive effect against dispersion is lost as the salts are removed.

MANAGEMENT OF SOILS AFFECTED BY SECONDARY SALINIZATION

Saline Seeps

RECHARGE AREA MANAGEMENT AND SALINE SEEP CONTROL

Saline soil improvement often includes managing the water table. In the case of saline seeps, the water table may be controlled by reducing local groundwater recharge. Eliminating summer fallow in upland recharge positions is generally the most effi-cient method of controlling the water table in a saline seep. Compared to native vegetation, cropping systems may not use moisture efficiently, particularly when summer fallow is included in the rotation. The result is high water tables that contribute to evaporative discharge and salinization of farmland. Where feasible, reduced summer fallow, continuous cropping, and inclusion of hay or pasture in long term rotations should reduce groundwater recharge in areas prone to saline seeps. Deep-rooted crops such as alfalfa have been shown to effectively withdraw moisture from recharge areas and reduce discharge from saline seeps downslope (Brun and Worcester, 1974; 1975).

INTERCEPTION MANAGEMENT AND SALINE SEEP CONTROL

Other management practices focus on interception of lateral flow with tile drains or bands of deep rooted crops. These methods have been successful; however, they have serious disadvantages. Interception of saline water with tile drains can be costly, and the problem of saline water disposal is created. Interception of lateral water with deep rooted crops may be short lived if salts build up in the root zone. Interception methods fail to deal with the source of the problem, recharge from locations farther upslope.

Road Ditch and Lagoon Margin Management for Salinity

Lateral movement of water to soils adjacent to road ditches can be reduced by preventing water from standing in the drainage ditches. Ditches should be designed and maintained to move water rapidly and minimize standing water. Lagoons should be designed to prevent leakage that causes salinization of adjacent soils.

Irrigation Management to Prevent Secondary Salinization

LEACHING AND DRAINAGE

When subsurface drainage is adequate, salt accumulation in irrigated soils can be avoided by applying more water than is needed by the crop. Excess water dissolves salts and percolates beyond the root zone (Figure 9).

The amount of water needed to adequately leach the salts (leaching requirement) is determined by the quality of the irrigation water. Poor quality water (high salinity) dictates a larger leaching requirement. Proper subsurface drainage is absolutely necessary to prevent shallow water tables from developing below irrigated soils. A shallow water table under an irrigated soil defeats the application of leaching water, because leached salts are moved back into the rooting zone by capillary action (Figure 9).

FIELD LEVELLING

Secondary salinization can occur from uneven distribution of irrigation water due to irregular topography. Microdepressions act as points of focused recharge; salts are leached from the recharge locations (Figure

12). Adjacent microknolls, however, act as points of focused evaporative discharge; salts accumulate and may cause salinity problems at the discharge locations (Figure 12). Levelling irrigated fields allows more even water distribution and avoids concentration of water and salts at specific places in the field (Figure 12).

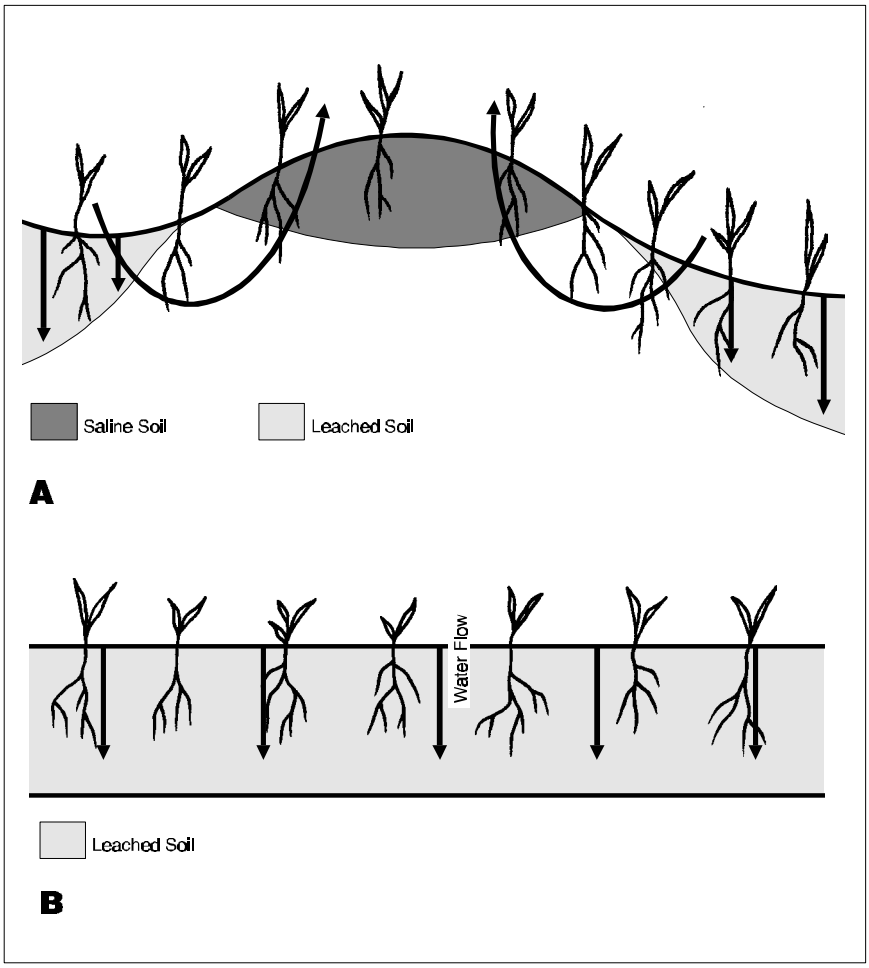

Figure 12. Secondary salinization in irrigated fields at points of evaporative discharge (A) may be eliminated by even distribution of irrigation water after field levelling (B).

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EB 57

001824

3M-11-91, 1M-12-97, 1M-6-00

North Dakota Department of Health

Environmental Section

Division of Water Quality

Attention: Karl Rockeman, P.E.

Additional Public Hearing Testimony Regarding the Rolling Green Family Farms Re LLP submitted from The Concerned Citizens of Buffalo

Dear Mr. Rockeman,

The Concerned Citizens of Buffalo hereby request that the Permit Applicant be rejected due to being incomplete. The Permit Application lacks calculations and disclosure of expected mortality rates of all groups of the hog population planned to be present at the facility. These expected rates, along with the expectation of stillbirth hog quantities, and afterbirth volume have not been disclosed nor have the proposed procedures for composting, calculations of total volume of carcass/carrion/animal material to be composed, and the actual verification of necessary compost bin area and volume necessary to safely and effectively compost the carrion. Without these calculations and "right sizing" of the compost bins, and without stated proposed procedures and processes, the composting process itself will become one of the most dangerous exposures of pathogen spread from flies/insects, scavengers and predators. The biological waste fluids will spill from the bin area and contaminate the site, the runoff areas, and subsequently the adjacent farm lands, with potentially lethal pathogens. As stated during the verbal presentation by yourself at the actual hearing, "…an incomplete permit application is one of the grounds for rejection…" Your follow-up and rejection of the permit is expected.

Thank you for clarifying those points in the hearing.

Alan D. Dostert, on behalf of

The Concerns Citizens of Buffalo

CC: (via email)

Derrick Braaten

Liane Stout

March 18, 2016

North Dakota Department of Health
Division of Water Quality
918 Divide Avenue, 4th Floor
Bismarck, ND 58501-1047

Attention: Karl Rockeman, Director

This addendum is submitted on behalf of the Concerned Citizens of Buffalo regarding the Rolling Green Family Farms illegal permit application.

"We demand that the nutrient application setbacks match those that have been submitted and filed at the North Dakota Department of Health by Howes Township on February 26, 2016."

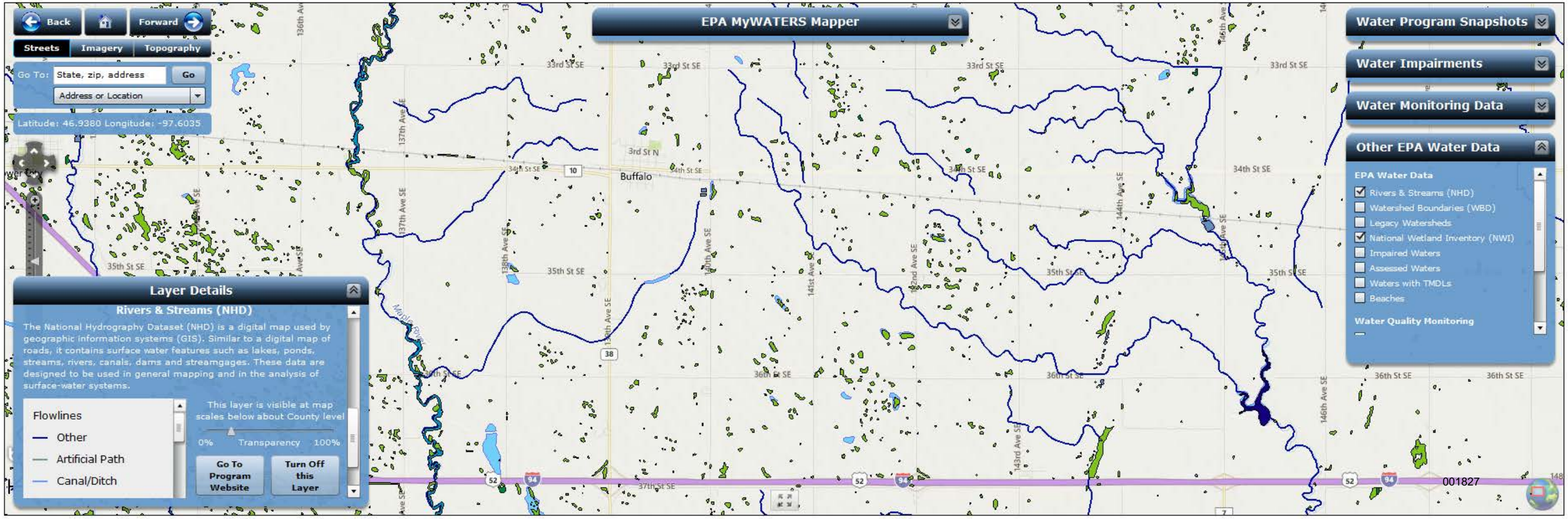
Please include this statement as part of testimony.

Liane Stout, on behalf of
The Concerned Citizens of Buffalo

cc: via email
Derrick Braaten

My WATERS Mapper

MyWATERS Mapper dynamically displays snapshots of EPA Office of Water program data. This version of MyWATERS Mapper depicts the status of NPDES permits for each State; summary information from the Clean Watershed Needs Survey; and water quality assessments. Future versions will include other Office of Water Program Snapshots. MyWATERS Mapper also contains water-related geographic themes such as 12-digit watersheds, the national stream network known as the National Hydrography Dataset, and other water-related map layers. MyWATERS Mapper enables you to create customized maps at national and local scales.



CAFO REVIEW FOR Rolling Green Family Farms RE LLP

March 17, 2016
Buffalo, ND

NORTH DAKOTA
DEPARTMENT of HEALTH

- State Animal Feeding Operations (AFOs)
  - NDCC 61-28-04
  - NDAC 33-16-03.1
    - ND Livestock Program Design Manual
  - NDAC 23-25 – Air Pollution Control

Rules and Regulations

Water Quality

- Review and approve design for manure management systems
- Ensure that surface and groundwater are protected according to established rules

Air Quality

- Nuisance standards for
  - Odors
  - Hydrogen Sulfide (H_2S)
- Air emission permits
  - Typically apply to larger industrial facilities

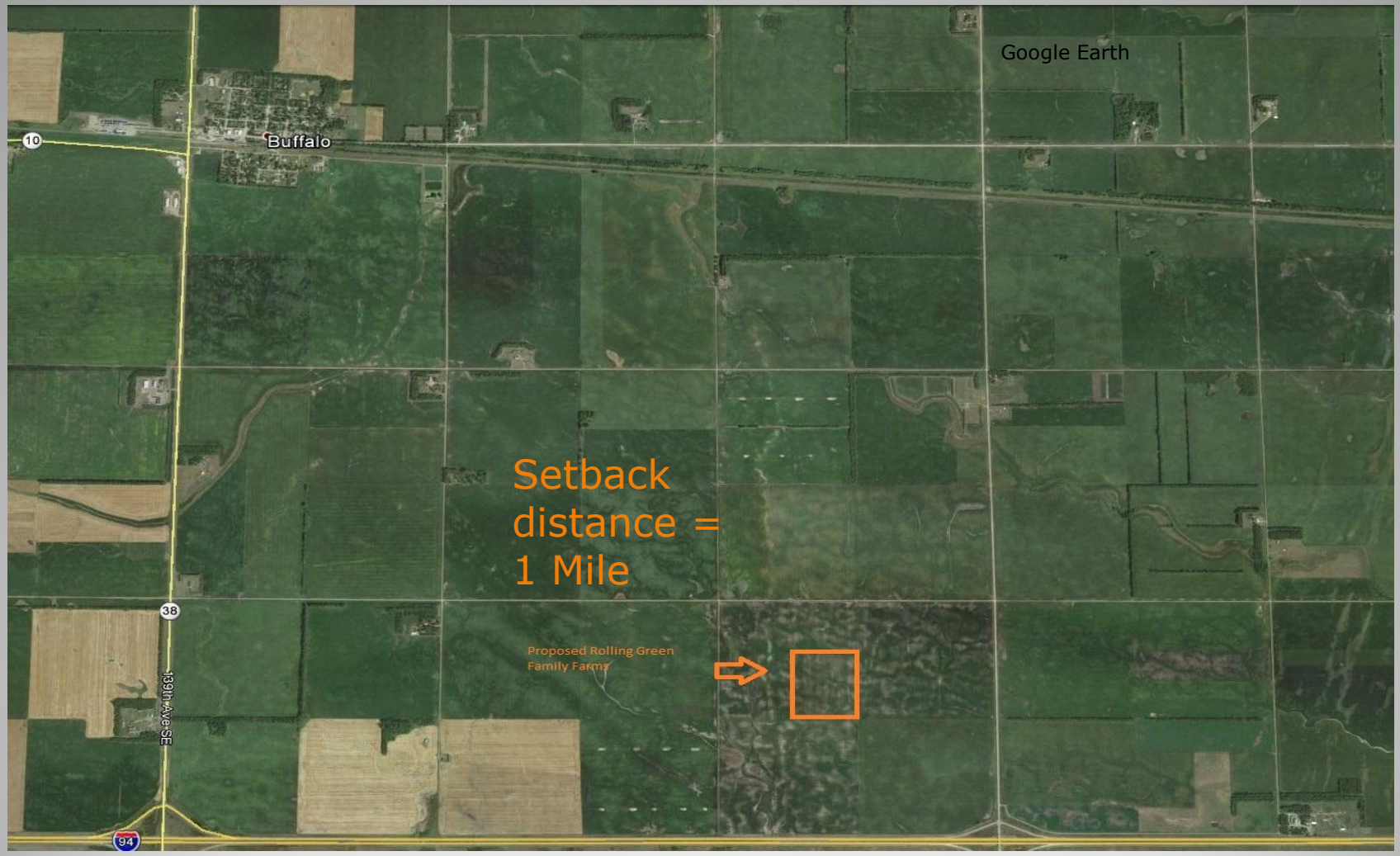
Other requirements

- Other local, state and federal requirements may apply, but are not part of the permitting process
- Land use, economic or social impacts are not part of the permitting process

- Application received: September 8, 2015
- Location: SE ¼ of the NW ¼ of Section 4, Township (Howes) 139 N, Range 54 W in Cass County
- 800 Nursery pigs
- 1,600 Finishing pigs
- 1,344 Farrowing sows
- 5,312 Gestation sows

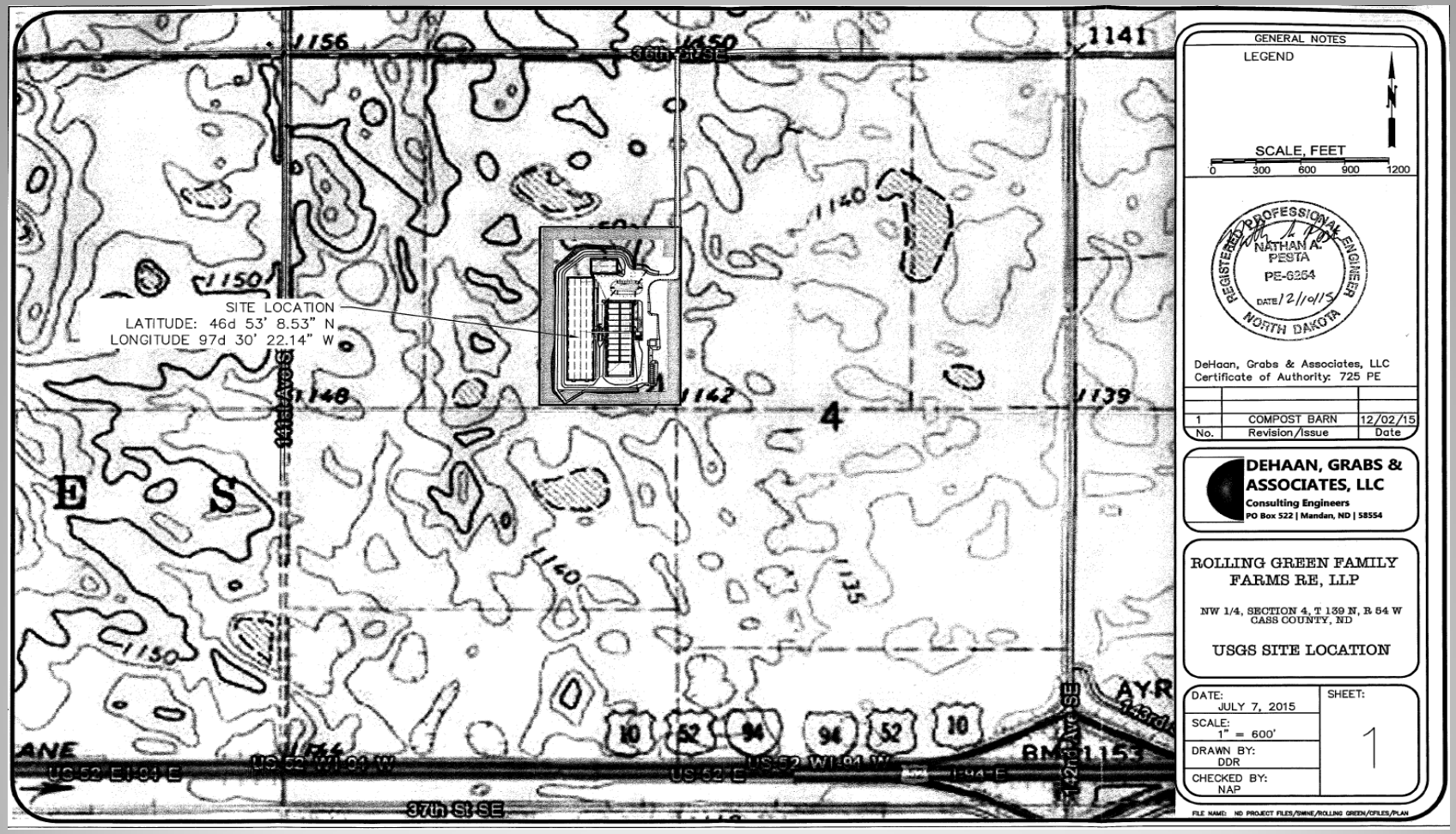
Rolling Green Family Farms LLP

NORTH DAKOTA
DEPARTMENT of HEALTH



Proposed Location - Overview

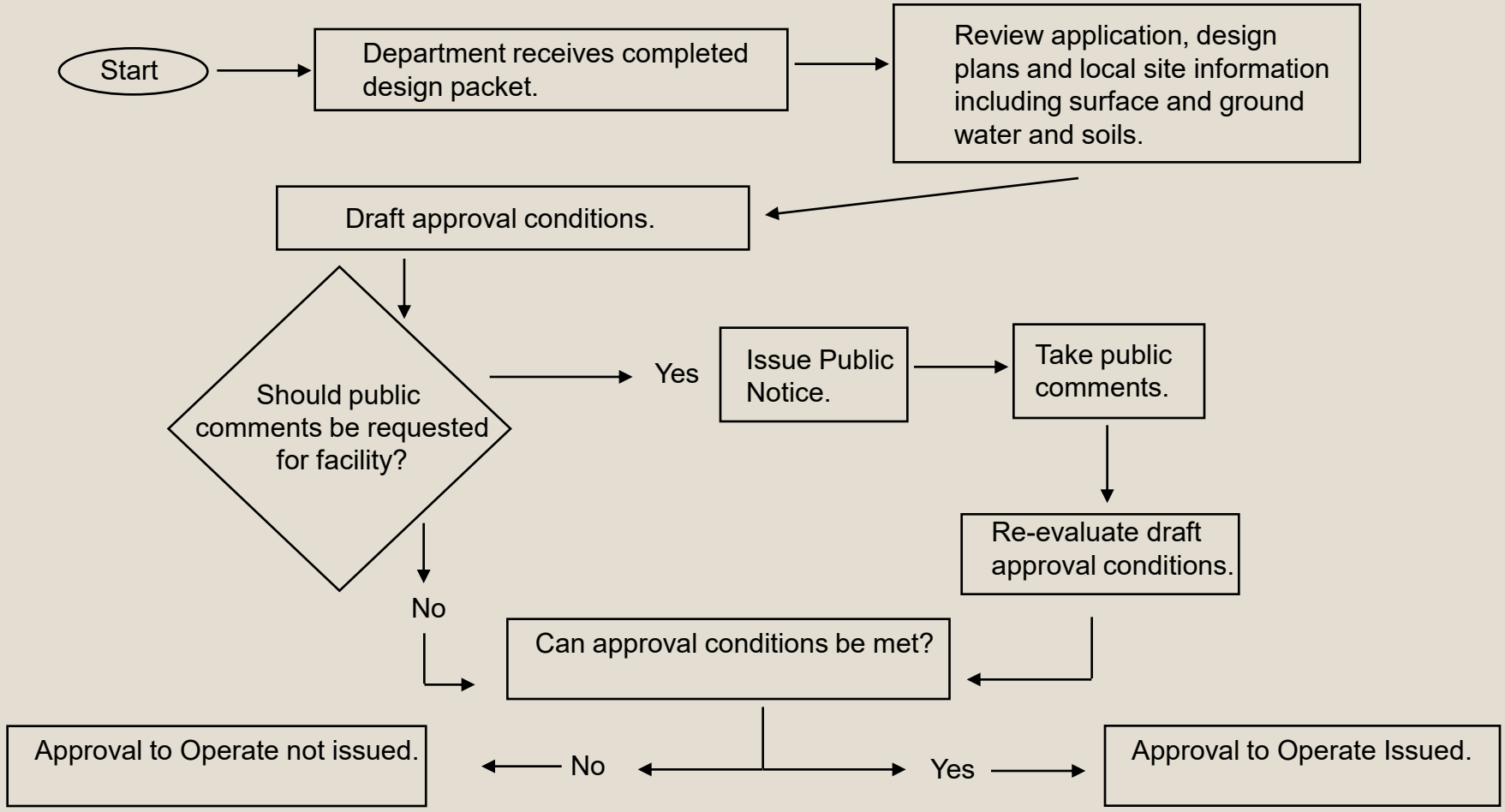
NORTH DAKOTA
DEPARTMENT of HEALTH



Proposed Location

NORTH DAKOTA
DEPARTMENT of HEALTH

Application process



001836

- NDAC 33-16-03.1-13
- Minimum 30 days to submit comments
  - Comment period may be extended
- Who gets notified:
  - County Newspaper
  - Local Post Office
  - Mailing list
  - E-mail notification if signed up on Dept of Health site (Approx 400).
- Public comment period for this site has been 80 days

Public Participation

- Manure will be stored underneath the barns in concrete pits
- Manure will not come into contact with precipitation
- No discharge of manure into waters of the state

Surface water protection- site

Manure storage Volumes

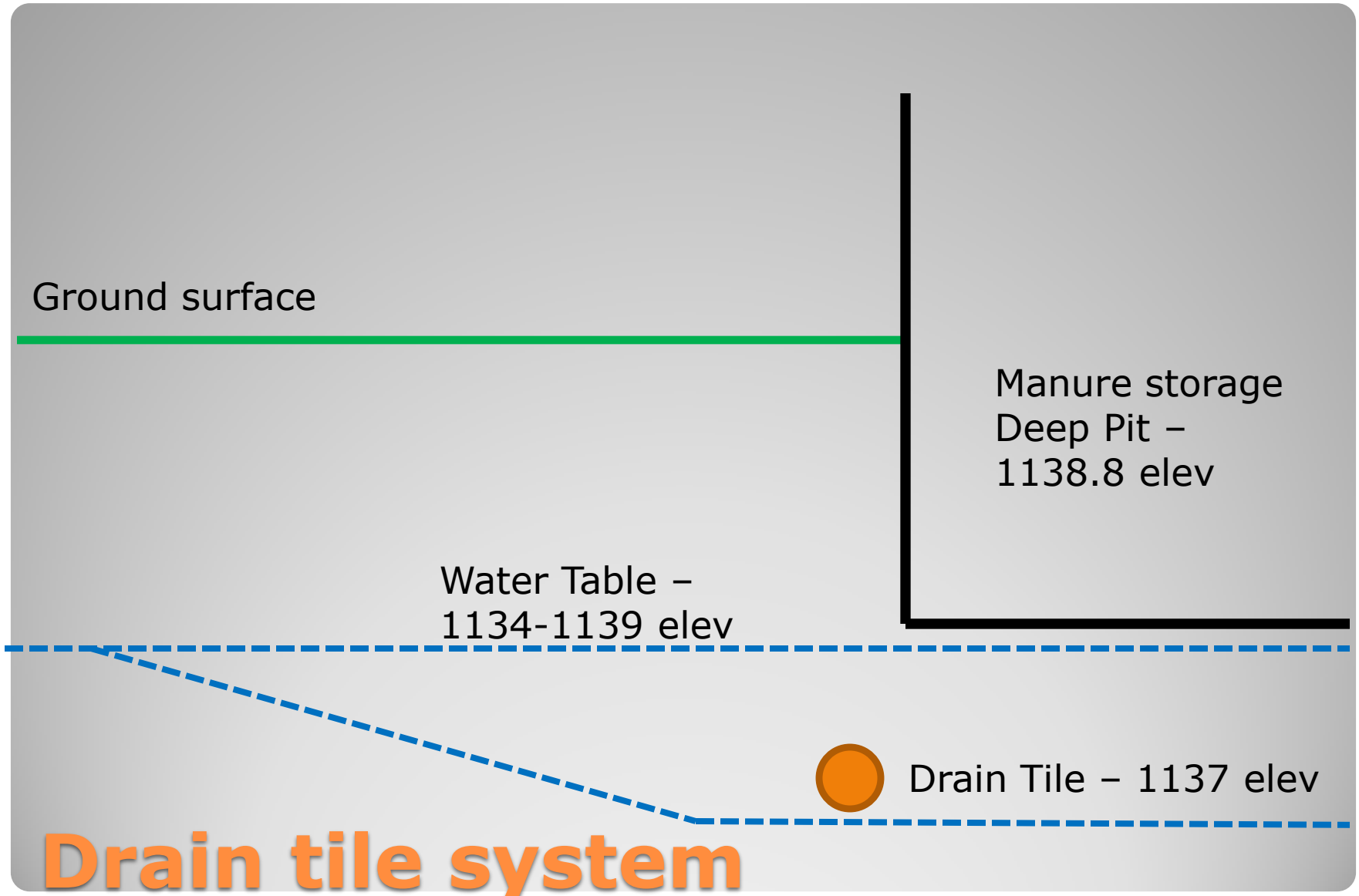
- Total manure storage:
  - 1,368,391 cu ft or 10.24 Mgal
- Required manure storage (270) days:
  - 854,081 cu ft or 6.39 Mgal
- About 432 days of storage available

- Most wells deeper than 50 ft
  - One bored well at 29ft
- Localized perched water table at a relative elevation of 1134ft-1139ft
- Bottom of manure storage at 1138.8ft
- Use of drain tile to lower water table

Groundwater Protection

Well Locations (Listed with Water Commission)

NORTH DAKOTA
DEPARTMENT of HEALTH



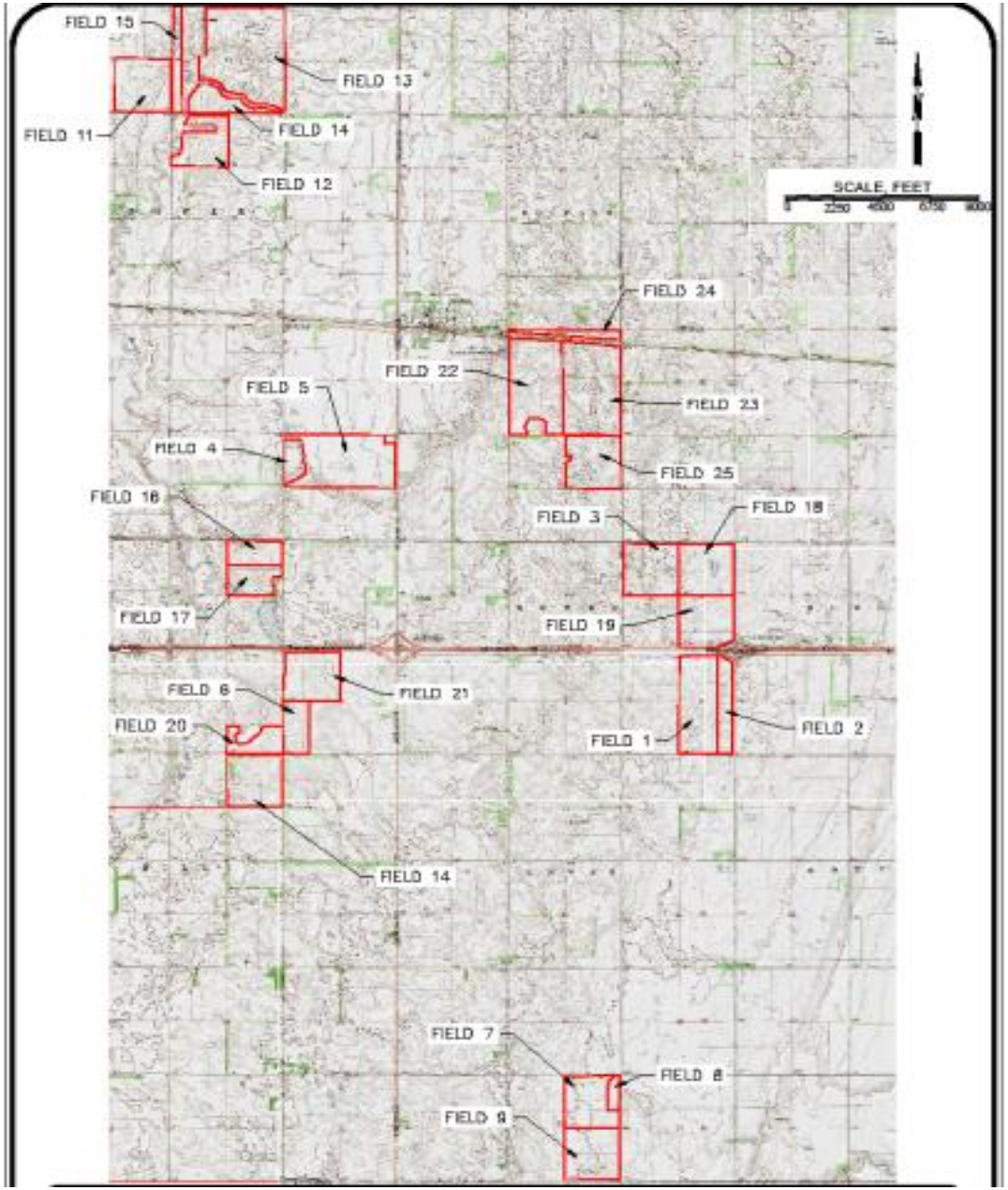
Drain tile system

Land Application

- Manure must not impact waters of the state, or cause excess odors.
  - Manure must be applied in a manner to protect surface and ground water.
  - 100ft buffer area around surface water.
  - Manure must be applied in a manner to minimize odors.
  - Manure must be applied in a manner that which nutrients will be utilized as fertilizer.
  - Manure will be injected into the soil

Field locations for Manure Application

NORTH DAKOTA
DEPARTMENT of HEALTH



NORTH DAKOTA
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NORTH DAKOTA
DEPARTMENT of HEALTH
001846

NORTH DAKOTA
DEPARTMENT of HEALTH

001847

Nutrients

- N produced: 284,256 lb/year
- N available:225,131 lb/year
- P produced: 218,562 lb/year
- P available: 174,850 lb/year
- Annual soil and manure sampling

Cropland

- Crops grown: Corn, soybeans, edible beans

- Acres available:3,312 acres
- 67.9 lbs N per acre
- 52.8 lbs P per acre (as P_2O_5)

- Nuisance standards
  - Based on annoyance to public or neighbors
  - Readings taken on complaint basis

- Ambient standards
  - Based on health effects
  - Higher than Nuisance standards

Air Quality Regulations

Nuisance Laws

- Apply to everyone
- Odor readings taken on a complaint basis
- Location where odor readings are taken based on
  - Applicable setback distances (1 mile)
  - Who was established first
- Prohibit odors 7 Odor Concentration Units (O.C.U) or higher, as measured with scentometer

Oversight

- For large CAFO's:
  - Inspections are done Annually
  - Records are reviewed
  - Manure application is reviewed
- Department follows up on all complaints of AFOs/CAFOs.
- Samples are collected when appropriate.
  - Soil
  - Water
  - Air
- Enforcement actions if needed

NORTH DAKOTA
DEPARTMENT of HEALTH

- By county (total):
  - Bottineau – 6,000
  - Bowman – 6,750
  - Dickey – 3,840
  - Grand Forks – 12,800 two facilities
  - Nelson – 6,400
  - Ramsey – 6,000
  - Ransom – 8,200 two facilities
  - Towner – 46,494 three facilities
  - Cass – 9,056 Proposed facility

Other ND hog facilities

- Department Address:

  918 E Divide Avenue, 4th Floor
  Bismarck, ND 58501-1947

  http://ndhealth.gov/WQ

  Karl Rockeman – Director of Water Quality
  Marty Haroldson – NDPDES Program Manager

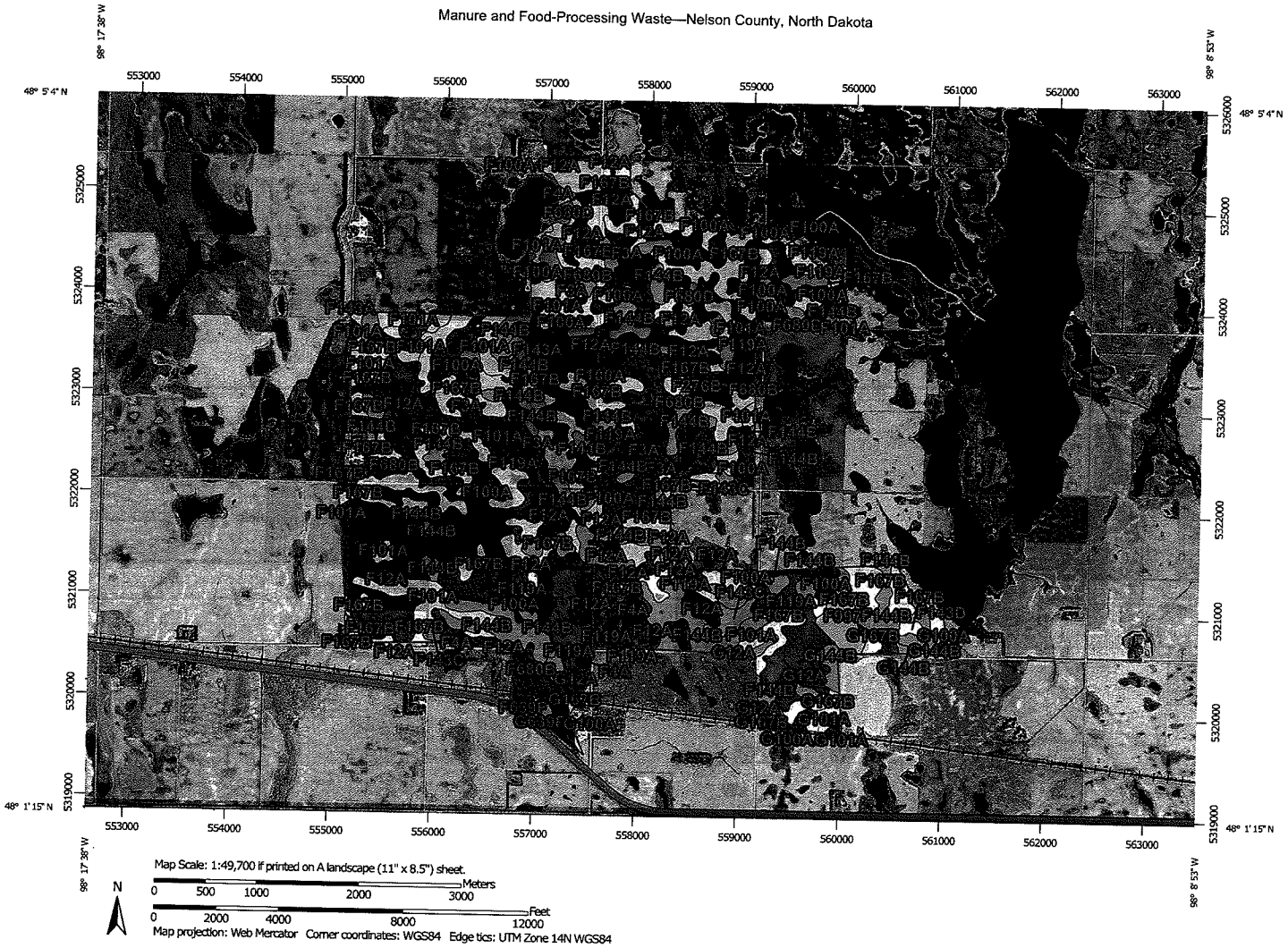
Questions

NORTH DAKOTA
DEPARTMENT of HEALTH

- Please refrain from cheering, booing, applauding or talking while testimony is being taken
- Address the hearing officer, and speak clearly
- Comments should address the environmental impacts
- Be courteous and respectful to others

Ground Rules for Hearing

NORTH DAKOTA
DEPARTMENT of HEALTH


98° 17' 38" W
98° 8' 53" W
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Map Scale: 1:49,700 if printed on A landscape (11" x 8.5") sheet.
N
0 500 1000 2000 3000 Meters
0 2000 4000 8000 12000 Feet
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:12,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Nelson County, North Dakota
Survey Area Data: Version 19, Sep 25, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Oct 16, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Nelson County, North Dakota (ND063)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F3A	Parnell silty clay loam, 0 to 1 percent slopes	Very limited	Parnell (64%)	Slow water movement (1.00)	73.4	1.6%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Vallers (10%)	Depth to saturated zone (1.00)		
				Leaching (0.70)		
			Vallers, moderately saline (9%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Southam (6%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Tonka (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Ferney (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
				Salinity (0.50)		

Manure and Food-Processing Waste— Summary by Map Unit — Nelson County, North Dakota (ND063)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F4A	Southam silty clay loam, 0 to 1 percent slopes	Very limited	Southam (68%)	Slow water movement (1.00)	17.9	0.4%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Vallers, moderately saline (9%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Arveson (8%)	Depth to saturated zone (1.00)		
				Leaching (0.90)		
			Parnell (4%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Manfred (3%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Sodium content (1.00)		
				Slow water movement (1.00)		
				Salinity (0.50)		
F6A	Vallers loam, 0 to 1 percent slopes	Very limited	Vallers (67%)	Depth to saturated zone (1.00)	3.1	0.1%
				Leaching (0.70)		
			Vallers, moderately saline (8%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		

Manure and Food-Processing Waste— Summary by Map Unit — Nelson County, North Dakota (ND063)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Leaching (0.70)		
				Sodium content (0.18)		
			Tonka (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Parnell (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cresbard (2%)	Slow water movement (1.00)		
				Sodium content (0.32)		
F12A	Vallers, saline-Parnell complex, 0 to 1 percent slopes	Very limited	Vallers, moderately saline (40%)	Depth to saturated zone (1.00)	616.9	13.9%
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (27%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Tonka (7%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Nelson County, North Dakota (ND063)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Leaching (0.50)		
			Manfred (5%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Sodium content (1.00)		
				Slow water movement (1.00)		
				Salinity (0.50)		
			Southam (4%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
				Salinity (0.01)		
			Wyard (3%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Easby (3%)	Depth to saturated zone (1.00)		
				Salinity (1.00)		
				Sodium content (1.00)		
				Droughty (1.00)		
				Slow water movement (0.50)		
F100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Tonka (28%)	Slow water movement (1.00)	1,013.8	22.8%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Wyard (7%)	Ponding (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Nelson County, North Dakota (ND063)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Depth to saturated zone (0.86)		
			Vallers, moderately saline (7%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cavour (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
F101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (46%)	Depth to saturated zone (0.86)	286.7	6.4%
			Balaton (7%)	Depth to saturated zone (0.22)		
			Hamerly, moderately saline (4%)	Depth to saturated zone (0.86)		
				Salinity (0.50)		
				Sodium content (0.18)		
F119A	Vallers-Hamerly loams, saline, 0 to 3 percent slopes	Very limited	Vallers, moderately saline (45%)	Depth to saturated zone (1.00)	535.3	12.0%
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Cresbard (6%)	Slow water movement (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Nelson County, North Dakota (ND063)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Sodium content (0.32)		
			Tonka (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Easby (2%)	Depth to saturated zone (1.00)		
				Salinity (1.00)		
				Sodium content (1.00)		
				Droughty (1.00)		
				Slow water movement (0.50)		
			Parnell (2%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
F122A	Svea-Cresbard loams, 0 to 3 percent slopes	Not limited	Svea, saline-sodic substratum (41%)		6.1	0.1%
			Barnes (5%)			
			Balaton, saline-sodic substratum (3%)			
F122B	Barnes-Cresbard loams, 3 to 6 percent slopes	Not limited	Barnes (42%)		0.3	0.0%
			Balaton, saline-sodic substratum (4%)			
			Buse (4%)			
			Svea, saline-sodic substratum (3%)			

Manure and Food-Processing Waste— Summary by Map Unit — Nelson County, North Dakota (ND063)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F143A	Barnes-Svea loams, 0 to 3 percent slopes	Not limited	Barnes (39%)		13.5	0.3%
			Svea (38%)			
			Buse (2%)			
F143C	Barnes-Buse-Langhei loams, 6 to 9 percent slopes	Not limited	Barnes (24%)		57.7	1.3%
			Buse (23%)			
			Langhei (18%)			
			Svea (14%)			
			Balaton (3%)			
			Lanona (3%)			
F143D	Barnes-Buse-Langhei loams, 9 to 15 percent slopes	Somewhat limited	Barnes (31%)	Slope (0.63)	0.1	0.0%
			Buse (24%)	Slope (0.84)		
			Langhei (15%)	Slope (0.84)		
			Langhei, very stony (6%)	Slope (0.84)		
				Large stones (0.47)		
F144B	Barnes-Buse loams, 3 to 6 percent slopes	Not limited	Barnes (25%)		573.6	12.9%
			Buse (24%)			
			Svea (14%)			
			Balaton (10%)			
			Langhei (4%)			
			Swenoda (3%)			
F167B	Balaton-Wyard loams, 0 to 6 percent slopes	Somewhat limited	Balaton (33%)	Depth to saturated zone (0.22)	895.5	20.1%
			Hamerly (9%)	Depth to saturated zone (0.86)		
F276B	Renshaw-Sioux complex, 2 to 6 percent slopes	Very limited	Renshaw (36%)	Filtering capacity (1.00)	15.0	0.3%
				Droughty (0.52)		
			Sioux (20%)	Filtering capacity (1.00)		
				Leaching (0.45)		
				Droughty (0.18)		
			Fordville (10%)	Filtering capacity (1.00)		
			Sioux (10%)	Filtering capacity (1.00)		
				Leaching (0.45)		
				Droughty (0.15)		

Manure and Food-Processing Waste— Summary by Map Unit — Nelson County, North Dakota (ND063)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Osakis (7%)	Filtering capacity (1.00)		
				Droughty (0.90)		
				Leaching (0.45)		
			Warsing (6%)	Filtering capacity (1.00)		
				Droughty (0.01)		
			Arvilla (4%)	Filtering capacity (1.00)		
				Droughty (0.98)		
				Leaching (0.45)		
			Marysland (3%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.70)		
F639F	Orthents-Aquents-Urban Land, highway complex, 0 to 35 percent slopes	Very limited	Orthents (41%)	Slope (1.00)	0.2	0.0%
				Slow water movement (0.50)		
				Large stones (0.04)		
			Aquents, clayey (16%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Renshaw (6%)	Filtering capacity (1.00)		
				Droughty (0.52)		
			Parnell (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
F680B	Barnes-Sioux complex, 1 to 6 percent slopes	Not limited	Barnes (39%)		86.9	2.0%
			Svea (7%)			

Manure and Food-Processing Waste— Summary by Map Unit — Nelson County, North Dakota (ND063)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Buse (7%)			
			Swenoda (6%)			
			Balaton (6%)			
			Langhei (3%)			
F680D	Barnes-Sioux complex, 6 to 15 percent slopes	Not limited	Barnes (31%)		23.6	0.5%
			Svea (9%)			
			Lanona (6%)			
			Balaton (3%)			
F997	Water, intermittent	Not rated	Water, intermittent (80%)		43.1	1.0%
G6A	Vallers loam, 0 to 1 percent slopes	Very limited	Vallers (67%)	Depth to saturated zone (1.00)	11.6	0.3%
				Leaching (0.70)		
			Vallers, moderately saline (8%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Tonka (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Parnell (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cresbard (2%)	Slow water movement (1.00)		
				Sodium content (0.32)		

Manure and Food-Processing Waste— Summary by Map Unit — Nelson County, North Dakota (ND063)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G12A	Vallers, saline-Parnell complex, 0 to 1 percent slopes	Very limited	Vallers, moderately saline (40%)	Depth to saturated zone (1.00)	30.6	0.7%
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (27%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Tonka (7%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Manfred (5%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Sodium content (1.00)		
				Slow water movement (1.00)		
				Salinity (0.50)		
			Southam (4%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
				Salinity (0.01)		
			Wyard (3%)	Ponding (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Nelson County, North Dakota (ND063)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Depth to saturated zone (0.86)		
			Easby (3%)	Depth to saturated zone (1.00)		
				Salinity (1.00)		
				Sodium content (1.00)		
				Droughty (1.00)		
				Slow water movement (0.50)		
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Tonka (28%)	Slow water movement (1.00)	64.1	1.4%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Wyard (7%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Vallers, moderately saline (7%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cavour (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Nelson County, North Dakota (ND063)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (46%)	Depth to saturated zone (0.86)	23.1	0.5%
			Balaton (7%)	Depth to saturated zone (0.22)		
			Hamerly, moderately saline (5%)	Depth to saturated zone (0.86)		
				Salinity (0.50)		
				Sodium content (0.18)		
G144B	Barnes-Buse loams, 3 to 6 percent slopes	Not limited	Barnes (25%)		30.8	0.7%
			Buse (24%)			
			Svea (14%)			
			Balaton (10%)			
			Langhei (4%)			
			Swenoda (3%)			
G167B	Balaton-Wyard loams, 0 to 6 percent slopes	Somewhat limited	Balaton (33%)	Depth to saturated zone (0.22)	20.2	0.5%
			Hamerly (9%)	Depth to saturated zone (0.86)		
G639F	Orthents-Aquents-Urban Land, highway complex, 0 to 35 percent slopes	Very limited	Orthents (41%)	Slope (1.00)	0.3	0.0%
				Slow water movement (0.50)		
				Large stones (0.04)		
			Aquents, clayey (16%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Renshaw (6%)	Filtering capacity (1.00)		
				Droughty (0.52)		
			Parnell (3%)	Slow water movement (1.00)		
				Ponding (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Nelson County, North Dakota (ND063)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
G680B	Barnes-Sioux complex, 1 to 6 percent slopes	Not limited	Barnes (39%)		9.8	0.2%
			Svea (7%)			
			Buse (7%)			
			Swenoda (6%)			
			Balaton (6%)			
			Langhei (3%)			
Totals for Area of Interest					**4,453.4**	**100.0%**

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Very limited	2,382.3	53.5%
Somewhat limited	1,225.6	27.5%
Not limited	802.3	18.0%
Null or Not Rated	43.1	1.0%
Totals for Area of Interest	**4,453.4**	**100.0%**

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

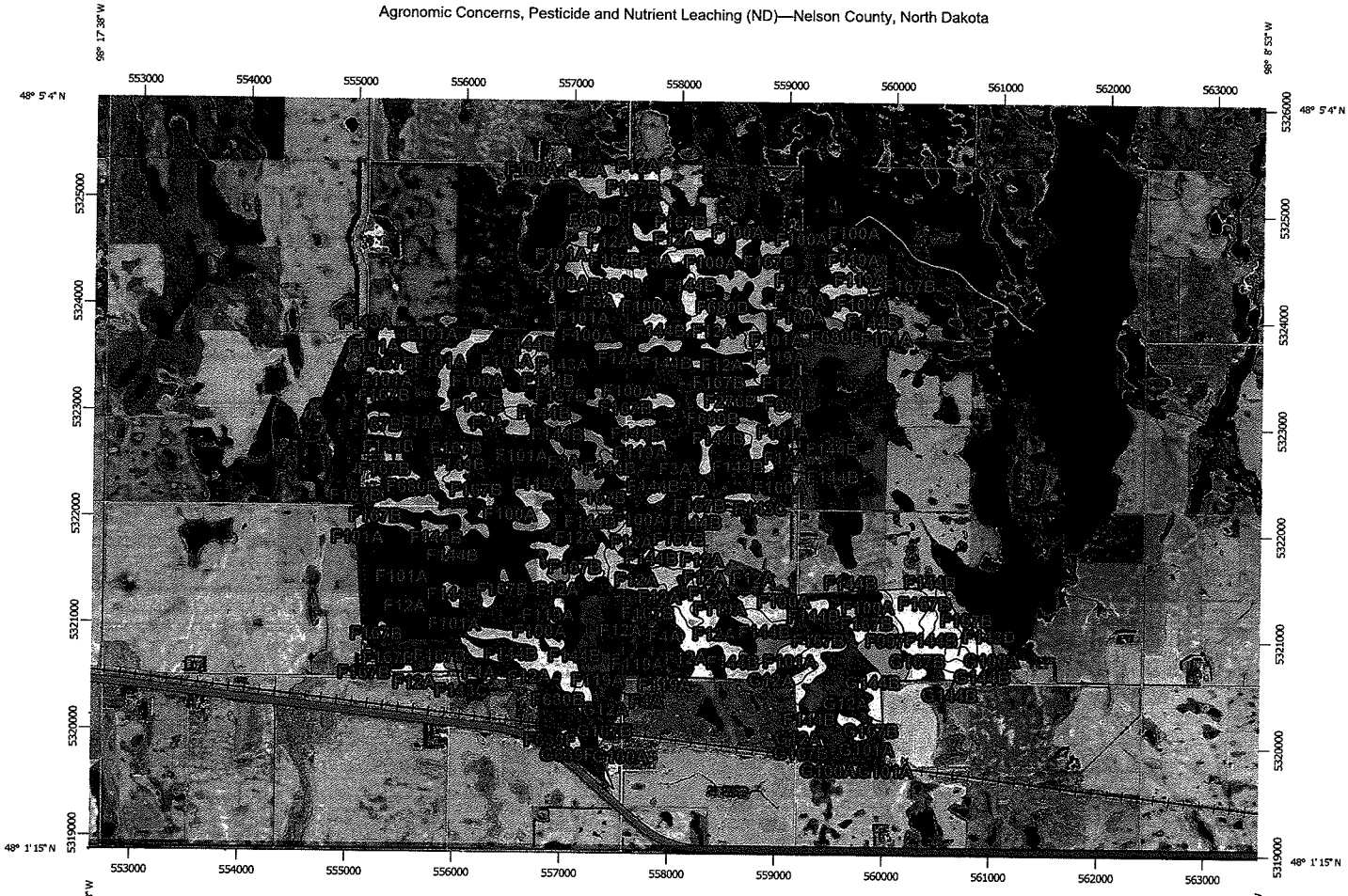
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)—Nelson County, North Dakota



Map Scale: 1:49,700 if printed on A landscape (11" x 8.5") sheet.

N

0 500 1000 2000 3000 Meters

0 2000 4000 8000 12000 Feet

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:12,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Nelson County, North Dakota
Survey Area Data: Version 19, Sep 25, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Oct 16, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Nelson County, North Dakota (ND063)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F3A	Parnell silty clay loam, 0 to 1 percent slopes	Very limited	Parnell (64%)	High water table (1.00)	73.4	1.6%
			Vallers (10%)	High water table (1.00)		
			Vallers, moderately saline (9%)	High water table (1.00)		
			Southam (6%)	High water table (1.00)		
			Tonka (5%)	High water table (1.00)		
			Hamerly (3%)	High water table (1.00)		
F4A	Southam silty clay loam, 0 to 1 percent slopes	Very limited	Southam (68%)	High water table (1.00)	17.9	0.4%
			Vallers, moderately saline (9%)	High water table (1.00)		
			Arveson (8%)	High water table (1.00)		
				High perc rate (0.04)		
			Parnell (4%)	High water table (1.00)		
			Manfred (3%)	High water table (1.00)		
			Mauvais (3%)	High water table (1.00)		
F6A	Vallers loam, 0 to 1 percent slopes	Very limited	Vallers (67%)	High water table (1.00)	3.1	0.1%
			Hamerly (13%)	High water table (1.00)		
			Vallers, moderately saline (8%)	High water table (1.00)		
			Tonka (5%)	High water table (1.00)		
			Parnell (3%)	High water table (1.00)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)—Summary by Map Unit — Nelson County, North Dakota (ND063)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F12A	Vallers, saline-Parnell complex, 0 to 1 percent slopes	Very limited	Vallers, moderately saline (40%)	High water table (1.00)	616.9	13.9%
			Parnell (27%)	High water table (1.00)		
			Hamerly, moderately saline (11%)	High water table (1.00)		
			Tonka (7%)	High water table (1.00)		
			Manfred (5%)	High water table (1.00)		
			Southam (4%)	High water table (1.00)		
			Wyard (3%)	High water table (1.00)		
			Easby (3%)	High water table (1.00)		
F100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Hamerly (42%)	High water table (1.00)	1,013.8	22.8%
			Tonka (28%)	High water table (1.00)		
			Wyard (7%)	High water table (1.00)		
			Vallers, moderately saline (7%)	High water table (1.00)		
			Parnell (5%)	High water table (1.00)		
F101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Very limited	Hamerly (46%)	High water table (1.00)	286.7	6.4%
			Wyard (24%)	High water table (1.00)		
			Tonka (8%)	High water table (1.00)		
			Vallers (5%)	High water table (1.00)		
			Hamerly, moderately saline (4%)	High water table (1.00)		
F119A	Vallers-Hamerly loams, saline, 0 to 3 percent slopes	Very limited	Vallers, moderately saline (45%)	High water table (1.00)	535.3	12.0%
			Hamerly, moderately saline (31%)	High water table (1.00)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Nelson County, North Dakota (ND063)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Hamerly (7%)	High water table (1.00)		
			Tonka (3%)	High water table (1.00)		
			Easby (2%)	High water table (1.00)		
			Parnell (2%)	High water table (1.00)		
F122A	Svea-Cresbard loams, 0 to 3 percent slopes	Somewhat limited	Svea, saline-sodic substratum (41%)	High water table (0.76)	6.1	0.1%
			Cresbard (30%)	High water table (0.76)		
			Barnes (5%)	High water table (0.19)		
			Ferney (4%)	High water table (0.76)		
			Cavour (3%)	High water table (0.76)		
			Fordville (3%)	High water table (0.19)		
			Balaton, saline-sodic substratum (3%)	High water table (0.76)		
F122B	Barnes-Cresbard loams, 3 to 6 percent slopes	Somewhat limited	Barnes (42%)	High water table (0.19)	0.3	0.0%
			Cresbard (39%)	High water table (0.76)		
			Balaton, saline-sodic substratum (4%)	High water table (0.76)		
			Cavour (3%)	High water table (0.76)		
			Svea, saline-sodic substratum (3%)	High water table (0.76)		
F143A	Barnes-Svea loams, 0 to 3 percent slopes	Somewhat limited	Barnes (39%)	High water table (0.19)	13.5	0.3%
			Svea (38%)	High water table (0.76)		
			Cresbard (3%)	High water table (0.76)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Nelson County, North Dakota (ND063)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F143C	Barnes-Buse-Langhei loams, 6 to 9 percent slopes	Not limited	Barnes (24%)		57.7	1.3%
			Buse (23%)			
			Langhei (18%)			
			Renshaw (3%)			
F143D	Barnes-Buse-Langhei loams, 9 to 15 percent slopes	Not limited	Barnes (31%)		0.1	0.0%
			Buse (24%)			
			Langhei (15%)			
			Langhei, very stony (6%)			
			Lanona (3%)			
F144B	Barnes-Buse loams, 3 to 6 percent slopes	Somewhat limited	Barnes (25%)	High water table (0.19)	573.6	12.9%
			Svea (14%)	High water table (0.76)		
			Balaton (10%)	High water table (0.76)		
			Cresbard (3%)	High water table (0.76)		
			Swenoda (3%)	High water table (0.76)		
			Sioux (2%)	High perc rate (0.22)		
F167B	Balaton-Wyard loams, 0 to 6 percent slopes	Somewhat limited	Balaton (33%)	High water table (0.76)	895.5	20.1%
			Svea (13%)	High water table (0.76)		
			Barnes (5%)	High water table (0.19)		
			Cresbard (4%)	High water table (0.76)		
F276B	Renshaw-Sioux complex, 2 to 6 percent slopes	Somewhat limited	Sioux (20%)	High perc rate (0.22)	15.0	0.3%
			Fordville (10%)	High water table (0.19)		
			Sioux (10%)	High perc rate (0.08)		
			Osakis (7%)	High water table (0.76)		
				High perc rate (0.08)		
			Warsing (6%)	High water table (0.76)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Nelson County, North Dakota (ND063)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Arvilla (4%)	High perc rate (0.08)		
F639F	Orthents-Aquents-Urban Land, highway complex, 0 to 35 percent slopes	Not limited	Orthents (41%)		0.2	0.0%
			Sisseton (10%)			
			Renshaw (6%)			
			Barnes (3%)			
F680B	Barnes-Sioux complex, 1 to 6 percent slopes	Somewhat limited	Barnes (39%)	High water table (0.19)	86.9	2.0%
			Sioux (26%)	High perc rate (0.22)		
			Svea (7%)	High water table (0.76)		
			Swenoda (6%)	High water table (0.76)		
			Balaton (6%)	High water table (0.76)		
F680D	Barnes-Sioux complex, 6 to 15 percent slopes	Not limited	Barnes (31%)		23.6	0.5%
			Buse, very stony (8%)			
			Buse (8%)			
			Lanona (6%)			
			Renshaw (6%)			
F997	Water, intermittent	Not rated	Water, intermittent (80%)		43.1	1.0%
G6A	Vallers loam, 0 to 1 percent slopes	Very limited	Vallers (67%)	High water table (1.00)	11.6	0.3%
			Hamerly (13%)	High water table (1.00)		
			Vallers, moderately saline (8%)	High water table (1.00)		
			Tonka (5%)	High water table (1.00)		
			Parnell (3%)	High water table (1.00)		
G12A	Vallers, saline-Parnell complex, 0 to 1 percent slopes	Very limited	Vallers, moderately saline (40%)	High water table (1.00)	30.6	0.7%
			Parnell (27%)	High water table (1.00)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Nelson County, North Dakota (ND063)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Hamerly, moderately saline (11%)	High water table (1.00)		
			Tonka (7%)	High water table (1.00)		
			Manfred (5%)	High water table (1.00)		
			Southam (4%)	High water table (1.00)		
			Wyard (3%)	High water table (1.00)		
			Easby (3%)	High water table (1.00)		
G100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Hamerly (42%)	High water table (1.00)	64.1	1.4%
			Tonka (28%)	High water table (1.00)		
			Wyard (7%)	High water table (1.00)		
			Vallers, moderately saline (7%)	High water table (1.00)		
			Parnell (5%)	High water table (1.00)		
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Very limited	Hamerly (46%)	High water table (1.00)	23.1	0.5%
			Wyard (24%)	High water table (1.00)		
			Tonka (8%)	High water table (1.00)		
			Hamerly, moderately saline (5%)	High water table (1.00)		
			Vallers (4%)	High water table (1.00)		
G144B	Barnes-Buse loams, 3 to 6 percent slopes	Somewhat limited	Barnes (25%)	High water table (0.19)	30.8	0.7%
			Svea (14%)	High water table (0.76)		
			Balaton (10%)	High water table (0.76)		
			Swenoda (3%)	High water table (0.76)		
			Cresbard (3%)	High water table (0.76)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Nelson County, North Dakota (ND063)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Sioux (2%)	High perc rate (0.22)		
G167B	Balaton-Wyard loams, 0 to 6 percent slopes	Somewhat limited	Balaton (33%)	High water table (0.76)	20.2	0.5%
			Svea (13%)	High water table (0.76)		
			Barnes (5%)	High water table (0.19)		
			Cresbard (4%)	High water table (0.76)		
G639F	Orthents-Aquents-Urban Land, highway complex, 0 to 35 percent slopes	Not limited	Orthents (41%)		0.3	0.0%
			Sisseton (10%)			
			Renshaw (6%)			
			Barnes (3%)			
G680B	Barnes-Sioux complex, 1 to 6 percent slopes	Somewhat limited	Barnes (39%)	High water table (0.19)	9.8	0.2%
			Sioux (26%)	High perc rate (0.22)		
			Svea (7%)	High water table (0.76)		
			Swenoda (6%)	High water table (0.76)		
			Balaton (6%)	High water table (0.76)		
Totals for Area of Interest					**4,453.4**	**100.0%**

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Very limited	2,676.5	60.1%
Somewhat limited	1,651.8	37.1%
Not limited	82.0	1.8%
Null or Not Rated	43.1	1.0%
Totals for Area of Interest	**4,453.4**	**100.0%**

Description

The interpretation for Agronomic Concerns, Pesticide and Nutrient Leaching evaluates limitations of a soil that increase the hazard of contaminating aquifers, springs, and local water tables.

The soil features considered are saturated hydraulic conductivity and depth to seasonal high water table.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soil is limited by all of the soil features that affect the interpretation. Numerical ratings indicate the severity of individual limitations; the highest numerical rating identifies the most limiting soil feature(s) considered in the rating process. Less restrictive soil features have a lower numerical value than the maximum used to rate the soil. They are identified to provide the user with additional information about soil limitations for the specific use. Restrictive soil features also need to be considered in planning, design, installation, and management. "Not limited" (numerical value for the most restrictive feature = 0.00) indicates that the soil has features that are very favorable for the specified use. "Somewhat limited" (numerical value for the most restrictive feature = 0.01 to 0.99) indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning. "Very limited" (numerical value for the most restrictive feature = 1.00) indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special planning, or expensive installation procedures.

The results of this interpretation are not designed or intended to be used in a regulatory manner.

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

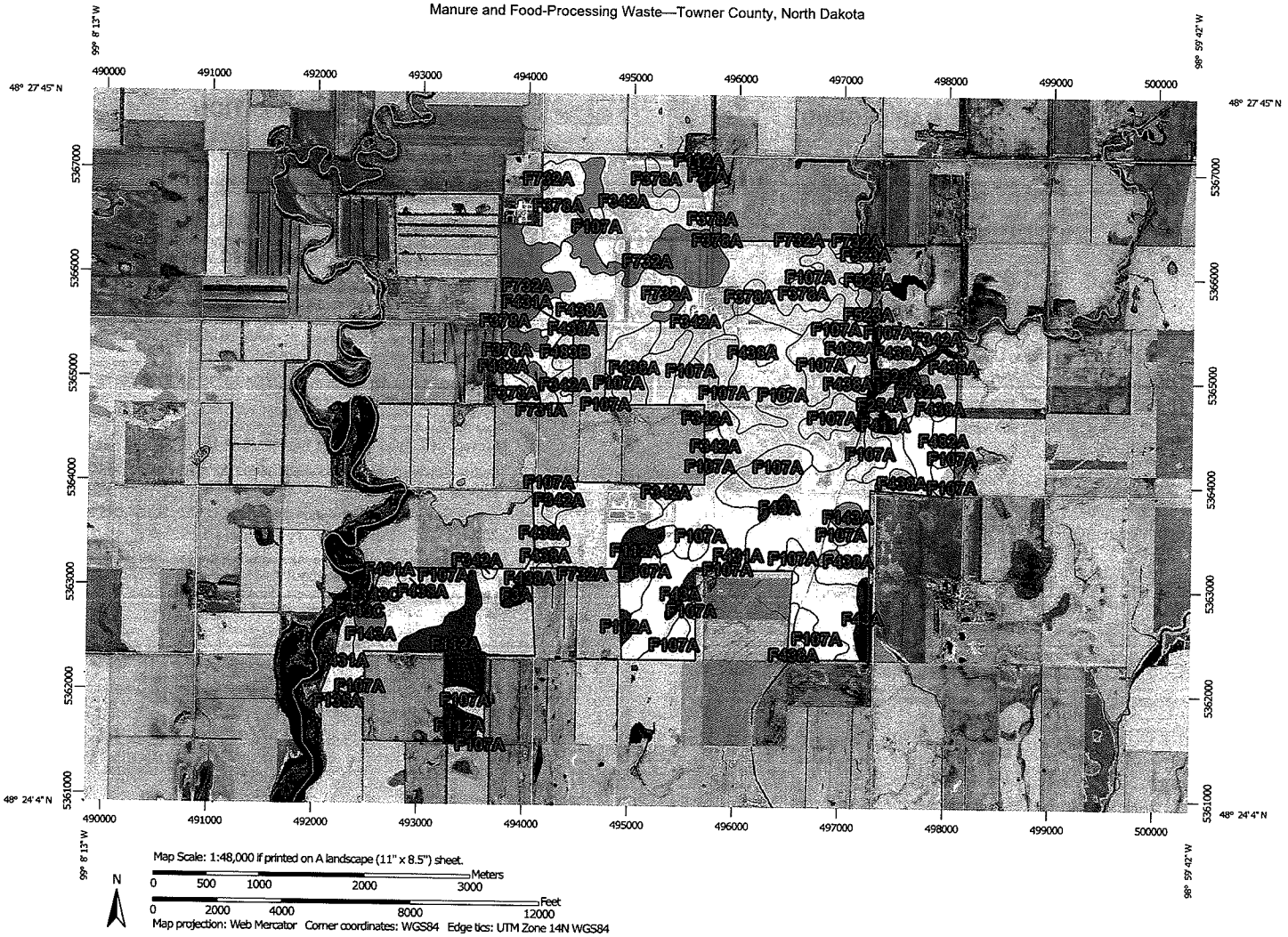
Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

H 8N -T

Manure and Food-Processing Waste—Towner County, North Dakota



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Towner County, North Dakota
Survey Area Data: Version 18, Sep 25, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Oct 12, 2010—Oct 16, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F3A	Parnell silty clay loam, 0 to 1 percent slopes	Very limited	Parnell (64%)	Slow water movement (1.00)	9.5	0.3%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Vallers (10%)	Depth to saturated zone (1.00)		
				Leaching (0.70)		
			Vallers, moderately saline (9%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Southam (6%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Tonka (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Ferney (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
				Salinity (0.50)		

Manure and Food-Processing Waste— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F27A	Marysland loam, shaly, 0 to 1 percent slopes	Very limited	Marysland, shaly (75%)	Depth to saturated zone (1.00)	8.7	0.2%
				Leaching (0.70)		
			Marysland, very poorly drained, shaly (7%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.70)		
			Totten (5%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Sodium content (1.00)		
				Salinity (0.50)		
				Slow water movement (0.50)		
			Tolna (3%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
				Too acid (0.03)		
F43A	Colvin silt loam, 0 to 1 percent slopes	Very limited	Colvin (62%)	Depth to saturated zone (1.00)	40.5	1.1%
				Slow water movement (0.50)		
				Leaching (0.50)		
			Arveson (8%)	Depth to saturated zone (1.00)		
				Leaching (0.90)		
			Colvin, very poorly drained (6%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Slow water movement (0.50)		
				Leaching (0.50)		
			Perella (5%)	Ponding (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Depth to saturated zone (1.00)		
				Leaching (0.70)		
			Kindred (3%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
				Slow water movement (0.50)		
			Colvin, moderately saline (3%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Slow water movement (0.50)		
				Leaching (0.50)		
				Sodium content (0.32)		
F107A	Hamerly-Barnes loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (45%)	Depth to saturated zone (0.86)	1,032.1	27.9%
			Balaton (11%)	Depth to saturated zone (0.22)		
F112A	Hamerly-Tonka-Parnell complex, 0 to 3 percent slopes	Very limited	Tonka (20%)	Slow water movement (1.00)	169.8	4.6%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Parnell (16%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Vallers, moderately saline (10%)	Depth to saturated zone (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Wyard (4%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Southam (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
				Salinity (0.01)		
F135A	Hamerly-Cresbard loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (44%)	Depth to saturated zone (0.86)	0.4	0.0%
			Balaton (5%)	Depth to saturated zone (0.22)		
F143A	Barnes-Svea loams, 0 to 3 percent slopes	Not limited	Barnes (39%)		30.1	0.8%
			Svea (38%)			
			Buse (2%)			
F143C	Barnes-Buse-Langhei loams, 6 to 9 percent slopes	Not limited	Barnes (24%)		3.2	0.1%
			Buse (23%)			
			Langhei (18%)			
			Svea (14%)			
			Balaton (3%)			
			Lanona (3%)			
F144B	Barnes-Buse loams, 3 to 6 percent slopes	Not limited	Barnes (25%)		10.7	0.3%
			Buse (24%)			
			Svea (14%)			
			Balaton (10%)			
			Langhei (4%)			
			Swenoda (3%)			
F254A	Divide loam, shaly, 0 to 2 percent slopes	Somewhat limited	Divide, shaly (70%)	Depth to saturated zone (0.86)	8.3	0.2%

Manure and Food-Processing Waste— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Kensal (4%)	Depth to saturated zone (0.02)		
			Walum (4%)	Leaching (0.45)		
				Depth to saturated zone (0.02)		
F342A	Wyndmere-Delamere loams, silty substratums, 0 to 2 percent slopes	Somewhat limited	Wyndmere, silty substratum (53%)	Depth to saturated zone (0.86)	658.2	17.8%
F378A	Egeland-Embden fine sandy loams, 0 to 2 percent slopes	Somewhat limited	Egeland (51%)	Leaching (0.45)	157.9	4.3%
			Embden (32%)	Leaching (0.45)		
			Wyndmere (7%)	Depth to saturated zone (0.84)		
			Hecla (3%)	Leaching (0.45)		
				Depth to saturated zone (0.02)		
			Glyndon (2%)	Depth to saturated zone (0.86)		
F411A	Fargo-Hegne silty clays, 0 to 1 percent slopes	Very limited	Fargo (48%)	Slow water movement (1.00)	7.6	0.2%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Hegne (47%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Dovray (3%)	Slow water movement (1.00)		
				Ponding (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
F431A	Bearden silt loam, 0 to 2 percent slopes	Somewhat limited	Bearden (72%)	Depth to saturated zone (0.86)	453.0	12.2%
				Slow water movement (0.50)		
			Bearden, moderately saline (5%)	Depth to saturated zone (0.86)		
				Salinity (0.50)		
				Slow water movement (0.50)		
				Sodium content (0.32)		
F438A	Bearden-Lindaas silt loams, 0 to 2 percent slopes	Somewhat limited	Bearden (57%)	Depth to saturated zone (0.86)	674.6	18.2%
				Slow water movement (0.50)		
			Overly (6%)	Slow water movement (0.50)		
F482A	Great Bend-Overly silt loams, 0 to 2 percent slopes	Somewhat limited	Great Bend (37%)	Slow water movement (0.50)	78.0	2.1%
			Overly, overflow (30%)	Slow water movement (0.50)		
			Bearden (13%)	Depth to saturated zone (0.86)		
				Slow water movement (0.50)		
F483B	Great Bend-Zell silt loams, 2 to 6 percent slopes	Somewhat limited	Great Bend (37%)	Slow water movement (0.30)	14.2	0.4%
			Overly (14%)	Slow water movement (0.50)		
			Egeland (11%)	Leaching (0.45)		

Manure and Food-Processing Waste— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Bearden (2%)	Depth to saturated zone (0.86)		
				Slow water movement (0.50)		
F523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	Very limited	Fluvaquents, channeled, frequently flooded (40%)	Ponding (1.00)	41.5	1.1%
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.90)		
			Lowe, frequently flooded (28%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
			Lowe, moderately saline, frequently flooded (20%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
				Salinity (0.50)		
			Lowe, very poorly drained, frequently flooded (5%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
F731A	Swenoda fine sandy loam, 0 to 3 percent slopes	Not limited	Swenoda (59%)		6.1	0.2%
			Towner (10%)			
			Barnes (10%)			
			Balaton (4%)			
			Lanona (3%)			
F732A	Swenoda-Barnes fine sandy loams, 0 to 3 percent slopes	Not limited	Swenoda (49%)		301.4	8.1%
			Barnes (20%)			
			Towner (10%)			
			Balaton (4%)			
			Lanona (3%)			

Manure and Food-Processing Waste— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F997	Water, intermittent	Not rated	Water, intermittent (80%)		0.2	0.0%
Totals for Area of Interest					**3,705.9**	**100.0%**

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Somewhat limited	3,076.7	83.0%
Not limited	351.4	9.5%
Very limited	277.6	7.5%
Null or Not Rated	0.2	0.0%
Totals for Area of Interest	**3,705.9**	**100.0%**

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

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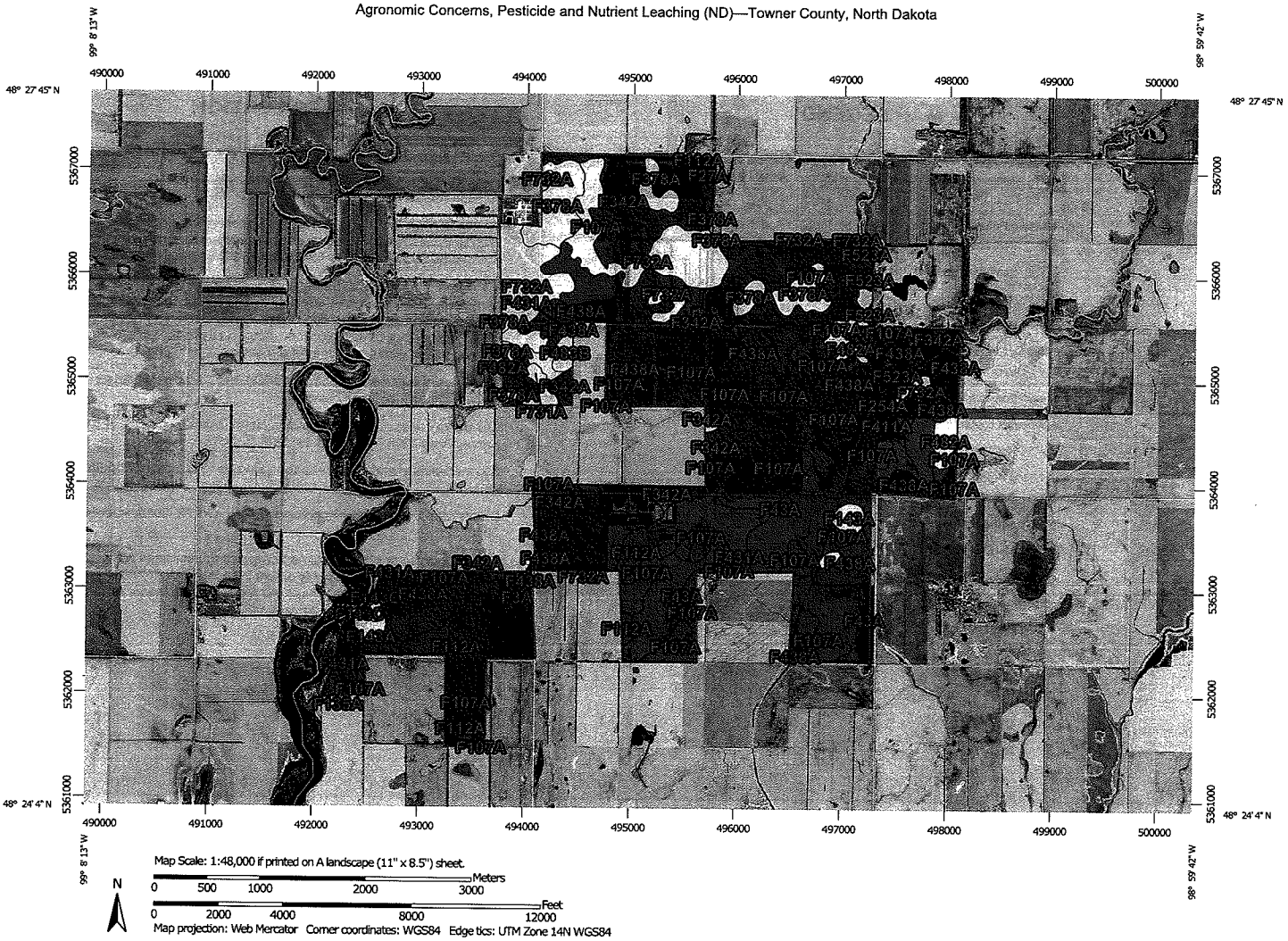
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher


99° 8' 13" W
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48° 27' 45" N
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Map Scale: 1:48,000 if printed on A landscape (11" x 8.5") sheet.
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0 500 1000 2000 3000 Meters
0 2000 4000 8000 12000 Feet
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
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Water Features
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Background
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MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

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Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

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Soil Survey Area: Towner County, North Dakota
Survey Area Data: Version 18, Sep 25, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Oct 12, 2010—Oct 16, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F3A	Parnell silty clay loam, 0 to 1 percent slopes	Very limited	Parnell (64%)	High water table (1.00)	9.5	0.3%
			Vallers (10%)	High water table (1.00)		
			Vallers, moderately saline (9%)	High water table (1.00)		
			Southam (6%)	High water table (1.00)		
			Tonka (5%)	High water table (1.00)		
			Hamerly (3%)	High water table (1.00)		
F27A	Marysland loam, shaly, 0 to 1 percent slopes	Very limited	Marysland, shaly (75%)	High water table (1.00)	8.7	0.2%
			Divide, shaly (10%)	High water table (1.00)		
			Marysland, very poorly drained, shaly (7%)	High water table (1.00)		
			Totten (5%)	High water table (1.00)		
			Tolna (3%)	High water table (1.00)		
F43A	Colvin silt loam, 0 to 1 percent slopes	Very limited	Colvin (62%)	High water table (1.00)	40.5	1.1%
			Bearden (10%)	High water table (1.00)		
			Arveson (8%)	High water table (1.00)		
				High perc rate (0.04)		
			Colvin, very poorly drained (6%)	High water table (1.00)		
			Perella (5%)	High water table (1.00)		
			Wyndmere (3%)	High water table (1.00)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				High perc rate (0.03)		
			Kindred (3%)	High water table (1.00)		
			Colvin, moderately saline (3%)	High water table (1.00)		
F107A	Hamerly-Barnes loams, 0 to 3 percent slopes	Very limited	Hamerly (45%)	High water table (1.00)	1,032.1	27.9%
			Vallers (8%)	High water table (1.00)		
			Tonka (7%)	High water table (1.00)		
			Parnell (1%)	High water table (1.00)		
F112A	Hamerly-Tonka-Parnell complex, 0 to 3 percent slopes	Very limited	Hamerly (43%)	High water table (1.00)	169.8	4.6%
			Tonka (20%)	High water table (1.00)		
			Parnell (16%)	High water table (1.00)		
			Vallers, moderately saline (10%)	High water table (1.00)		
			Wyard (4%)	High water table (1.00)		
			Southam (3%)	High water table (1.00)		
F135A	Hamerly-Cresbard loams, 0 to 3 percent slopes	Somewhat limited	Cresbard (41%)	High water table (0.76)	0.4	0.0%
			Balaton (5%)	High water table (0.76)		
			Cavour (2%)	High water table (0.76)		
			Barnes (2%)	High water table (0.19)		
			Svea (2%)	High water table (0.76)		
F143A	Barnes-Svea loams, 0 to 3 percent slopes	Somewhat limited	Barnes (39%)	High water table (0.19)	30.1	0.8%
			Svea (38%)	High water table (0.76)		
			Cresbard (3%)	High water table (0.76)		
F143C	Barnes-Buse-Langhei	Not limited	Barnes (24%)		3.2	0.1%

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
	loams, 6 to 9 percent slopes		Buse (23%)			
			Langhei (18%)			
			Renshaw (3%)			
F144B	Barnes-Buse loams, 3 to 6 percent slopes	Somewhat limited	Barnes (25%)	High water table (0.19)	10.7	0.3%
			Svea (14%)	High water table (0.76)		
			Balaton (10%)	High water table (0.76)		
			Cresbard (3%)	High water table (0.76)		
			Swenoda (3%)	High water table (0.76)		
			Sioux (2%)	High perc rate (0.22)		
F254A	Divide loam, shaly, 0 to 2 percent slopes	Very limited	Divide, shaly (70%)	High water table (1.00)	8.3	0.2%
			Marysland, shaly (14%)	High water table (1.00)		
			Tolna (3%)	High water table (1.00)		
F342A	Wyndmere-Delamere loams, silty substratums, 0 to 2 percent slopes	Very limited	Wyndmere, silty substratum (53%)	High water table (1.00)	658.2	17.8%
			Delamere, silty substratum (29%)	High water table (1.00)		
			Tiffany, silty substratum (12%)	High water table (1.00)		
F378A	Egeland-Embden fine sandy loams, 0 to 2 percent slopes	Somewhat limited	Egeland (51%)	High water table (0.19)	157.9	4.3%
				High perc rate (0.04)		
			Embden (32%)	High water table (0.76)		
				High perc rate (0.04)		
			Hecla (3%)	High water table (0.94)		
				High perc rate (0.04)		
			Zell (3%)	High water table (0.19)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Maddock (2%)	High perc rate (0.87)		
				High water table (0.19)		
F411A	Fargo-Hegne silty clays, 0 to 1 percent slopes	Very limited	Fargo (48%)	High water table (1.00)	7.6	0.2%
			Hegne (47%)	High water table (1.00)		
			Dovray (3%)	High water table (1.00)		
			Bearden (2%)	High water table (1.00)		
F431A	Bearden silt loam, 0 to 2 percent slopes	Very limited	Bearden (72%)	High water table (1.00)	453.0	12.2%
			Kindred (7%)	High water table (1.00)		
			Perella (7%)	High water table (1.00)		
			Bearden, moderately saline (5%)	High water table (1.00)		
			Colvin, moderately saline (4%)	High water table (1.00)		
F438A	Bearden-Lindaas silt loams, 0 to 2 percent slopes	Very limited	Bearden (57%)	High water table (1.00)	674.6	18.2%
			Lindaas (20%)	High water table (1.00)		
			Colvin, moderately saline (6%)	High water table (1.00)		
			Kindred (3%)	High water table (1.00)		
F482A	Great Bend-Overly silt loams, 0 to 2 percent slopes	Somewhat limited	Great Bend (37%)	High water table (0.19)	78.0	2.1%
			Overly, overflow (30%)	High water table (0.76)		
			Zell (2%)	High water table (0.19)		
			Aberdeen (2%)	High water table (0.76)		
F483B	Great Bend-Zell silt loams, 2 to 6 percent slopes	Somewhat limited	Great Bend (37%)	High water table (0.19)	14.2	0.4%
			Zell (34%)	High water table (0.19)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Overly (14%)	High water table (0.76)		
			Egeland (11%)	High water table (0.19)		
				High perc rate (0.04)		
			Coe (1%)	High perc rate (0.08)		
F523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	Very limited	Fluvaquents, channeled, frequently flooded (40%)	High water table (1.00)	41.5	1.1%
				High perc rate (0.21)		
			Lowe, frequently flooded (28%)	High water table (1.00)		
			Lowe, moderately saline, frequently flooded (20%)	High water table (1.00)		
			Moritz, occasionally flooded (5%)	High water table (1.00)		
			Lowe, very poorly drained, frequently flooded (5%)	High water table (1.00)		
F731A	Swenoda fine sandy loam, 0 to 3 percent slopes	Somewhat limited	Swenoda (59%)	High water table (0.76)	6.1	0.2%
			Towner (10%)	High water table (0.76)		
			Barnes (10%)	High water table (0.19)		
			Balaton (4%)	High water table (0.76)		
			Lanona (3%)	High water table (0.19)		
F732A	Swenoda-Barnes fine sandy loams, 0 to 3 percent slopes	Somewhat limited	Swenoda (49%)	High water table (0.76)	301.4	8.1%
			Barnes (20%)	High water table (0.19)		
			Towner (10%)	High water table (0.76)		
			Balaton (4%)	High water table (0.76)		
			Lanona (3%)	High water table (0.19)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F997	Water, intermittent	Not rated	Water, intermittent (80%)		0.2	0.0%
Totals for Area of Interest					**3,705.9**	**100.0%**

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Very limited	3,103.8	83.8%
Somewhat limited	598.7	16.2%
Not limited	3.2	0.1%
Null or Not Rated	0.2	0.0%
Totals for Area of Interest	**3,705.9**	**100.0%**

Description

The interpretation for Agronomic Concerns, Pesticide and Nutrient Leaching evaluates limitations of a soil that increase the hazard of contaminating aquifers, springs, and local water tables.

The soil features considered are saturated hydraulic conductivity and depth to seasonal high water table.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soil is limited by all of the soil features that affect the interpretation. Numerical ratings indicate the severity of individual limitations; the highest numerical rating identifies the most limiting soil feature(s) considered in the rating process. Less restrictive soil features have a lower numerical value than the maximum used to rate the soil. They are identified to provide the user with additional information about soil limitations for the specific use. Restrictive soil features also need to be considered in planning, design, installation, and management. "Not limited" (numerical value for the most restrictive feature = 0.00) indicates that the soil has features that are very favorable for the specified use. "Somewhat limited" (numerical value for the most restrictive feature = 0.01 to 0.99) indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning. "Very limited" (numerical value for the most restrictive feature = 1.00) indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special planning, or expensive installation procedures.

The results of this interpretation are not designed or intended to be used in a regulatory manner.

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

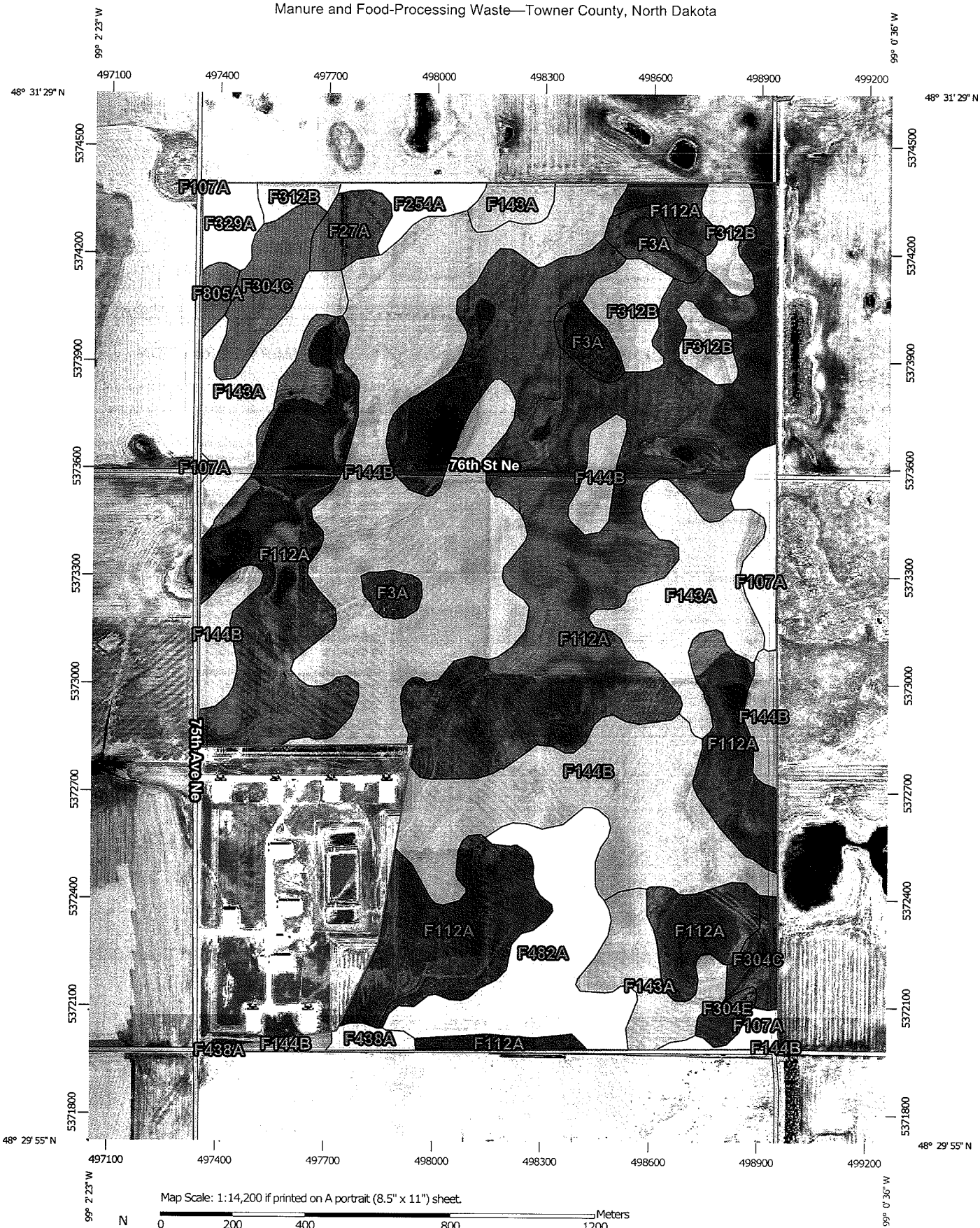
Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher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F312B
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F144B
F112A
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75th Ave Ne
F144B
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F304C
F143A
F304E
F107A
F438A
F144B
F438A
F112A
F144B
Map Scale: 1:14,200 if printed on A portrait (8.5" x 11") sheet.
Meters
0
200
400
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1200
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Feet
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500
1000
2000
3000
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Towner County, North Dakota
Survey Area Data: Version 18, Sep 25, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Oct 12, 2010—Oct 16, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F3A	Parnell silty clay loam, 0 to 1 percent slopes	Very limited	Parnell (64%)	Slow water movement (1.00)	19.0	2.2%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Vallers (10%)	Depth to saturated zone (1.00)		
				Leaching (0.70)		
			Vallers, moderately saline (9%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Southam (6%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Tonka (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Ferney (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
				Salinity (0.50)		

Manure and Food-Processing Waste— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F27A	Marysland loam, shaly, 0 to 1 percent slopes	Very limited	Marysland, shaly (75%)	Depth to saturated zone (1.00)	9.0	1.1%
				Leaching (0.70)		
			Marysland, very poorly drained, shaly (7%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.70)		
			Totten (5%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Sodium content (1.00)		
				Salinity (0.50)		
				Slow water movement (0.50)		
			Tolna (3%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
				Too acid (0.03)		
F107A	Hamerly-Barnes loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (45%)	Depth to saturated zone (0.86)	14.7	1.7%
			Balaton (11%)	Depth to saturated zone (0.22)		
F112A	Hamerly-Tonka-Parnell complex, 0 to 3 percent slopes	Very limited	Tonka (20%)	Slow water movement (1.00)	363.9	42.5%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Parnell (16%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		

Manure and Food-Processing Waste— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Vallers, moderately saline (10%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Wyard (4%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Southam (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
				Salinity (0.01)		
F143A	Barnes-Svea loams, 0 to 3 percent slopes	Not limited	Barnes (39%)		88.5	10.3%
			Svea (38%)			
			Buse (2%)			
F144B	Barnes-Buse loams, 3 to 6 percent slopes	Not limited	Barnes (25%)		232.4	27.2%
			Buse (24%)			
			Svea (14%)			
			Balaton (10%)			
			Langhei (4%)			
			Swenoda (3%)			
F254A	Divide loam, shaly, 0 to 2 percent slopes	Somewhat limited	Divide, shaly (70%)	Depth to saturated zone (0.86)	7.8	0.9%
			Kensal (4%)	Depth to saturated zone (0.02)		
			Walum (4%)	Leaching (0.45)		
				Depth to saturated zone (0.02)		
F304C	Coe-Binford complex, 6 to 9 percent slopes	Very limited	Coe (43%)	Droughty (1.00)	23.6	2.8%
				Leaching (0.45)		
			Coe (10%)	Droughty (1.00)		
				Leaching (0.45)		

Manure and Food-Processing Waste— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F304E	Coe-Binford sandy loams, 9 to 25 percent slopes	Very limited	Coe (41%)	Slope (1.00)	3.9	0.5%
				Droughty (1.00)		
				Leaching (0.45)		
			Coe (15%)	Slope (1.00)		
				Droughty (1.00)		
				Leaching (0.45)		
F312B	Brantford-Coe complex, 2 to 6 percent slopes	Not limited	Brantford (36%)		30.3	3.5%
			Vang (10%)			
F329A	Wyndmere fine sandy loam, 0 to 2 percent slopes	Somewhat limited	Wyndmere (73%)	Depth to saturated zone (0.84)	8.6	1.0%
			Wyrene (5%)	Depth to saturated zone (0.84)		
				Droughty (0.31)		
			Wyndmere, moderately saline (3%)	Depth to saturated zone (0.84)		
				Salinity (0.50)		
				Sodium content (0.32)		
				Droughty (0.25)		
			Embden (3%)	Leaching (0.45)		
F438A	Bearden-Lindaas silt loams, 0 to 2 percent slopes	Somewhat limited	Bearden (57%)	Depth to saturated zone (0.86)	3.7	0.4%
				Slow water movement (0.50)		
			Overly (6%)	Slow water movement (0.50)		
F482A	Great Bend-Overly silt loams, 0 to 2 percent slopes	Somewhat limited	Great Bend (37%)	Slow water movement (0.50)	46.5	5.4%
			Overly, overflow (30%)	Slow water movement (0.50)		
			Bearden (13%)	Depth to saturated zone (0.86)		
				Slow water movement (0.50)		

Manure and Food-Processing Waste— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F805A	Bearden-Colvin silt loams, saline, 0 to 2 percent slopes	Very limited	Colvin, moderately saline (29%)	Ponding (1.00)	3.5	0.4%
				Depth to saturated zone (1.00)		
				Salinity (0.50)		
				Slow water movement (0.50)		
				Leaching (0.50)		
			Colvin (13%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Slow water movement (0.50)		
				Leaching (0.50)		
			Aberdeen (3%)	Slow water movement (1.00)		
				Sodium content (0.18)		
			Parnell (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Exline (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
				Depth to saturated zone (0.86)		
				Salinity (0.78)		
				Runoff (0.40)		
Totals for Area of Interest					**855.5**	**100.0%**

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Very limited	423.0	49.4%

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	**Acres in AOI**	**Percent of AOI**
Not limited	351.3	41.1%
Somewhat limited	81.3	9.5%
Totals for Area of Interest	**855.5**	**100.0%**

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Anderson, Carl J.

From: Russell, Evan [erussell@quonticbank.com]
Sent: Tuesday, March 15, 2016 12:04 PM
To: Anderson, Carl J.; RS@quonticbank.com
Subject: RE: well log

Carl thank you for this information although not what we were hoping for. In order for us to confirm and have someone put the below in writing what would your suggestions be for us?

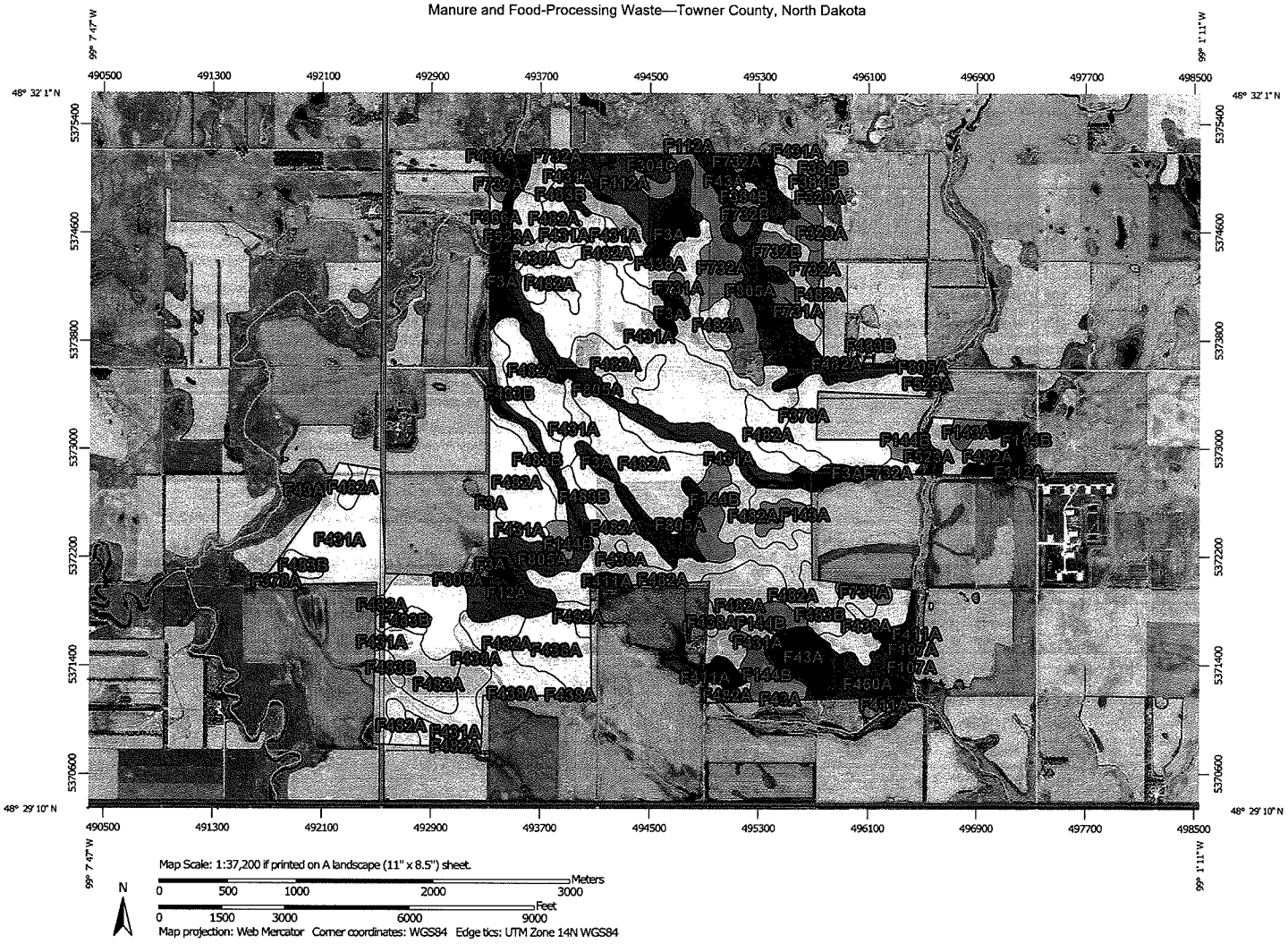
Letter from local authority confirming "well meets all requirements."

From: Anderson, Carl J. [mailto:cjanders@nd.gov]
Sent: Tuesday, March 15, 2016 12:58 PM
To: RS@quonticbank.com
Subject: well log

Attention Delores,

I have attached the log for the well I found. The well appears to have been drilled by a certified well contractor (last license renewal date is 2012), but I can't verify for sure if they were licensed in 2003. I do see one potential issue on the log that I cannot verify or research. "No" is checked for the question regarding pump installation and for "well head completion" it says "by others". It appears that the well driller did not install a pump or any supply piping. Pumps, pitless units, or other well appurtenances also must be installed by a certified well contractor or water well and pitless installer. I do not have any way to verify that the water pump and distribution piping were installed properly.

Carl J. Anderson
Ground Water Protection Program Manager
North Dakota Department of Health
Divison of Water Quality
701-328-5213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Map Scale: 1:37,200 if printed on A landscape (11" x 8.5") sheet.
N
Meters
0 500 1000 2000 3000
Feet
0 1500 3000 6000 9000
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Towner County, North Dakota
Survey Area Data: Version 18, Sep 25, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Oct 12, 2010—Oct 16, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F3A	Parnell silty clay loam, 0 to 1 percent slopes	Very limited	Parnell (64%)	Slow water movement (1.00)	76.1	2.6%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Vallers (10%)	Depth to saturated zone (1.00)		
				Leaching (0.70)		
			Vallers, moderately saline (9%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Southam (6%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Tonka (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Ferney (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
				Salinity (0.50)		

Manure and Food-Processing Waste— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F12A	Vallers, saline-Parnell complex, 0 to 1 percent slopes	Very limited	Vallers, moderately saline (40%)	Depth to saturated zone (1.00)	52.8	1.8%
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (27%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Tonka (7%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Manfred (5%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Sodium content (1.00)		
				Slow water movement (1.00)		
				Salinity (0.50)		
			Southam (4%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
				Salinity (0.01)		
			Wyard (3%)	Ponding (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Depth to saturated zone (0.86)		
			Easby (3%)	Depth to saturated zone (1.00)		
				Salinity (1.00)		
				Sodium content (1.00)		
				Droughty (1.00)		
				Slow water movement (0.50)		
F43A	Colvin silt loam, 0 to 1 percent slopes	Very limited	Colvin (62%)	Depth to saturated zone (1.00)	51.1	1.7%
				Slow water movement (0.50)		
				Leaching (0.50)		
			Arveson (8%)	Depth to saturated zone (1.00)		
				Leaching (0.90)		
			Colvin, very poorly drained (6%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Slow water movement (0.50)		
				Leaching (0.50)		
			Perella (5%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.70)		
			Kindred (3%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
				Slow water movement (0.50)		

Manure and Food-Processing Waste— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Colvin, moderately saline (3%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Slow water movement (0.50)		
				Leaching (0.50)		
				Sodium content (0.32)		
F107A	Hamerly-Barnes loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (45%)	Depth to saturated zone (0.86)	6.8	0.2%
			Balaton (11%)	Depth to saturated zone (0.22)		
F112A	Hamerly-Tonka-Parnell complex, 0 to 3 percent slopes	Very limited	Tonka (20%)	Slow water movement (1.00)	98.8	3.4%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Parnell (16%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Vallers, moderately saline (10%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Wyard (4%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Southam (3%)	Slow water movement (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
				Salinity (0.01)		
F143A	Barnes-Svea loams, 0 to 3 percent slopes	Not limited	Barnes (39%)		25.4	0.9%
			Svea (38%)			
			Buse (2%)			
F144B	Barnes-Buse loams, 3 to 6 percent slopes	Not limited	Barnes (25%)		110.4	3.8%
			Buse (24%)			
			Svea (14%)			
			Balaton (10%)			
			Langhei (4%)			
			Swenoda (3%)			
F304C	Coe-Binford complex, 6 to 9 percent slopes	Very limited	Coe (43%)	Droughty (1.00)	13.4	0.5%
				Leaching (0.45)		
			Coe (10%)	Droughty (1.00)		
				Leaching (0.45)		
F329A	Wyndmere fine sandy loam, 0 to 2 percent slopes	Somewhat limited	Wyndmere (73%)	Depth to saturated zone (0.84)	2.7	0.1%
			Wyrene (5%)	Depth to saturated zone (0.84)		
				Droughty (0.31)		
			Embden (3%)	Leaching (0.45)		
			Wyndmere, moderately saline (3%)	Depth to saturated zone (0.84)		
				Salinity (0.50)		
				Sodium content (0.32)		
				Droughty (0.25)		
F366A	Hecla loamy fine sand, 0 to 2 percent slopes	Somewhat limited	Hecla (62%)	Leaching (0.45)	5.9	0.2%
				Depth to saturated zone (0.02)		
			Hecla (9%)	Leaching (0.45)		
				Depth to saturated zone (0.02)		

Manure and Food-Processing Waste— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Embden (3%)	Leaching (0.45)		
F378A	Egeland-Embden fine sandy loams, 0 to 2 percent slopes	Somewhat limited	Egeland (51%)	Leaching (0.45)	76.1	2.6%
			Embden (32%)	Leaching (0.45)		
			Wyndmere (7%)	Depth to saturated zone (0.84)		
			Hecla (3%)	Leaching (0.45)		
				Depth to saturated zone (0.02)		
			Glyndon (2%)	Depth to saturated zone (0.86)		
F384B	Maddock-Hecla loamy fine sands, 0 to 6 percent slopes	Somewhat limited	Maddock (54%)	Leaching (0.45)	16.0	0.5%
				Droughty (0.12)		
			Hecla (24%)	Leaching (0.45)		
				Depth to saturated zone (0.02)		
			Bantry (4%)	Depth to saturated zone (0.84)		
				Droughty (0.72)		
				Leaching (0.45)		
			Hecla (4%)	Leaching (0.45)		
				Depth to saturated zone (0.02)		
			Maddock (4%)	Leaching (0.45)		
				Droughty (0.01)		
F411A	Fargo-Hegne silty clays, 0 to 1 percent slopes	Very limited	Fargo (48%)	Slow water movement (1.00)	16.1	0.5%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Hegne (47%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Leaching (0.50)		
			Dovray (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
F431A	Bearden silt loam, 0 to 2 percent slopes	Somewhat limited	Bearden (72%)	Depth to saturated zone (0.86)	472.1	16.1%
				Slow water movement (0.50)		
			Bearden, moderately saline (5%)	Depth to saturated zone (0.86)		
				Salinity (0.50)		
				Slow water movement (0.50)		
				Sodium content (0.32)		
F438A	Bearden-Lindaas silt loams, 0 to 2 percent slopes	Somewhat limited	Bearden (57%)	Depth to saturated zone (0.86)	433.6	14.8%
				Slow water movement (0.50)		
			Overly (6%)	Slow water movement (0.50)		
F460A	Aberdeen-Bearden complex, 0 to 2 percent slopes	Very limited	Aberdeen (45%)	Slow water movement (1.00)	53.0	1.8%
				Sodium content (0.18)		
			Lindaas (4%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		

Manure and Food-Processing Waste— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Colvin, moderately saline (3%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Salinity (0.50)		
				Slow water movement (0.50)		
				Leaching (0.50)		
			Nahon (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
			Fargo, saline-sodic substratum (2%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Exline (2%)	Slow water movement (1.00)		
				Sodium content (1.00)		
				Depth to saturated zone (0.86)		
				Salinity (0.78)		
				Runoff (0.40)		
F482A	Great Bend-Overly silt loams, 0 to 2 percent slopes	Somewhat limited	Great Bend (37%)	Slow water movement (0.50)	746.2	25.4%
			Overly, overflow (30%)	Slow water movement (0.50)		
			Bearden (13%)	Depth to saturated zone (0.86)		
				Slow water movement (0.50)		
F483B	Great Bend-Zell silt loams, 2 to	Somewhat limited	Great Bend (37%)	Slow water movement (0.30)	115.1	3.9%

Manure and Food-Processing Waste— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
	6 percent slopes		Overly (14%)	Slow water movement (0.50)		
			Egeland (11%)	Leaching (0.45)		
			Bearden (2%)	Depth to saturated zone (0.86)		
				Slow water movement (0.50)		
F523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	Very limited	Fluvaquents, channeled, frequently flooded (40%)	Ponding (1.00)	57.5	2.0%
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.90)		
			Lowe, frequently flooded (28%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
			Lowe, moderately saline, frequently flooded (20%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
				Salinity (0.50)		
			Lowe, very poorly drained, frequently flooded (5%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
F731A	Swenoda fine sandy loam, 0 to 3 percent slopes	Not limited	Swenoda (59%)		27.4	0.9%
			Towner (10%)			
			Barnes (10%)			
			Balaton (4%)			
			Lanona (3%)			
F732A	Swenoda-Barnes fine sandy loams, 0	Not limited	Swenoda (49%)		133.1	4.5%
			Barnes (20%)			

Manure and Food-Processing Waste— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
	to 3 percent slopes		Towner (10%)			
			Balaton (4%)			
			Lanona (3%)			
F732B	Swenoda-Barnes complex, 3 to 6 percent slopes	Not limited	Swenoda (39%)		26.1	0.9%
			Barnes (27%)			
			Lanona (12%)			
			Buse (5%)			
			Towner (5%)			
F805A	Bearden-Colvin silt loams, saline, 0 to 2 percent slopes	Very limited	Colvin, moderately saline (29%)	Ponding (1.00)	320.4	10.9%
				Depth to saturated zone (1.00)		
				Salinity (0.50)		
				Slow water movement (0.50)		
				Leaching (0.50)		
			Colvin (13%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Slow water movement (0.50)		
				Leaching (0.50)		
			Exline (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
				Depth to saturated zone (0.86)		
				Salinity (0.78)		
				Runoff (0.40)		
			Aberdeen (3%)	Slow water movement (1.00)		
				Sodium content (0.18)		
			Parnell (3%)	Slow water movement (1.00)		
				Ponding (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
Totals for Area of Interest					**2,936.2**	**100.0%**

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Somewhat limited	1,874.7	63.8%
Very limited	739.1	25.2%
Not limited	322.4	11.0%
Totals for Area of Interest	**2,936.2**	**100.0%**

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

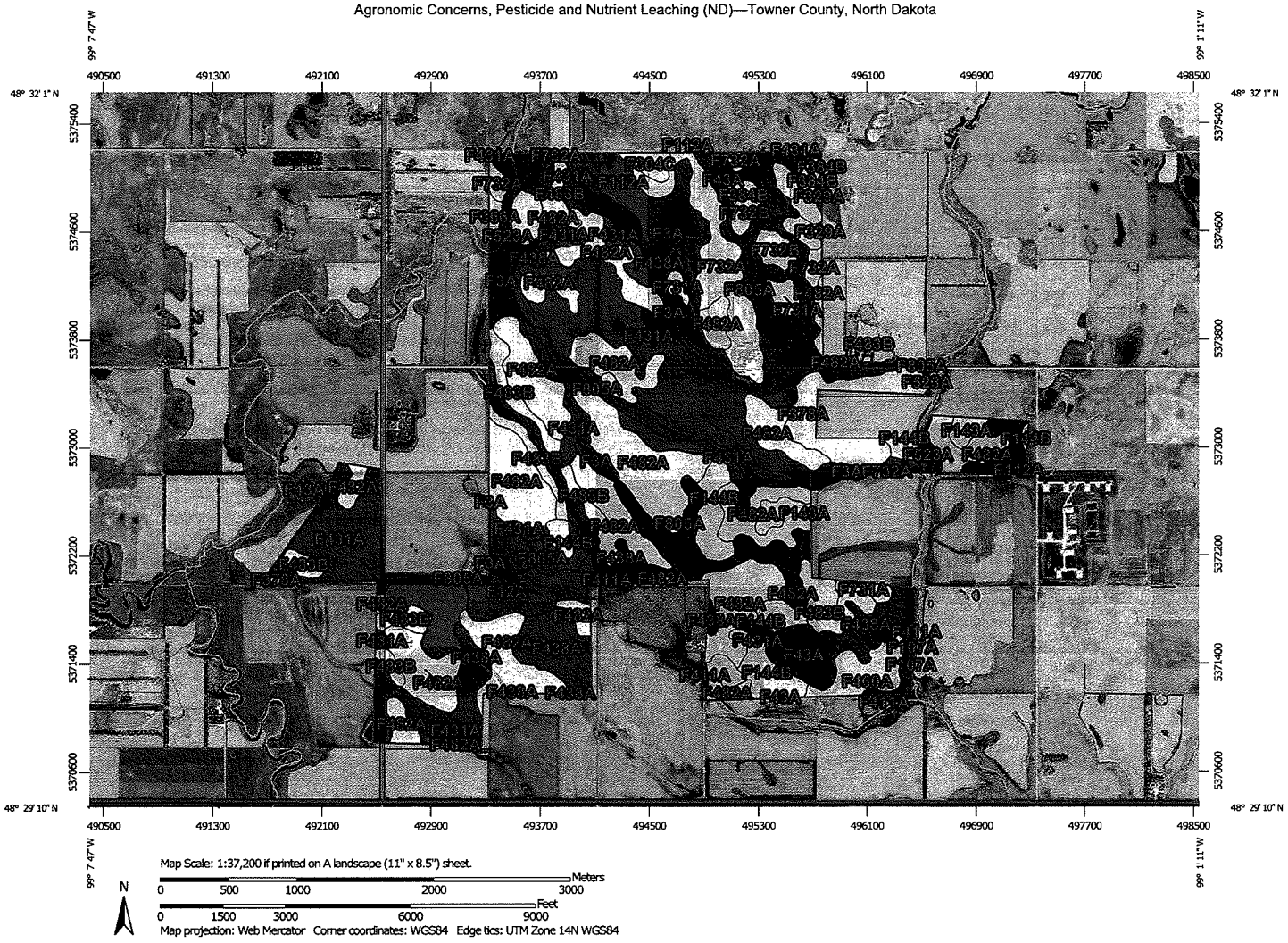
Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher



Map Scale: 1:37,200 if printed on A landscape (11" x 8.5") sheet.

N

Meters
0 500 1000 2000 3000

Feet
0 1500 3000 6000 9000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Towner County, North Dakota
Survey Area Data: Version 18, Sep 25, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Oct 12, 2010—Oct 16, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F3A	Parnell silty clay loam, 0 to 1 percent slopes	Very limited	Parnell (64%)	High water table (1.00)	76.1	2.6%
			Vallers (10%)	High water table (1.00)		
			Vallers, moderately saline (9%)	High water table (1.00)		
			Southam (6%)	High water table (1.00)		
			Tonka (5%)	High water table (1.00)		
			Hamerly (3%)	High water table (1.00)		
F12A	Vallers, saline-Parnell complex, 0 to 1 percent slopes	Very limited	Vallers, moderately saline (40%)	High water table (1.00)	52.8	1.8%
			Parnell (27%)	High water table (1.00)		
			Hamerly, moderately saline (11%)	High water table (1.00)		
			Tonka (7%)	High water table (1.00)		
			Manfred (5%)	High water table (1.00)		
			Southam (4%)	High water table (1.00)		
			Wyard (3%)	High water table (1.00)		
			Easby (3%)	High water table (1.00)		
F43A	Colvin silt loam, 0 to 1 percent slopes	Very limited	Colvin (62%)	High water table (1.00)	51.1	1.7%
			Bearden (10%)	High water table (1.00)		
			Arveson (8%)	High water table (1.00)		
				High perc rate (0.04)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Colvin, very poorly drained (6%)	High water table (1.00)		
			Perella (5%)	High water table (1.00)		
			Wyndmere (3%)	High water table (1.00)		
				High perc rate (0.03)		
			Kindred (3%)	High water table (1.00)		
			Colvin, moderately saline (3%)	High water table (1.00)		
F107A	Hamerly-Barnes loams, 0 to 3 percent slopes	Very limited	Hamerly (45%)	High water table (1.00)	6.8	0.2%
			Vallers (8%)	High water table (1.00)		
			Tonka (7%)	High water table (1.00)		
			Parnell (1%)	High water table (1.00)		
F112A	Hamerly-Tonka-Parnell complex, 0 to 3 percent slopes	Very limited	Hamerly (43%)	High water table (1.00)	98.8	3.4%
			Tonka (20%)	High water table (1.00)		
			Parnell (16%)	High water table (1.00)		
			Vallers, moderately saline (10%)	High water table (1.00)		
			Wyard (4%)	High water table (1.00)		
			Southam (3%)	High water table (1.00)		
F143A	Barnes-Svea loams, 0 to 3 percent slopes	Somewhat limited	Barnes (39%)	High water table (0.19)	25.4	0.9%
			Svea (38%)	High water table (0.76)		
			Cresbard (3%)	High water table (0.76)		
F144B	Barnes-Buse loams, 3 to 6 percent slopes	Somewhat limited	Barnes (25%)	High water table (0.19)	110.4	3.8%
			Svea (14%)	High water table (0.76)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Balaton (10%)	High water table (0.76)		
			Swenoda (3%)	High water table (0.76)		
			Cresbard (3%)	High water table (0.76)		
			Sioux (2%)	High perc rate (0.22)		
F304C	Coe-Binford complex, 6 to 9 percent slopes	Somewhat limited	Coe (43%)	High perc rate (0.22)	13.4	0.5%
			Binford (25%)	High perc rate (0.08)		
			Coe (10%)	High perc rate (0.08)		
			Walum (6%)	High water table (0.76)		
				High perc rate (0.08)		
			Brantford (5%)	High water table (0.19)		
			Lohnes (4%)	High perc rate (0.87)		
			Vang (4%)	High water table (0.76)		
F329A	Wyndmere fine sandy loam, 0 to 2 percent slopes	Very limited	Wyndmere (73%)	High water table (1.00)	2.7	0.1%
				High perc rate (0.04)		
			Wyrene (5%)	High water table (1.00)		
				High perc rate (0.08)		
			Tiffany (4%)	High water table (1.00)		
			Ulen (4%)	High water table (1.00)		
				High perc rate (0.87)		
			Wyndmere, moderately saline (3%)	High water table (1.00)		
				High perc rate (0.04)		
			Arveson (3%)	High water table (1.00)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				High perc rate (0.04)		
F366A	Hecla loamy fine sand, 0 to 2 percent slopes	Somewhat limited	Hecla (62%)	High water table (0.94)	5.9	0.2%
				High perc rate (0.08)		
			Hecla (9%)	High water table (0.94)		
				High perc rate (0.04)		
			Maddock (5%)	High perc rate (0.87)		
				High water table (0.19)		
			Falsen (5%)	High perc rate (0.98)		
				High water table (0.76)		
			Embden (3%)	High water table (0.76)		
				High perc rate (0.04)		
F378A	Egeland-Embden fine sandy loams, 0 to 2 percent slopes	Somewhat limited	Egeland (51%)	High water table (0.19)	76.1	2.6%
				High perc rate (0.04)		
			Embden (32%)	High water table (0.76)		
				High perc rate (0.04)		
			Hecla (3%)	High water table (0.94)		
				High perc rate (0.04)		
			Zell (3%)	High water table (0.19)		
			Maddock (2%)	High perc rate (0.87)		
				High water table (0.19)		
F384B	Maddock-Hecla loamy fine sands, 0 to 6 percent slopes	Somewhat limited	Maddock (54%)	High perc rate (0.87)	16.0	0.5%
				High water table (0.19)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)—Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Hecla (24%)	High water table (0.94)		
				High perc rate (0.08)		
			Hecla (4%)	High water table (0.94)		
				High perc rate (0.04)		
			Maddock (4%)	High water table (0.19)		
				High perc rate (0.04)		
			Arvilla (3%)	High perc rate (0.08)		
			Letcher (2%)	High water table (0.76)		
F411A	Fargo-Hegne silty clays, 0 to 1 percent slopes	Very limited	Fargo (48%)	High water table (1.00)	16.1	0.5%
			Hegne (47%)	High water table (1.00)		
			Dovray (3%)	High water table (1.00)		
			Bearden (2%)	High water table (1.00)		
F431A	Bearden silt loam, 0 to 2 percent slopes	Very limited	Bearden (72%)	High water table (1.00)	472.1	16.1%
			Kindred (7%)	High water table (1.00)		
			Perella (7%)	High water table (1.00)		
			Bearden, moderately saline (5%)	High water table (1.00)		
			Colvin, moderately saline (4%)	High water table (1.00)		
F438A	Bearden-Lindaas silt loams, 0 to 2 percent slopes	Very limited	Bearden (57%)	High water table (1.00)	433.6	14.8%
			Lindaas (20%)	High water table (1.00)		
			Colvin, moderately saline (6%)	High water table (1.00)		
			Kindred (3%)	High water table (1.00)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F460A	Aberdeen-Bearden complex, 0 to 2 percent slopes	Somewhat limited	Aberdeen (45%)	High water table (0.76)	53.0	1.8%
			Overly, saline-sodic substratum (7%)	High water table (0.76)		
			Great Bend (5%)	High water table (0.19)		
			Nahon (3%)	High water table (0.76)		
F482A	Great Bend-Overly silt loams, 0 to 2 percent slopes	Somewhat limited	Great Bend (37%)	High water table (0.19)	746.2	25.4%
			Overly, overflow (30%)	High water table (0.76)		
			Aberdeen (2%)	High water table (0.76)		
			Zell (2%)	High water table (0.19)		
F483B	Great Bend-Zell silt loams, 2 to 6 percent slopes	Somewhat limited	Great Bend (37%)	High water table (0.19)	115.1	3.9%
			Zell (34%)	High water table (0.19)		
			Overly (14%)	High water table (0.76)		
			Egeland (11%)	High water table (0.19)		
				High perc rate (0.04)		
			Coe (1%)	High perc rate (0.08)		
F523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	Very limited	Fluvaquents, channeled, frequently flooded (40%)	High water table (1.00)	57.5	2.0%
				High perc rate (0.21)		
			Lowe, frequently flooded (28%)	High water table (1.00)		
			Lowe, moderately saline, frequently flooded (20%)	High water table (1.00)		
			Moritz, occasionally flooded (5%)	High water table (1.00)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Lowe, very poorly drained, frequently flooded (5%)	High water table (1.00)		
F731A	Swenoda fine sandy loam, 0 to 3 percent slopes	Somewhat limited	Swenoda (59%)	High water table (0.76)	27.4	0.9%
			Towner (10%)	High water table (0.76)		
			Barnes (10%)	High water table (0.19)		
			Balaton (4%)	High water table (0.76)		
			Lanona (3%)	High water table (0.19)		
F732A	Swenoda-Barnes fine sandy loams, 0 to 3 percent slopes	Somewhat limited	Swenoda (49%)	High water table (0.76)	133.1	4.5%
			Barnes (20%)	High water table (0.19)		
			Towner (10%)	High water table (0.76)		
			Balaton (4%)	High water table (0.76)		
			Lanona (3%)	High water table (0.19)		
F732B	Swenoda-Barnes complex, 3 to 6 percent slopes	Somewhat limited	Swenoda (39%)	High water table (0.76)	26.1	0.9%
			Barnes (27%)	High water table (0.19)		
			Lanona (12%)	High water table (0.19)		
			Towner (5%)	High water table (0.76)		
F805A	Bearden-Colvin silt loams, saline, 0 to 2 percent slopes	Very limited	Bearden, moderately saline (32%)	High water table (1.00)	320.4	10.9%
			Colvin, moderately saline (29%)	High water table (1.00)		
			Bearden (14%)	High water table (1.00)		
			Colvin (13%)	High water table (1.00)		
			Exline (3%)	High water table (1.00)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Parnell (3%)	High water table (1.00)		
Totals for Area of Interest					**2,936.2**	**100.0%**

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Very limited	1,588.0	54.1%
Somewhat limited	1,348.2	45.9%
Totals for Area of Interest	**2,936.2**	**100.0%**

Description

The interpretation for Agronomic Concerns, Pesticide and Nutrient Leaching evaluates limitations of a soil that increase the hazard of contaminating aquifers, springs, and local water tables.

The soil features considered are saturated hydraulic conductivity and depth to seasonal high water table.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soil is limited by all of the soil features that affect the interpretation. Numerical ratings indicate the severity of individual limitations; the highest numerical rating identifies the most limiting soil feature(s) considered in the rating process. Less restrictive soil features have a lower numerical value than the maximum used to rate the soil. They are identified to provide the user with additional information about soil limitations for the specific use. Restrictive soil features also need to be considered in planning, design, installation, and management. "Not limited" (numerical value for the most restrictive feature = 0.00) indicates that the soil has features that are very favorable for the specified use. "Somewhat limited" (numerical value for the most restrictive feature = 0.01 to 0.99) indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning. "Very limited" (numerical value for the most restrictive feature = 1.00) indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special planning, or expensive installation procedures.

The results of this interpretation are not designed or intended to be used in a regulatory manner.

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

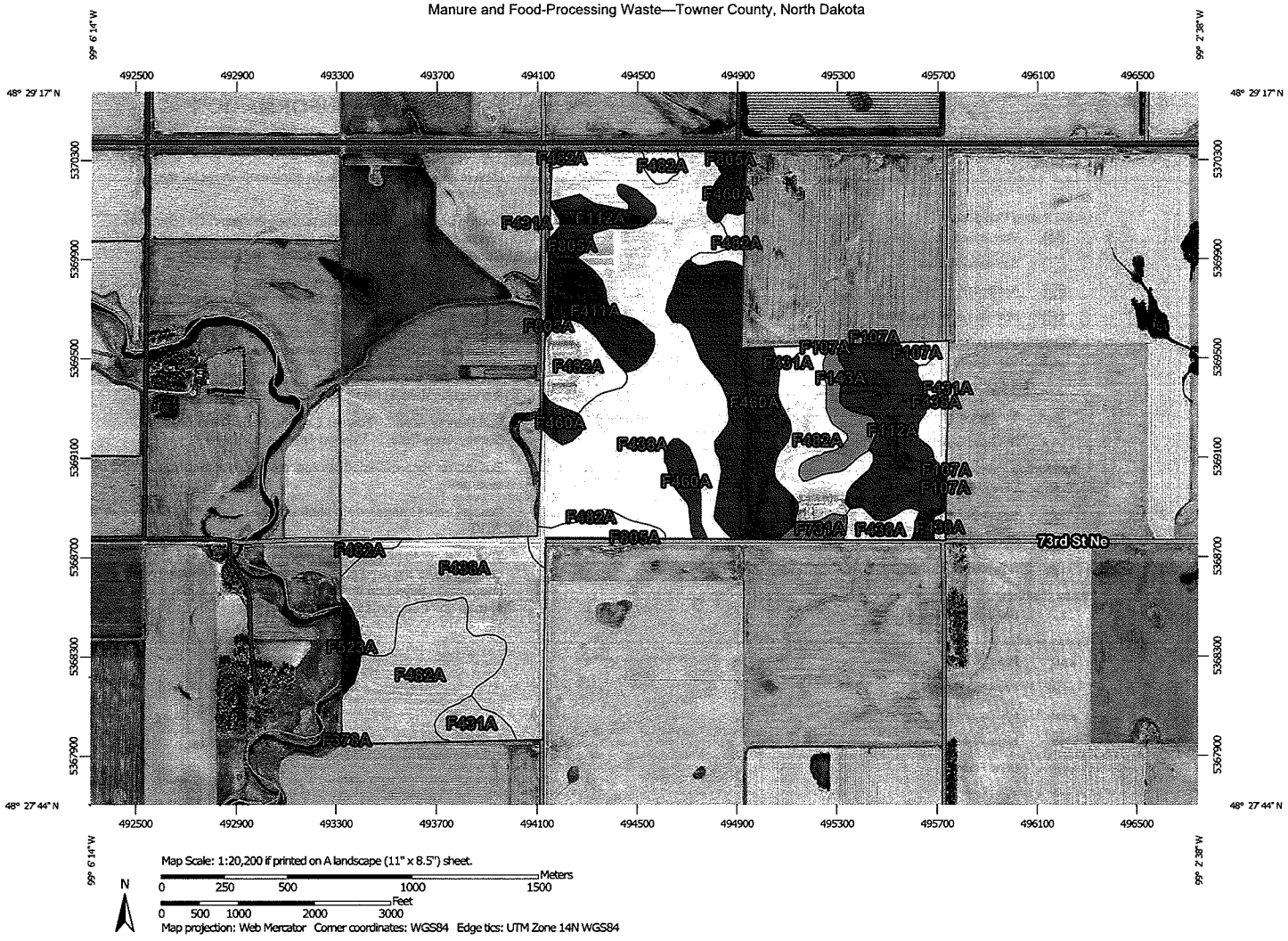
Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher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48° 29' 17" N
48° 27' 44" N
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495300
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F305A
F111A
F160A
F107A
F143A
F498A
F523A
73rd St Ne
Map Scale: 1:20,200 if printed on A landscape (11" x 8.5") sheet.
Meters
0 250 500 1000 1500
Feet
0 500 1000 2000 3000
N
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Background
- Aerial Photography

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Towner County, North Dakota
Survey Area Data: Version 18, Sep 25, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Oct 12, 2010—Oct 16, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F107A	Hamerly-Barnes loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (45%)	Depth to saturated zone (0.86)	2.6	0.4%
			Balaton (11%)	Depth to saturated zone (0.22)		
F112A	Hamerly-Tonka-Parnell complex, 0 to 3 percent slopes	Very limited	Tonka (20%)	Slow water movement (1.00)	62.6	9.9%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Parnell (16%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Vallers, moderately saline (10%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Wyard (4%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Southam (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		

Manure and Food-Processing Waste— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Salinity (0.01)		
F119A	Vallers-Hamerly loams, saline, 0 to 3 percent slopes	Very limited	Vallers, moderately saline (45%)	Depth to saturated zone (1.00)	2.0	0.3%
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Cresbard (6%)	Slow water movement (1.00)		
				Sodium content (0.32)		
			Tonka (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Easby (2%)	Depth to saturated zone (1.00)		
				Salinity (1.00)		
				Sodium content (1.00)		
				Droughty (1.00)		
				Slow water movement (0.50)		
			Parnell (2%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
F143A	Barnes-Svea loams, 0 to 3 percent slopes	Not limited	Barnes (39%)		13.9	2.2%
			Svea (38%)			
			Buse (2%)			
F378A	Egeland-Embden fine sandy loams, 0	Somewhat limited	Egeland (51%)	Leaching (0.45)	0.4	0.1%
			Embden (32%)	Leaching (0.45)		

Manure and Food-Processing Waste— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
	to 2 percent slopes		Wyndmere (7%)	Depth to saturated zone (0.84)		
			Hecla (3%)	Leaching (0.45)		
				Depth to saturated zone (0.02)		
			Glyndon (2%)	Depth to saturated zone (0.86)		
F411A	Fargo-Hegne silty clays, 0 to 1 percent slopes	Very limited	Fargo (48%)	Slow water movement (1.00)	24.1	3.8%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Hegne (47%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Dovray (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
F431A	Bearden silt loam, 0 to 2 percent slopes	Somewhat limited	Bearden (72%)	Depth to saturated zone (0.86)	12.0	1.9%
				Slow water movement (0.50)		
			Bearden, moderately saline (5%)	Depth to saturated zone (0.86)		
				Salinity (0.50)		
				Slow water movement (0.50)		

Manure and Food-Processing Waste— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Sodium content (0.32)		
F438A	Bearden-Lindaas silt loams, 0 to 2 percent slopes	Somewhat limited	Bearden (57%)	Depth to saturated zone (0.86)	269.0	42.6%
				Slow water movement (0.50)		
			Overly (6%)	Slow water movement (0.50)		
F460A	Aberdeen-Bearden complex, 0 to 2 percent slopes	Very limited	Aberdeen (45%)	Slow water movement (1.00)	91.2	14.5%
				Sodium content (0.18)		
			Lindaas (4%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Nahon (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
			Colvin, moderately saline (3%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Salinity (0.50)		
				Slow water movement (0.50)		
				Leaching (0.50)		
			Exline (2%)	Slow water movement (1.00)		
				Sodium content (1.00)		
				Depth to saturated zone (0.86)		
				Salinity (0.78)		

Manure and Food-Processing Waste— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Runoff (0.40)		
			Fargo, saline-sodic substratum (2%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
F482A	Great Bend-Overly silt loams, 0 to 2 percent slopes	Somewhat limited	Great Bend (37%)	Slow water movement (0.50)	137.6	21.8%
			Overly, overflow (30%)	Slow water movement (0.50)		
			Bearden (13%)	Depth to saturated zone (0.86)		
				Slow water movement (0.50)		
F523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	Very limited	Fluvaquents, channeled, frequently flooded (40%)	Ponding (1.00)	5.8	0.9%
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.90)		
			Lowe, frequently flooded (28%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
			Lowe, moderately saline, frequently flooded (20%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
				Salinity (0.50)		
			Lowe, very poorly drained, frequently flooded (5%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Leaching (0.70)		
F731A	Swenoda fine sandy loam, 0 to 3 percent slopes	Not limited	Swenoda (59%)		4.6	0.7%
			Towner (10%)			
			Barnes (10%)			
			Balaton (4%)			
			Lanona (3%)			
F805A	Bearden-Colvin silt loams, saline, 0 to 2 percent slopes	Very limited	Colvin, moderately saline (29%)	Ponding (1.00)	5.3	0.8%
				Depth to saturated zone (1.00)		
				Salinity (0.50)		
				Slow water movement (0.50)		
				Leaching (0.50)		
			Colvin (13%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Slow water movement (0.50)		
				Leaching (0.50)		
			Aberdeen (3%)	Slow water movement (1.00)		
				Sodium content (0.18)		
			Parnell (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Exline (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
				Depth to saturated zone (0.86)		
				Salinity (0.78)		

Manure and Food-Processing Waste— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Runoff (0.40)		
Totals for Area of Interest					**631.2**	**100.0%**

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Somewhat limited	421.6	66.8%
Very limited	191.1	30.3%
Not limited	18.5	2.9%
Totals for Area of Interest	**631.2**	**100.0%**

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

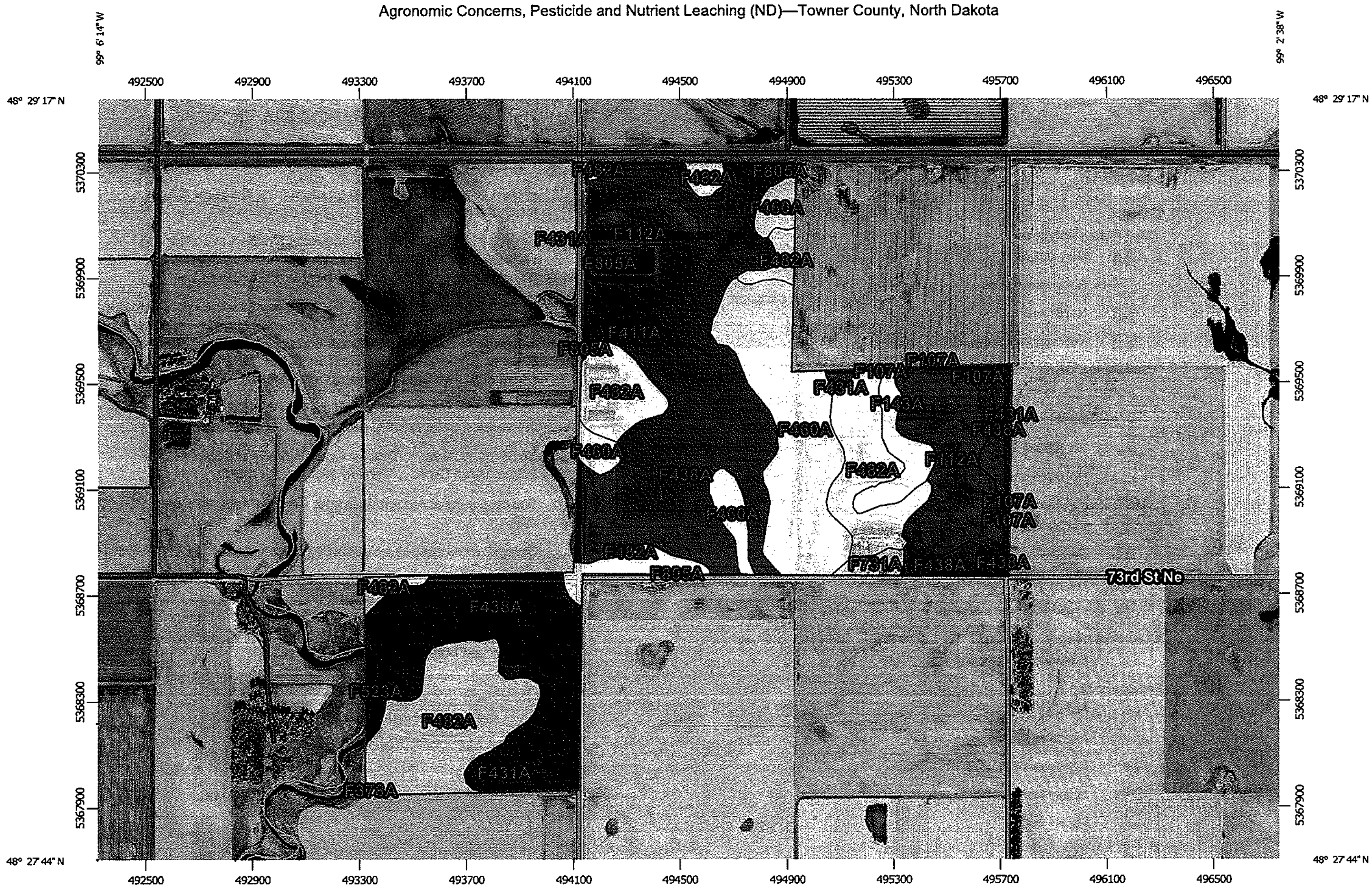
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)—Towner County, North Dakota



Map Scale: 1:20,200 if printed on A landscape (11" x 8.5") sheet.

Meters: 0, 250, 500, 1000, 1500

Feet: 0, 500, 1000, 2000, 3000

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Towner County, North Dakota
Survey Area Data: Version 18, Sep 25, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Oct 12, 2010—Oct 16, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F107A	Hamerly-Barnes loams, 0 to 3 percent slopes	Very limited	Hamerly (45%)	High water table (1.00)	2.6	0.4%
			Vallers (8%)	High water table (1.00)		
			Tonka (7%)	High water table (1.00)		
			Parnell (1%)	High water table (1.00)		
F112A	Hamerly-Tonka-Parnell complex, 0 to 3 percent slopes	Very limited	Hamerly (43%)	High water table (1.00)	62.6	9.9%
			Tonka (20%)	High water table (1.00)		
			Parnell (16%)	High water table (1.00)		
			Vallers, moderately saline (10%)	High water table (1.00)		
			Wyard (4%)	High water table (1.00)		
			Southam (3%)	High water table (1.00)		
F119A	Vallers-Hamerly loams, saline, 0 to 3 percent slopes	Very limited	Vallers, moderately saline (45%)	High water table (1.00)	2.0	0.3%
			Hamerly, moderately saline (31%)	High water table (1.00)		
			Hamerly (7%)	High water table (1.00)		
			Tonka (3%)	High water table (1.00)		
			Easby (2%)	High water table (1.00)		
			Parnell (2%)	High water table (1.00)		
F143A	Barnes-Svea loams, 0 to 3 percent slopes	Somewhat limited	Barnes (39%)	High water table (0.19)	13.9	2.2%
			Svea (38%)	High water table (0.76)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Cresbard (3%)	High water table (0.76)		
F378A	Egeland-Embden fine sandy loams, 0 to 2 percent slopes	Somewhat limited	Egeland (51%)	High water table (0.19)	0.4	0.1%
				High perc rate (0.04)		
			Embden (32%)	High water table (0.76)		
				High perc rate (0.04)		
			Zell (3%)	High water table (0.19)		
			Hecla (3%)	High water table (0.94)		
				High perc rate (0.04)		
			Maddock (2%)	High perc rate (0.87)		
				High water table (0.19)		
F411A	Fargo-Hegne silty clays, 0 to 1 percent slopes	Very limited	Fargo (48%)	High water table (1.00)	24.1	3.8%
			Hegne (47%)	High water table (1.00)		
			Dovray (3%)	High water table (1.00)		
			Bearden (2%)	High water table (1.00)		
F431A	Bearden silt loam, 0 to 2 percent slopes	Very limited	Bearden (72%)	High water table (1.00)	12.0	1.9%
			Kindred (7%)	High water table (1.00)		
			Perella (7%)	High water table (1.00)		
			Bearden, moderately saline (5%)	High water table (1.00)		
			Colvin, moderately saline (4%)	High water table (1.00)		
F438A	Bearden-Lindaas silt loams, 0 to 2 percent slopes	Very limited	Bearden (57%)	High water table (1.00)	269.0	42.6%
			Lindaas (20%)	High water table (1.00)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Colvin, moderately saline (6%)	High water table (1.00)		
			Kindred (3%)	High water table (1.00)		
F460A	Aberdeen-Bearden complex, 0 to 2 percent slopes	Somewhat limited	Aberdeen (45%)	High water table (0.76)	91.2	14.5%
			Overly, saline-sodic substratum (7%)	High water table (0.76)		
			Great Bend (5%)	High water table (0.19)		
			Nahon (3%)	High water table (0.76)		
F482A	Great Bend-Overly silt loams, 0 to 2 percent slopes	Somewhat limited	Great Bend (37%)	High water table (0.19)	137.6	21.8%
			Overly, overflow (30%)	High water table (0.76)		
			Aberdeen (2%)	High water table (0.76)		
			Zell (2%)	High water table (0.19)		
F523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	Very limited	Fluvaquents, channeled, frequently flooded (40%)	High water table (1.00)	5.8	0.9%
				High perc rate (0.21)		
			Lowe, frequently flooded (28%)	High water table (1.00)		
			Lowe, moderately saline, frequently flooded (20%)	High water table (1.00)		
			Moritz, occasionally flooded (5%)	High water table (1.00)		
			Lowe, very poorly drained, frequently flooded (5%)	High water table (1.00)		
F731A	Swenoda fine sandy loam, 0 to 3 percent slopes	Somewhat limited	Swenoda (59%)	High water table (0.76)	4.6	0.7%
			Towner (10%)	High water table (0.76)		
			Barnes (10%)	High water table (0.19)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Towner County, North Dakota (ND095)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Balaton (4%)	High water table (0.76)		
			Lanona (3%)	High water table (0.19)		
F805A	Bearden-Colvin silt loams, saline, 0 to 2 percent slopes	Very limited	Bearden, moderately saline (32%)	High water table (1.00)	5.3	0.8%
			Colvin, moderately saline (29%)	High water table (1.00)		
			Bearden (14%)	High water table (1.00)		
			Colvin (13%)	High water table (1.00)		
			Parnell (3%)	High water table (1.00)		
			Exline (3%)	High water table (1.00)		
Totals for Area of Interest					**631.2**	**100.0%**

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Very limited	383.5	60.8%
Somewhat limited	247.7	39.2%
Totals for Area of Interest	**631.2**	**100.0%**

Description

The interpretation for Agronomic Concerns, Pesticide and Nutrient Leaching evaluates limitations of a soil that increase the hazard of contaminating aquifers, springs, and local water tables.

The soil features considered are saturated hydraulic conductivity and depth to seasonal high water table.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soil is limited by all of the soil features that affect the interpretation. Numerical ratings indicate the severity of individual limitations; the highest numerical rating identifies the most limiting soil feature(s) considered in the rating process. Less restrictive soil features have a lower numerical value than the maximum used to rate the soil. They are identified to provide the user with additional information about soil limitations for the specific use. Restrictive soil features also need to be considered in planning, design, installation, and management. "Not limited" (numerical value for the most restrictive feature = 0.00) indicates that the soil has features that are very favorable for the specified use. "Somewhat limited" (numerical value for the most restrictive feature = 0.01 to 0.99) indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning. "Very limited" (numerical value for the most restrictive feature = 1.00) indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special planning, or expensive installation procedures.

The results of this interpretation are not designed or intended to be used in a regulatory manner.

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

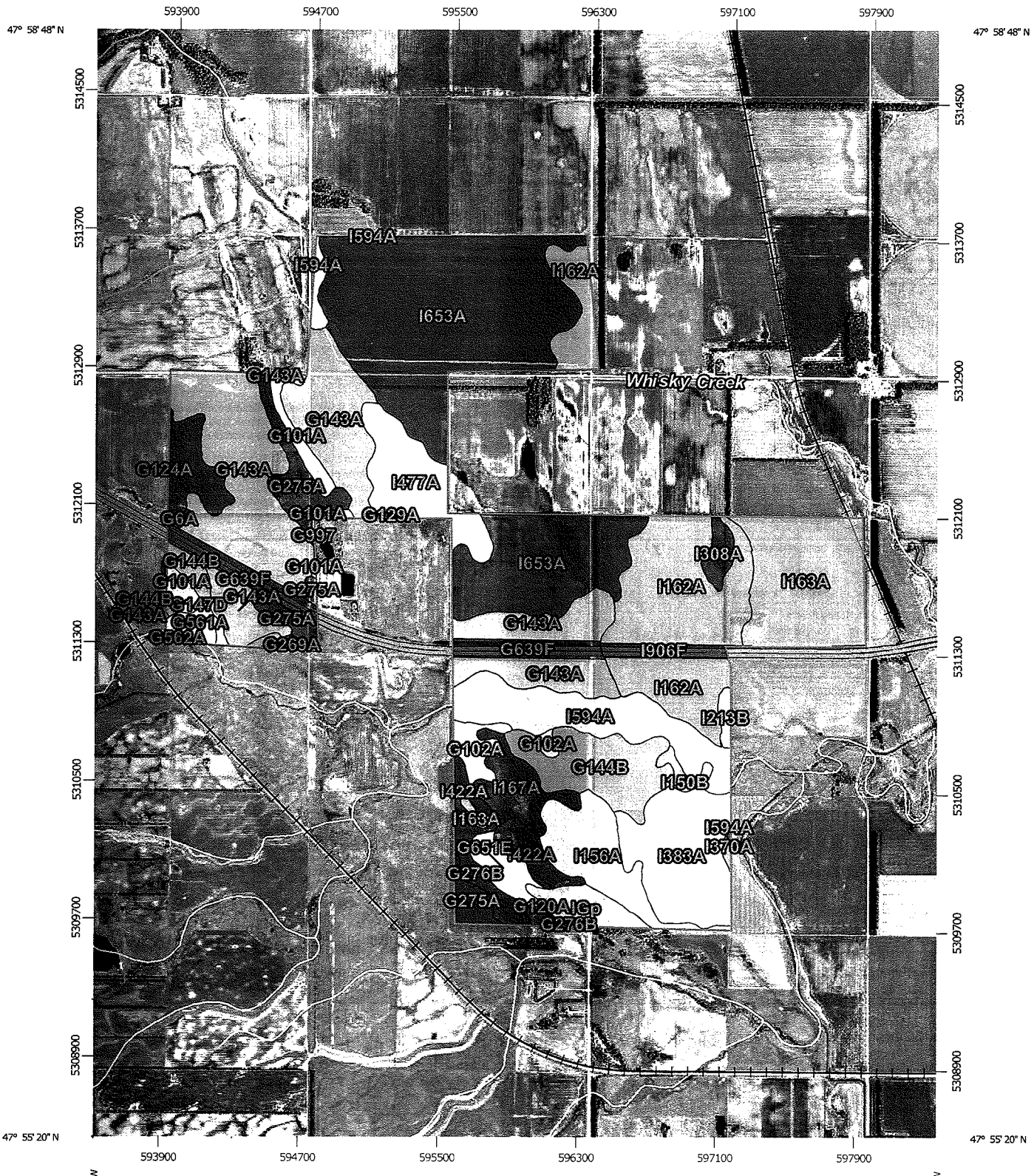
Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher



Map Scale: 1:31,200 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0 450 900 1800 2700

Feet: 0 1500 3000 6000 9000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Grand Forks County, North Dakota
Survey Area Data: Version 19, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 7, 2011—Jul 31, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Grand Forks County, North Dakota (ND035)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G6A	Vallers loam, 0 to 1 percent slopes	Very limited	Vallers (67%)	Depth to saturated zone (1.00)	2.9	0.2%
				Leaching (0.70)		
			Vallers, moderately saline (8%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Tonka (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Parnell (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cresbard (2%)	Slow water movement (1.00)		
				Sodium content (0.32)		
G25A	Marysland loam, 0 to 1 percent slopes	Very limited	Marysland (74%)	Depth to saturated zone (1.00)	2.2	0.1%
				Leaching (0.70)		
			Marysland, very poorly drained (7%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.70)		

Manure and Food-Processing Waste— Summary by Map Unit — Grand Forks County, North Dakota (ND035)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Totten (5%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Sodium content (1.00)		
				Salinity (0.50)		
				Slow water movement (0.50)		
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (46%)	Depth to saturated zone (0.86)	23.9	1.3%
			Balaton (7%)	Depth to saturated zone (0.22)		
			Hamerly, moderately saline (5%)	Depth to saturated zone (0.86)		
				Salinity (0.50)		
				Sodium content (0.18)		
G102A	Hamerly loam, 0 to 3 percent slopes	Somewhat limited	Hamerly (87%)	Depth to saturated zone (0.86)	19.9	1.0%
			Divide, loamy substratum (4%)	Depth to saturated zone (0.86)		
G120A	Vallers, saline-Manfred complex, 0 to 1 percent slopes	Very limited	Vallers, moderately saline (45%)	Depth to saturated zone (1.00)	4.2	0.2%
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Manfred (25%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Sodium content (1.00)		
				Slow water movement (1.00)		
				Salinity (0.50)		

Manure and Food-Processing Waste— Summary by Map Unit — Grand Forks County, North Dakota (ND035)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Easby (6%)	Depth to saturated zone (1.00)		
				Salinity (1.00)		
				Sodium content (1.00)		
				Droughty (1.00)		
				Slow water movement (0.50)		
			Parnell (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Wyard (5%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Tonka (4%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Ferney (2%)	Slow water movement (1.00)		
				Sodium content (1.00)		
				Salinity (0.50)		
G124A	Cresbard-Cavour loams, 0 to 3 percent slopes	Very limited	Cresbard (49%)	Slow water movement (1.00)	34.1	1.8%
				Sodium content (0.18)		
			Cavour (25%)	Slow water movement (1.00)		
				Sodium content (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Grand Forks County, North Dakota (ND035)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Ferney (5%)	Slow water movement (1.00)		
				Sodium content (1.00)		
				Salinity (0.50)		
			Tonka (2%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Vallers, moderately saline (2%)	Depth to saturated zone (1.00)		
				Leaching (0.70)		
				Salinity (0.50)		
				Sodium content (0.32)		
				Droughty (0.03)		
G129A	Cavour-Ferney loams, 0 to 3 percent slopes	Very limited	Cavour (50%)	Slow water movement (1.00)	1.4	0.1%
				Sodium content (1.00)		
			Ferney (25%)	Slow water movement (1.00)		
				Sodium content (1.00)		
				Salinity (0.50)		
			Vallers, moderately saline (6%)	Depth to saturated zone (1.00)		
				Leaching (0.70)		
				Salinity (0.50)		
				Sodium content (0.32)		
				Droughty (0.03)		
			Manfred (5%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Grand Forks County, North Dakota (ND035)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Sodium content (1.00)		
				Salinity (0.50)		
				Slow water movement (0.50)		
			Cresbard (3%)	Slow water movement (1.00)		
				Sodium content (0.18)		
G143A	Barnes-Svea loams, 0 to 3 percent slopes	Not limited	Barnes (39%)		324.7	17.1%
			Svea (38%)			
			Buse (2%)			
G143C	Barnes-Buse-Langhei loams, 6 to 9 percent slopes	Not limited	Barnes (24%)		2.1	0.1%
			Buse (23%)			
			Langhei (18%)			
			Svea (14%)			
			Balaton (3%)			
			Lanona (3%)			
G144B	Barnes-Buse loams, 3 to 6 percent slopes	Not limited	Barnes (25%)		84.8	4.5%
			Buse (24%)			
			Svea (14%)			
			Balaton (10%)			
			Langhei (4%)			
			Swenoda (3%)			
G147D	Buse-Barnes-Darnen loams, 6 to 15 percent slopes	Somewhat limited	Buse (28%)	Slope (0.84)	7.5	0.4%
			Barnes (26%)	Slope (0.63)		
			Langhei (9%)	Slope (0.84)		
			Langhei, very stony (6%)	Slope (0.84)		
				Large stones (0.47)		
G148D	Buse-Barnes-La Prairie, occasionally flooded loams, 6 to 15 percent slopes	Somewhat limited	Buse (31%)	Slope (0.84)	0.1	0.0%
			Barnes (28%)	Slope (0.63)		
			La Prairie, occasionally flooded (18%)	Flooding (0.60)		
			Langhei (9%)	Slope (0.84)		
			Langhei, very stony (6%)	Slope (0.84)		
				Large stones (0.47)		

Manure and Food-Processing Waste— Summary by Map Unit — Grand Forks County, North Dakota (ND035)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G269A	Fordville-Renshaw loams, 0 to 2 percent slopes	Very limited	Fordville (54%)	Filtering capacity (1.00)	3.4	0.2%
			Renshaw (23%)	Filtering capacity (1.00)		
				Droughty (0.52)		
			Warsing (7%)	Filtering capacity (1.00)		
				Droughty (0.01)		
			Arvilla (4%)	Filtering capacity (1.00)		
				Droughty (0.98)		
				Leaching (0.45)		
			Sioux (3%)	Filtering capacity (1.00)		
				Leaching (0.45)		
				Droughty (0.18)		
			Osakis (3%)	Filtering capacity (1.00)		
				Droughty (0.90)		
				Leaching (0.45)		
G275A	Renshaw loam, 0 to 2 percent slopes	Very limited	Renshaw (67%)	Filtering capacity (1.00)	58.9	3.1%
				Droughty (0.52)		
			Sioux (12%)	Filtering capacity (1.00)		
				Leaching (0.45)		
				Droughty (0.18)		
			Warsing (8%)	Filtering capacity (1.00)		
				Droughty (0.01)		
			Fordville (5%)	Filtering capacity (1.00)		
			Arvilla, thick surface (4%)	Filtering capacity (1.00)		
				Droughty (0.74)		
				Leaching (0.45)		
G276B	Renshaw-Sioux complex, 2 to 6 percent slopes	Very limited	Renshaw (36%)	Filtering capacity (1.00)	22.3	1.2%
				Droughty (0.52)		
			Sioux (20%)	Filtering capacity (1.00)		
				Leaching (0.45)		

Manure and Food-Processing Waste— Summary by Map Unit — Grand Forks County, North Dakota (ND035)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Droughty (0.18)		
			Sioux (10%)	Filtering capacity (1.00)		
				Leaching (0.45)		
				Droughty (0.15)		
			Fordville (10%)	Filtering capacity (1.00)		
			Osakis (7%)	Filtering capacity (1.00)		
				Droughty (0.90)		
				Leaching (0.45)		
			Warsing (6%)	Filtering capacity (1.00)		
				Droughty (0.01)		
			Arvilla (4%)	Filtering capacity (1.00)		
				Droughty (0.98)		
				Leaching (0.45)		
			Marysland (3%)	Depth to saturated zone (1.00)		
				Leaching (0.70)		
G561A	La Prairie loam, 0 to 2 percent slopes, occasionally flooded	Somewhat limited	La Prairie, occasionally flooded (73%)	Flooding (0.60)	5.0	0.3%
			Velva, moist, occasionally flooded (10%)	Flooding (0.60)		
				Leaching (0.45)		
			Fairdale, occasionally flooded (2%)	Flooding (0.60)		
				Slow water movement (0.50)		
G562A	La Prairie-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	Very limited	La Prairie, frequently flooded (35%)	Flooding (1.00)	2.1	0.1%
			Fluvaquents, channeled, frequently flooded (33%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.90)		
			Velva, moist, frequently flooded (10%)	Flooding (1.00)		
				Leaching (0.45)		

Manure and Food-Processing Waste— Summary by Map Unit — Grand Forks County, North Dakota (ND035)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Fairdale, frequently flooded (10%)	Flooding (1.00)		
				Slow water movement (0.50)		
			Ludden, moderately saline, frequently flooded (5%)	Slow water movement (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Salinity (0.50)		
				Leaching (0.50)		
			Lowe, frequently flooded (4%)	Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
			Rauville, frequently flooded (3%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Slow water movement (0.50)		
				Leaching (0.50)		
G639F	Orthents-Aquents-Urban Land, highway complex, 0 to 35 percent slopes	Very limited	Orthents (41%)	Slope (1.00)	46.9	2.5%
				Slow water movement (0.50)		
				Large stones (0.04)		
			Aquents, clayey (16%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Renshaw (6%)	Filtering capacity (1.00)		
				Droughty (0.52)		

Manure and Food-Processing Waste— Summary by Map Unit — Grand Forks County, North Dakota (ND035)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Parnell (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
G651E	Udarents loamy, abandoned gravel pits, 0 to 25 percent slopes	Somewhat limited	Udarents, loamy, abandoned gravel pits (74%)	Slope (0.63)	20.2	1.1%
				Slow water movement (0.50)		
				Large stones (0.04)		
			Binford (3%)	Leaching (0.45)		
				Droughty (0.01)		
G997	Water, intermittent	Not rated	Water, intermittent (80%)		0.3	0.0%
I150B	Zell, fine-silty-LaDelle silt loams, 2 to 6 percent slopes	Not limited	Zell (55%)		7.8	0.4%
			LaDelle (35%)			
I156A	Antler silt loam, 0 to 2 percent slopes	Somewhat limited	Antler (80%)	Depth to saturated zone (0.86)	64.3	3.4%
				Slow water movement (0.41)		
			Lankin (5%)	Slow water movement (0.41)		
			Antler, moderately saline (5%)	Depth to saturated zone (0.86)		
				Salinity (0.50)		
				Slow water movement (0.41)		
				Sodium content (0.32)		
I162A	Walsh loam, 0 to 2 percent slopes	Not limited	Walsh (85%)		204.1	10.7%
			Inkster (3%)			
I163A	Inkster sandy loam, 0 to 3 percent slopes	Not limited	Inkster (85%)		129.2	6.8%

Manure and Food-Processing Waste— Summary by Map Unit — Grand Forks County, North Dakota (ND035)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
I167A	Exline-Aberdeen silty clays, 0 to 1 percent slopes	Very limited	Exline (60%)	Slow water movement (1.00)	38.1	2.0%
				Sodium content (1.00)		
				Depth to saturated zone (0.86)		
				Salinity (0.50)		
				Runoff (0.40)		
			Aberdeen (30%)	Slow water movement (1.00)		
				Sodium content (0.82)		
			Nutley (10%)	Slow water movement (1.00)		
I213B	Embden fine sandy loam, 2 to 6 percent slopes	Somewhat limited	Embden (55%)	Leaching (0.45)	5.2	0.3%
			Maddock (10%)	Leaching (0.45)		
				Droughty (0.38)		
			Egeland (10%)	Leaching (0.45)		
			Embden, nearly level (10%)	Leaching (0.45)		
			Hecla (5%)	Leaching (0.45)		
				Depth to saturated zone (0.02)		
I308A	Tiffany loam, 0 to 1 percent slopes	Very limited	Tiffany (72%)	Ponding (1.00)	12.4	0.7%
				Depth to saturated zone (1.00)		
				Leaching (0.70)		
			Arveson (10%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.90)		
			Delamere (5%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Hamar (2%)	Ponding (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Grand Forks County, North Dakota (ND035)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Depth to saturated zone (1.00)		
				Leaching (0.90)		
				Droughty (0.00)		
			Venlo (1%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.90)		
I370A	Rauville silty clay loam, 0 to 1 percent slopes, frequently flooded	Very limited	Rauville (70%)	Ponding (1.00)	0.4	0.0%
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
			Lamoure (10%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.70)		
				Flooding (0.60)		
			Marysland (5%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.70)		
			Lowe, moderately saline (3%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.70)		
				Flooding (0.60)		
				Salinity (0.50)		
			Fluvaquents, channeled, frequently flooded (2%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.90)		
I383A	Overly silty clay loam, 0 to 2 percent slopes	Somewhat limited	Overly (75%)	Slow water movement (0.81)	101.7	5.4%

Manure and Food-Processing Waste— Summary by Map Unit — Grand Forks County, North Dakota (ND035)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Bearden (10%)	Depth to saturated zone (0.86)		
				Slow water movement (0.43)		
			Kindred (7%)	Depth to saturated zone (0.86)		
				Slow water movement (0.43)		
			Bearden, moderately saline (4%)	Depth to saturated zone (0.86)		
				Salinity (0.50)		
				Slow water movement (0.43)		
				Sodium content (0.32)		
I422A	Renshaw loam, 0 to 2 percent slopes	Very limited	Renshaw (70%)	Filtering capacity (1.00)	28.3	1.5%
				Droughty (0.52)		
				Leaching (0.45)		
			Sioux (8%)	Filtering capacity (1.00)		
				Droughty (0.76)		
				Leaching (0.45)		
			Sioux, gravelly sandy loam (2%)	Filtering capacity (1.00)		
				Droughty (0.99)		
				Leaching (0.45)		
I477A	Antler silty clay loam, moderately saline, 0 to 2 percent slopes	Somewhat limited	Antler, moderately saline (75%)	Depth to saturated zone (0.86)	66.7	3.5%
				Salinity (0.50)		
				Slow water movement (0.41)		
				Sodium content (0.32)		
			Gilby (7%)	Depth to saturated zone (0.86)		

Manure and Food-Processing Waste— Summary by Map Unit — Grand Forks County, North Dakota (ND035)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Slow water movement (0.41)		
			Doran (7%)	Depth to saturated zone (0.86)		
				Slow water movement (0.41)		
I594A	LaDelle silt loam, 0 to 2 percent slopes, occasionally flooded	Somewhat limited	LaDelle (90%)	Flooding (0.60)	104.0	5.5%
			Fairdale (5%)	Flooding (0.60)		
I653A	Nutley silty clay, 0 to 2 percent slopes	Very limited	Nutley (85%)	Slow water movement (1.00)	430.2	22.6%
			Sinai (6%)	Slow water movement (1.00)		
				Too acid (0.01)		
			Aberdeen (5%)	Slow water movement (1.00)		
				Sodium content (0.82)		
				Depth to saturated zone (0.78)		
				Runoff (0.40)		
			Wahpeton (4%)	Slow water movement (1.00)		
				Flooding (0.60)		
I906F	Orthents-Aquents-Urban Land, highway complex, 0 to 35 percent slopes	Very limited	Aquents (25%)	Slow water movement (1.00)	15.0	0.8%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Orthents (25%)	Slope (1.00)		
				Slow water movement (0.81)		
IGp	Pits, gravel and sand	Not rated	Pits, gravel and sand (85%)		26.0	1.4%

Manure and Food-Processing Waste— Summary by Map Unit — Grand Forks County, North Dakota (ND035)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Water, intermittent (1%)			
Totals for Area of Interest					**1,900.4**	**100.0%**

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Not limited	752.7	39.6%
Very limited	702.9	37.0%
Somewhat limited	418.5	22.0%
Null or Not Rated	26.2	1.4%
Totals for Area of Interest	**1,900.4**	**100.0%**

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Map Scale: 1:31,200 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0 450 900 1800 2700

Feet: 0 1500 3000 6000 9000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Background
- Aerial Photography

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Grand Forks County, North Dakota
Survey Area Data: Version 19, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 7, 2011—Jul 31, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Grand Forks County, North Dakota (ND035)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G6A	Vallers loam, 0 to 1 percent slopes	Very limited	Vallers (67%)	High water table (1.00)	2.9	0.2%
			Hamerly (13%)	High water table (1.00)		
			Vallers, moderately saline (8%)	High water table (1.00)		
			Tonka (5%)	High water table (1.00)		
			Parnell (3%)	High water table (1.00)		
G25A	Marysland loam, 0 to 1 percent slopes	Very limited	Marysland (74%)	High water table (1.00)	2.2	0.1%
			Divide (14%)	High water table (1.00)		
			Marysland, very poorly drained (7%)	High water table (1.00)		
			Totten (5%)	High water table (1.00)		
G101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Very limited	Hamerly (46%)	High water table (1.00)	23.9	1.3%
			Wyard (24%)	High water table (1.00)		
			Tonka (8%)	High water table (1.00)		
			Hamerly, moderately saline (5%)	High water table (1.00)		
			Vallers (4%)	High water table (1.00)		
G102A	Hamerly loam, 0 to 3 percent slopes	Very limited	Hamerly (87%)	High water table (1.00)	19.9	1.0%
			Divide, loamy substratum (4%)	High water table (1.00)		
			Tonka (2%)	High water table (1.00)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Grand Forks County, North Dakota (ND035)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Vallers, moderately saline (2%)	High water table (1.00)		
G120A	Vallers, saline-Manfred complex, 0 to 1 percent slopes	Very limited	Vallers, moderately saline (45%)	High water table (1.00)	4.2	0.2%
			Manfred (25%)	High water table (1.00)		
			Hamerly (8%)	High water table (1.00)		
			Easby (6%)	High water table (1.00)		
			Parnell (5%)	High water table (1.00)		
			Wyard (5%)	High water table (1.00)		
			Tonka (4%)	High water table (1.00)		
G124A	Cresbard-Cavour loams, 0 to 3 percent slopes	Somewhat limited	Cresbard (49%)	High water table (0.76)	34.1	1.8%
			Cavour (25%)	High water table (0.76)		
			Barnes (9%)	High water table (0.19)		
			Ferney (5%)	High water table (0.76)		
			Svea, saline-sodic substratum (3%)	High water table (0.76)		
G129A	Cavour-Ferney loams, 0 to 3 percent slopes	Somewhat limited	Cavour (50%)	High water table (0.76)	1.4	0.1%
			Ferney (25%)	High water table (0.76)		
			Cresbard (3%)	High water table (0.76)		
			Balaton, saline-sodic substratum (3%)	High water table (0.76)		
			Svea, saline-sodic substratum (2%)	High water table (0.76)		
G143A	Barnes-Svea loams, 0 to 3 percent slopes	Somewhat limited	Barnes (39%)	High water table (0.19)	324.7	17.1%

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Grand Forks County, North Dakota (ND035)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Svea (38%)	High water table (0.76)		
			Cresbard (3%)	High water table (0.76)		
G143C	Barnes-Buse-Langhei loams, 6 to 9 percent slopes	Not limited	Barnes (24%)		2.1	0.1%
			Buse (23%)			
			Langhei (18%)			
			Renshaw (3%)			
G144B	Barnes-Buse loams, 3 to 6 percent slopes	Somewhat limited	Barnes (25%)	High water table (0.19)	84.8	4.5%
			Svea (14%)	High water table (0.76)		
			Balaton (10%)	High water table (0.76)		
			Swenoda (3%)	High water table (0.76)		
			Cresbard (3%)	High water table (0.76)		
			Sioux (2%)	High perc rate (0.22)		
G147D	Buse-Barnes-Darnen loams, 6 to 15 percent slopes	Not limited	Buse (28%)		7.5	0.4%
			Barnes (26%)			
			Darnen (23%)			
			Langhei (9%)			
			Langhei, very stony (6%)			
G148D	Buse-Barnes-La Prairie, occasionally flooded loams, 6 to 15 percent slopes	Not limited	Buse (31%)		0.1	0.0%
			Barnes (28%)			
			Langhei (9%)			
			Langhei, very stony (6%)			
G269A	Fordville-Renshaw loams, 0 to 2 percent slopes	Somewhat limited	Fordville (54%)	High water table (0.19)	3.4	0.2%
			Warsing (7%)	High water table (0.76)		
			Arvilla (4%)	High perc rate (0.08)		
			Sioux (3%)	High perc rate (0.22)		
			Osakis (3%)	High water table (0.76)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Grand Forks County, North Dakota (ND035)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				High perc rate (0.08)		
G275A	Renshaw loam, 0 to 2 percent slopes	Not limited	Renshaw (67%)		58.9	3.1%
G276B	Renshaw-Sioux complex, 2 to 6 percent slopes	Somewhat limited	Sioux (20%)	High perc rate (0.22)	22.3	1.2%
			Sioux (10%)	High perc rate (0.08)		
			Fordville (10%)	High water table (0.19)		
			Osakis (7%)	High water table (0.76)		
				High perc rate (0.08)		
			Warsing (6%)	High water table (0.76)		
			Arvilla (4%)	High perc rate (0.08)		
G561A	La Prairie loam, 0 to 2 percent slopes, occasionally flooded	Somewhat limited	La Prairie, occasionally flooded (73%)	High water table (0.76)	5.0	0.3%
			Velva, moist, occasionally flooded (10%)	High water table (0.19)		
				High perc rate (0.04)		
			Fairdale, occasionally flooded (2%)	High water table (0.76)		
G562A	La Prairie-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	Somewhat limited	La Prairie, frequently flooded (35%)	High water table (0.76)	2.1	0.1%
			Velva, moist, frequently flooded (10%)	High water table (0.19)		
				High perc rate (0.04)		
			Fairdale, frequently flooded (10%)	High water table (0.76)		
G639F	Orthents-Aquents-Urban Land, highway complex, 0 to 35 percent slopes	Not limited	Orthents (41%)		46.9	2.5%
			Sisseton (10%)			
			Renshaw (6%)			
			Barnes (3%)			

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Grand Forks County, North Dakota (ND035)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
G651E	Udarents loamy, abandoned gravel pits, 0 to 25 percent slopes	Not limited	Udarents, loamy, abandoned gravel pits (74%)		20.2	1.1%
			Renshaw (3%)			
G997	Water, intermittent	Not rated	Water, intermittent (80%)		0.3	0.0%
I150B	Zell, fine-silty-LaDelle silt loams, 2 to 6 percent slopes	Somewhat limited	Zell (55%)	High water table (0.19)	7.8	0.4%
			LaDelle (35%)	High water table (0.76)		
I156A	Antler silt loam, 0 to 2 percent slopes	Very limited	Antler (80%)	High water table (1.00)	64.3	3.4%
			Mustinka (5%)	High water table (1.00)		
			Antler, moderately saline (5%)	High water table (1.00)		
			Winger (5%)	High water table (1.00)		
I162A	Walsh loam, 0 to 2 percent slopes	Somewhat limited	Walsh (85%)	High water table (0.19)	204.1	10.7%
			Vang (5%)	High water table (0.76)		
			Inkster (3%)	High water table (0.76)		
I163A	Inkster sandy loam, 0 to 3 percent slopes	Somewhat limited	Inkster (85%)	High water table (0.76)	129.2	6.8%
			Sioux (4%)	High perc rate (0.08)		
I167A	Exline-Aberdeen silty clays, 0 to 1 percent slopes	Very limited	Exline (60%)	High water table (1.00)	38.1	2.0%
I213B	Embden fine sandy loam, 2 to 6 percent slopes	Somewhat limited	Embden (55%)	High water table (0.76)	5.2	0.3%
				High perc rate (0.08)		
			Egeland (10%)	High water table (0.19)		
				High perc rate (0.08)		
			Embden, nearly level (10%)	High water table (0.76)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Grand Forks County, North Dakota (ND035)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				High perc rate (0.08)		
			Maddock (10%)	High perc rate (0.88)		
			Hecla (5%)	High water table (0.94)		
				High perc rate (0.08)		
I308A	Tiffany loam, 0 to 1 percent slopes	Very limited	Tiffany (72%)	High water table (1.00)	12.4	0.7%
			Wyndmere (10%)	High water table (1.00)		
			Arveson (10%)	High water table (1.00)		
				High perc rate (0.08)		
			Delamere (5%)	High water table (1.00)		
				High perc rate (0.08)		
			Hamar (2%)	High water table (1.00)		
				High perc rate (0.08)		
			Venlo (1%)	High water table (1.00)		
				High perc rate (0.98)		
I370A	Rauville silty clay loam, 0 to 1 percent slopes, frequently flooded	Very limited	Rauville (70%)	High water table (1.00)	0.4	0.0%
			Lamoure (10%)	High water table (1.00)		
			Marysland (5%)	High water table (1.00)		
			Lowe, moderately saline (3%)	High water table (1.00)		
			Fluvaquents, channeled, frequently flooded (2%)	High water table (1.00)		
				High perc rate (0.21)		
I383A	Overly silty clay loam, 0 to 2 percent slopes	Somewhat limited	Overly (75%)	High water table (0.76)	101.7	5.4%

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Grand Forks County, North Dakota (ND035)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
I422A	Renshaw loam, 0 to 2 percent slopes	Somewhat limited	Renshaw (70%)	High perc rate (0.08)	28.3	1.5%
			Sioux (8%)	High perc rate (0.08)		
			Embden (5%)	High water table (0.76)		
			Hecla (5%)	High water table (0.94)		
				High perc rate (0.08)		
			Fordville (5%)	High water table (0.19)		
			Sioux, gravelly sandy loam (2%)	High perc rate (0.08)		
I477A	Antler silty clay loam, moderately saline, 0 to 2 percent slopes	Very limited	Antler, moderately saline (75%)	High water table (1.00)	66.7	3.5%
			Gilby (7%)	High water table (1.00)		
			Doran (7%)	High water table (1.00)		
			Mustinka (6%)	High water table (1.00)		
			Winger, moderately saline (5%)	High water table (1.00)		
I594A	LaDelle silt loam, 0 to 2 percent slopes, occasionally flooded	Somewhat limited	LaDelle (90%)	High water table (0.76)	104.0	5.5%
			Fairdale (5%)	High water table (0.76)		
I653A	Nutley silty clay, 0 to 2 percent slopes	Somewhat limited	Nutley (85%)	High water table (0.19)	430.2	22.6%
			Sinai (6%)	High water table (0.19)		
			Wahpeton (4%)	High water table (0.76)		
I906F	Orthents-Aquents-Urban Land, highway complex, 0 to 35 percent slopes	Somewhat limited	Orthents (30%)	High water table (0.76)	15.0	0.8%
			Orthents (25%)	High water table (0.76)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Grand Forks County, North Dakota (ND035)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
IGp	Pits, gravel and sand	Very limited	Pits, gravel and sand (85%)	High perc rate (1.00)	26.0	1.4%
Totals for Area of Interest					**1,900.4**	**100.0%**

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Somewhat limited	1,503.4	79.1%
Very limited	261.0	13.7%
Not limited	135.7	7.1%
Null or Not Rated	0.3	0.0%
Totals for Area of Interest	**1,900.4**	**100.0%**

Description

The interpretation for Agronomic Concerns, Pesticide and Nutrient Leaching evaluates limitations of a soil that increase the hazard of contaminating aquifers, springs, and local water tables.

The soil features considered are saturated hydraulic conductivity and depth to seasonal high water table.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soil is limited by all of the soil features that affect the interpretation. Numerical ratings indicate the severity of individual limitations; the highest numerical rating identifies the most limiting soil feature(s) considered in the rating process. Less restrictive soil features have a lower numerical value than the maximum used to rate the soil. They are identified to provide the user with additional information about soil limitations for the specific use. Restrictive soil features also need to be considered in planning, design, installation, and management. "Not limited" (numerical value for the most restrictive feature = 0.00) indicates that the soil has features that are very favorable for the specified use. "Somewhat limited" (numerical value for the most restrictive feature = 0.01 to 0.99) indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning. "Very limited" (numerical value for the most restrictive feature = 1.00) indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special planning, or expensive installation procedures.

The results of this interpretation are not designed or intended to be used in a regulatory manner.

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Map Scale: 1:30,900 if printed on A portrait (8.5" x 11") sheet.

N

0 450 900 1800 2700 Meters

0 1500 3000 6000 9000 Feet

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at scales ranging from 1:12,000 to 1:20,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cavalier County, North Dakota
Survey Area Data: Version 20, Sep 24, 2015

Soil Survey Area: Ramsey County, North Dakota
Survey Area Data: Version 21, Sep 25, 2015

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Oct 16, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Cavalier County, North Dakota (ND019)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F12A	Vallers, saline-Parnell complex, 0 to 1 percent slopes	Very limited	Vallers, moderately saline (40%)	Depth to saturated zone (1.00)	51.0	2.0%
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (27%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Tonka (7%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Manfred (5%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Sodium content (1.00)		
				Slow water movement (1.00)		
				Salinity (0.50)		
			Southam (4%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		

Manure and Food-Processing Waste— Summary by Map Unit — Cavalier County, North Dakota (ND019)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Salinity (0.01)		
			Wyard (3%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Easby (3%)	Depth to saturated zone (1.00)		
				Salinity (1.00)		
				Sodium content (1.00)		
				Droughty (1.00)		
				Slow water movement (0.50)		
F100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Tonka (28%)	Slow water movement (1.00)	677.3	26.5%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Wyard (7%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Vallers, moderately saline (7%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cavour (3%)	Slow water movement (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Cavalier County, North Dakota (ND019)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Sodium content (1.00)		
F101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (46%)	Depth to saturated zone (0.86)	1.5	0.1%
			Balaton (7%)	Depth to saturated zone (0.22)		
			Hamerly, moderately saline (4%)	Depth to saturated zone (0.86)		
				Salinity (0.50)		
				Sodium content (0.18)		
F116A	Easby clay loam, 0 to 1 percent slopes	Very limited	Easby (92%)	Ponding (1.00)	4.2	0.2%
				Depth to saturated zone (1.00)		
				Salinity (1.00)		
				Droughty (1.00)		
				Slow water movement (0.50)		
			Easby, very strongly saline (3%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Salinity (1.00)		
				Droughty (1.00)		
				Slow water movement (0.50)		
			Vallers, moderately saline (3%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Droughty (0.03)		
			Parnell (2%)	Slow water movement (1.00)		
				Ponding (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Cavalier County, North Dakota (ND019)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
F119A	Vallers-Hamerly loams, saline, 0 to 3 percent slopes	Very limited	Vallers, moderately saline (45%)	Depth to saturated zone (1.00)	148.7	5.8%
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Cresbard (6%)	Slow water movement (1.00)		
				Sodium content (0.32)		
			Tonka (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Easby (2%)	Depth to saturated zone (1.00)		
				Salinity (1.00)		
				Sodium content (1.00)		
				Droughty (1.00)		
				Slow water movement (0.50)		
			Parnell (2%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
F135A	Hamerly-Cresbard loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (44%)	Depth to saturated zone (0.86)	13.4	0.5%

Manure and Food-Processing Waste— Summary by Map Unit — Cavalier County, North Dakota (ND019)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Balaton (5%)	Depth to saturated zone (0.22)		
F143C	Barnes-Buse-Langhei loams, 6 to 9 percent slopes	Not limited	Barnes (24%)		16.2	0.6%
			Buse (23%)			
			Langhei (18%)			
			Svea (14%)			
			Balaton (3%)			
			Lanona (3%)			
F144B	Barnes-Buse loams, 3 to 6 percent slopes	Not limited	Barnes (25%)		141.0	5.5%
			Buse (24%)			
			Svea (14%)			
			Balaton (10%)			
			Langhei (4%)			
			Swenoda (3%)			
F154B	Svea-Buse loams, 3 to 6 percent slopes	Not limited	Svea (45%)		376.7	14.7%
			Buse (33%)			
			Barnes (10%)			
F256A	Divide loam, shaly, loamy substratum, 0 to 2 percent slopes	Somewhat limited	Divide, shaly, loamy substratum (74%)	Depth to saturated zone (0.86)	17.1	0.7%
			Sverdrup, loamy substratum (6%)	Leaching (0.45)		
			Wyrene, shaly, loamy substratum (5%)	Depth to saturated zone (0.86)		
F523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	Very limited	Fluvaquents, channeled, frequently flooded (40%)	Ponding (1.00)	153.9	6.0%
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.90)		
			Lowe, frequently flooded (28%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
			Lowe, moderately	Ponding (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Cavalier County, North Dakota (ND019)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			saline, frequently flooded (20%)	Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
				Salinity (0.50)		
			Lowe, very poorly drained, frequently flooded (5%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
Subtotals for Soil Survey Area					**1,601.1**	**62.5%**
Totals for Area of Interest					**2,560.3**	**100.0%**

Manure and Food-Processing Waste— Summary by Map Unit — Ramsey County, North Dakota (ND071)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F2A	Tonka silt loam, 0 to 1 percent slopes	Very limited	Tonka (73%)	Slow water movement (1.00)	8.3	0.3%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Parnell (9%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Wyard (6%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Vallers (4%)	Depth to saturated zone (1.00)		
				Leaching (0.70)		
			Manfred (3%)	Ponding (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Ramsey County, North Dakota (ND071)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Depth to saturated zone (1.00)		
				Sodium content (1.00)		
				Slow water movement (1.00)		
				Salinity (0.50)		
			Cavour (2%)	Slow water movement (1.00)		
				Sodium content (1.00)		
F3A	Parnell silty clay loam, 0 to 1 percent slopes	Very limited	Parnell (64%)	Slow water movement (1.00)	14.5	0.6%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Vallers (10%)	Depth to saturated zone (1.00)		
				Leaching (0.70)		
			Vallers, moderately saline (9%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Southam (6%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Tonka (5%)	Slow water movement (1.00)		
				Ponding (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Ramsey County, North Dakota (ND071)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Ferney (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
				Salinity (0.50)		
F12A	Vallers, saline-Parnell complex, 0 to 1 percent slopes	Very limited	Vallers, moderately saline (40%)	Depth to saturated zone (1.00)	77.1	3.0%
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (27%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Tonka (7%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Manfred (5%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Sodium content (1.00)		
				Slow water movement (1.00)		
				Salinity (0.50)		
			Southam (4%)	Slow water movement (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Ramsey County, North Dakota (ND071)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
				Salinity (0.01)		
			Wyard (3%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Easby (3%)	Depth to saturated zone (1.00)		
				Salinity (1.00)		
				Sodium content (1.00)		
				Droughty (1.00)		
				Slow water movement (0.50)		
F100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Tonka (28%)	Slow water movement (1.00)	0.3	0.0%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Wyard (7%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Vallers, moderately saline (7%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (5%)	Slow water movement (1.00)		
				Ponding (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Ramsey County, North Dakota (ND071)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cavour (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
F101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (46%)	Depth to saturated zone (0.86)	57.6	2.3%
			Balaton (7%)	Depth to saturated zone (0.22)		
			Hamerly, moderately saline (4%)	Depth to saturated zone (0.86)		
				Salinity (0.50)		
				Sodium content (0.18)		
F119A	Vallers-Hamerly loams, saline, 0 to 3 percent slopes	Very limited	Vallers, moderately saline (45%)	Depth to saturated zone (1.00)	159.9	6.2%
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Cresbard (6%)	Slow water movement (1.00)		
				Sodium content (0.32)		
			Tonka (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Easby (2%)	Depth to saturated zone (1.00)		
				Salinity (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Ramsey County, North Dakota (ND071)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Sodium content (1.00)		
				Droughty (1.00)		
				Slow water movement (0.50)		
			Parnell (2%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
F122A	Svea-Cresbard loams, 0 to 3 percent slopes	Not limited	Svea, saline-sodic substratum (41%)		8.5	0.3%
			Barnes (5%)			
			Balaton, saline-sodic substratum (3%)			
F122B	Barnes-Cresbard loams, 3 to 6 percent slopes	Not limited	Barnes (42%)		29.8	1.2%
			Balaton, saline-sodic substratum (4%)			
			Buse (4%)			
			Svea, saline-sodic substratum (3%)			
F135A	Hamerly-Cresbard loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (44%)	Depth to saturated zone (0.86)	345.0	13.5%
			Balaton (5%)	Depth to saturated zone (0.22)		
F143C	Barnes-Buse-Langhei loams, 6 to 9 percent slopes	Not limited	Barnes (24%)		11.3	0.4%
			Buse (23%)			
			Langhei (18%)			
			Svea (14%)			
			Balaton (3%)			
			Lanona (3%)			

Manure and Food-Processing Waste— Summary by Map Unit — Ramsey County, North Dakota (ND071)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F144B	Barnes-Buse loams, 3 to 6 percent slopes	Not limited	Barnes (25%)		241.1	9.4%
			Buse (24%)			
			Svea (14%)			
			Balaton (10%)			
			Langhei (4%)			
			Swenoda (3%)			
F249C	Esmond-Emrick loams, sandy substratums, 3 to 9 percent slopes	Not limited	Esmond, sandy substratum (37%)		5.4	0.2%
			Emrick, sandy substratum (31%)			
			Heimdal (12%)			
			Ortonville (5%)			
F256A	Divide loam, shaly, loamy substratum, 0 to 2 percent slopes	Somewhat limited	Divide, shaly, loamy substratum (74%)	Depth to saturated zone (0.86)	0.1	0.0%
			Sverdrup, loamy substratum (6%)	Leaching (0.45)		
			Wyrene, shaly, loamy substratum (5%)	Depth to saturated zone (0.86)		
F523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	Very limited	Fluvaquents, channeled, frequently flooded (40%)	Ponding (1.00)	0.2	0.0%
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.90)		
			Lowe, frequently flooded (28%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
			Lowe, moderately saline, frequently flooded (20%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
				Salinity (0.50)		

Manure and Food-Processing Waste— Summary by Map Unit — Ramsey County, North Dakota (ND071)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Lowe, very poorly drained, frequently flooded (5%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
Subtotals for Soil Survey Area					**959.2**	**37.5%**
Totals for Area of Interest					**2,560.3**	**100.0%**

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Very limited	1,295.5	50.6%
Not limited	830.1	32.4%
Somewhat limited	434.7	17.0%
Totals for Area of Interest	**2,560.3**	**100.0%**

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

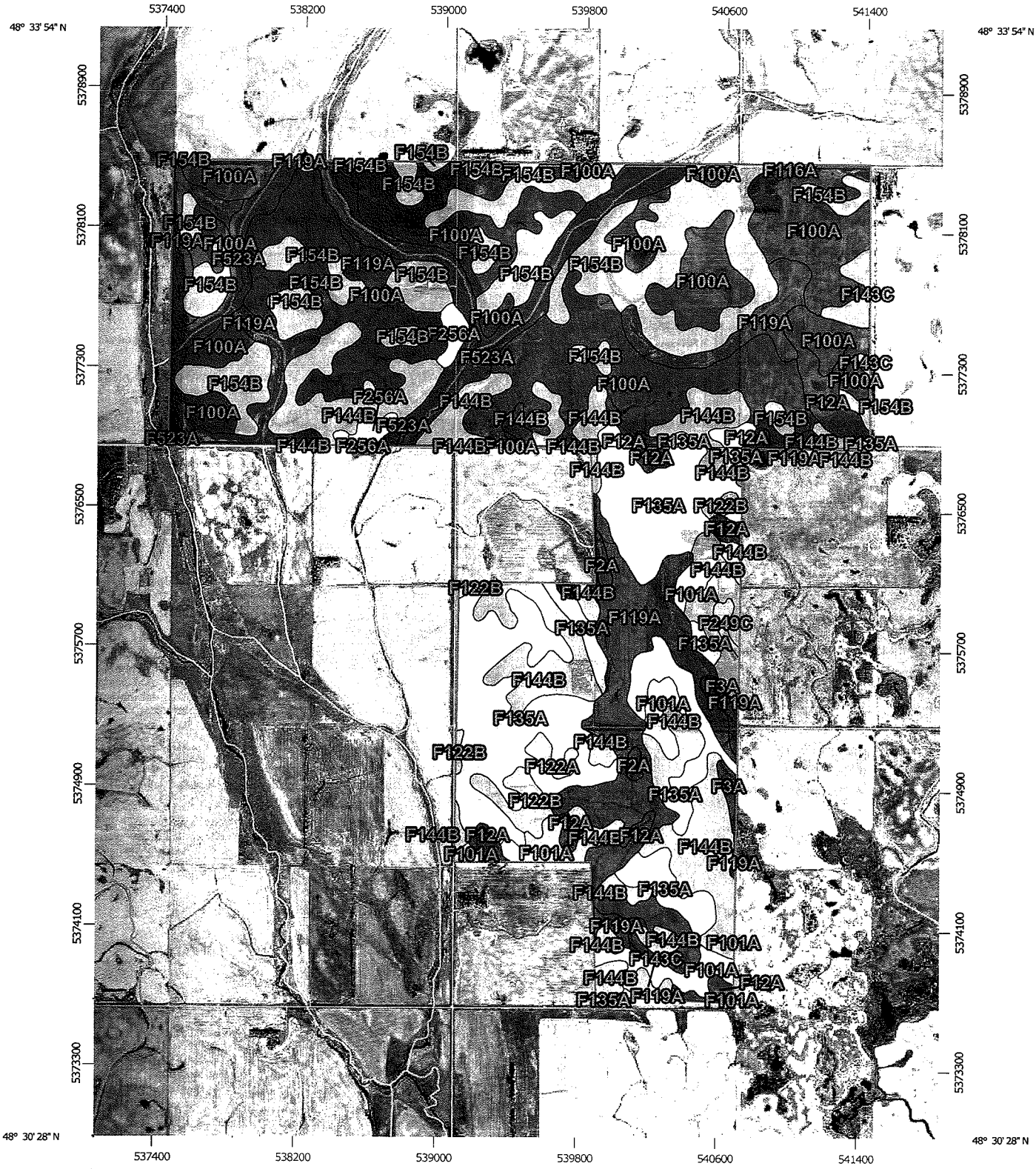
Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher



Map Scale: 1:30,900 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0 450 900 1800 2700

Feet: 0 1500 3000 6000 9000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
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Soil Survey Area: Cavalier County, North Dakota
Survey Area Data: Version 20, Sep 24, 2015

Soil Survey Area: Ramsey County, North Dakota
Survey Area Data: Version 21, Sep 25, 2015

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Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Cavalier County, North Dakota (ND019)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F12A	Vallers, saline-Parnell complex, 0 to 1 percent slopes	Very limited	Vallers, moderately saline (40%)	Depth to saturated zone (1.00)	51.0	2.0%
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (27%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Tonka (7%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Manfred (5%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Sodium content (1.00)		
				Slow water movement (1.00)		
				Salinity (0.50)		
			Southam (4%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		

Manure and Food-Processing Waste— Summary by Map Unit — Cavalier County, North Dakota (ND019)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Salinity (0.01)		
			Wyard (3%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Easby (3%)	Depth to saturated zone (1.00)		
				Salinity (1.00)		
				Sodium content (1.00)		
				Droughty (1.00)		
				Slow water movement (0.50)		
F100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Tonka (28%)	Slow water movement (1.00)	677.3	26.5%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Wyard (7%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Vallers, moderately saline (7%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cavour (3%)	Slow water movement (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Cavalier County, North Dakota (ND019)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Sodium content (1.00)		
F101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (46%)	Depth to saturated zone (0.86)	1.5	0.1%
			Balaton (7%)	Depth to saturated zone (0.22)		
			Hamerly, moderately saline (4%)	Depth to saturated zone (0.86)		
				Salinity (0.50)		
				Sodium content (0.18)		
F116A	Easby clay loam, 0 to 1 percent slopes	Very limited	Easby (92%)	Ponding (1.00)	4.2	0.2%
				Depth to saturated zone (1.00)		
				Salinity (1.00)		
				Droughty (1.00)		
				Slow water movement (0.50)		
			Easby, very strongly saline (3%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Salinity (1.00)		
				Droughty (1.00)		
				Slow water movement (0.50)		
			Vallers, moderately saline (3%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Droughty (0.03)		
			Parnell (2%)	Slow water movement (1.00)		
				Ponding (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Cavalier County, North Dakota (ND019)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
F119A	Vallers-Hamerly loams, saline, 0 to 3 percent slopes	Very limited	Vallers, moderately saline (45%)	Depth to saturated zone (1.00)	148.7	5.8%
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Cresbard (6%)	Slow water movement (1.00)		
				Sodium content (0.32)		
			Tonka (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Easby (2%)	Depth to saturated zone (1.00)		
				Salinity (1.00)		
				Sodium content (1.00)		
				Droughty (1.00)		
				Slow water movement (0.50)		
			Parnell (2%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
F135A	Hamerly-Cresbard loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (44%)	Depth to saturated zone (0.86)	13.4	0.5%

Manure and Food-Processing Waste— Summary by Map Unit — Cavalier County, North Dakota (ND019)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Balaton (5%)	Depth to saturated zone (0.22)		
F143C	Barnes-Buse-Langhei loams, 6 to 9 percent slopes	Not limited	Barnes (24%)		16.2	0.6%
			Buse (23%)			
			Langhei (18%)			
			Svea (14%)			
			Balaton (3%)			
			Lanona (3%)			
F144B	Barnes-Buse loams, 3 to 6 percent slopes	Not limited	Barnes (25%)		141.0	5.5%
			Buse (24%)			
			Svea (14%)			
			Balaton (10%)			
			Langhei (4%)			
			Swenoda (3%)			
F154B	Svea-Buse loams, 3 to 6 percent slopes	Not limited	Svea (45%)		376.7	14.7%
			Buse (33%)			
			Barnes (10%)			
F256A	Divide loam, shaly, loamy substratum, 0 to 2 percent slopes	Somewhat limited	Divide, shaly, loamy substratum (74%)	Depth to saturated zone (0.86)	17.1	0.7%
			Sverdrup, loamy substratum (6%)	Leaching (0.45)		
			Wyrene, shaly, loamy substratum (5%)	Depth to saturated zone (0.86)		
F523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	Very limited	Fluvaquents, channeled, frequently flooded (40%)	Ponding (1.00)	153.9	6.0%
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.90)		
			Lowe, frequently flooded (28%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
			Lowe, moderately	Ponding (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Cavalier County, North Dakota (ND019)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			saline, frequently flooded (20%)	Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
				Salinity (0.50)		
			Lowe, very poorly drained, frequently flooded (5%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
Subtotals for Soil Survey Area					**1,601.1**	**62.5%**
Totals for Area of Interest					**2,560.3**	**100.0%**

Manure and Food-Processing Waste— Summary by Map Unit — Ramsey County, North Dakota (ND071)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F2A	Tonka silt loam, 0 to 1 percent slopes	Very limited	Tonka (73%)	Slow water movement (1.00)	8.3	0.3%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Parnell (9%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Wyard (6%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Vallers (4%)	Depth to saturated zone (1.00)		
				Leaching (0.70)		
			Manfred (3%)	Ponding (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Ramsey County, North Dakota (ND071)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Depth to saturated zone (1.00)		
				Sodium content (1.00)		
				Slow water movement (1.00)		
				Salinity (0.50)		
			Cavour (2%)	Slow water movement (1.00)		
				Sodium content (1.00)		
F3A	Parnell silty clay loam, 0 to 1 percent slopes	Very limited	Parnell (64%)	Slow water movement (1.00)	14.5	0.6%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Vallers (10%)	Depth to saturated zone (1.00)		
				Leaching (0.70)		
			Vallers, moderately saline (9%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Southam (6%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Tonka (5%)	Slow water movement (1.00)		
				Ponding (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Ramsey County, North Dakota (ND071)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Ferney (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
				Salinity (0.50)		
F12A	Vallers, saline-Parnell complex, 0 to 1 percent slopes	Very limited	Vallers, moderately saline (40%)	Depth to saturated zone (1.00)	77.1	3.0%
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (27%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Tonka (7%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Manfred (5%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Sodium content (1.00)		
				Slow water movement (1.00)		
				Salinity (0.50)		
			Southam (4%)	Slow water movement (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Ramsey County, North Dakota (ND071)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
				Salinity (0.01)		
			Wyard (3%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Easby (3%)	Depth to saturated zone (1.00)		
				Salinity (1.00)		
				Sodium content (1.00)		
				Droughty (1.00)		
				Slow water movement (0.50)		
F100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Tonka (28%)	Slow water movement (1.00)	0.3	0.0%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Wyard (7%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Vallers, moderately saline (7%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (5%)	Slow water movement (1.00)		
				Ponding (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Ramsey County, North Dakota (ND071)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cavour (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
F101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (46%)	Depth to saturated zone (0.86)	57.6	2.3%
			Balaton (7%)	Depth to saturated zone (0.22)		
			Hamerly, moderately saline (4%)	Depth to saturated zone (0.86)		
				Salinity (0.50)		
				Sodium content (0.18)		
F119A	Vallers-Hamerly loams, saline, 0 to 3 percent slopes	Very limited	Vallers, moderately saline (45%)	Depth to saturated zone (1.00)	159.9	6.2%
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Cresbard (6%)	Slow water movement (1.00)		
				Sodium content (0.32)		
			Tonka (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Easby (2%)	Depth to saturated zone (1.00)		
				Salinity (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Ramsey County, North Dakota (ND071)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Sodium content (1.00)		
				Droughty (1.00)		
				Slow water movement (0.50)		
			Parnell (2%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
F122A	Svea-Cresbard loams, 0 to 3 percent slopes	Not limited	Svea, saline-sodic substratum (41%)		8.5	0.3%
			Barnes (5%)			
			Balaton, saline-sodic substratum (3%)			
F122B	Barnes-Cresbard loams, 3 to 6 percent slopes	Not limited	Barnes (42%)		29.8	1.2%
			Balaton, saline-sodic substratum (4%)			
			Buse (4%)			
			Svea, saline-sodic substratum (3%)			
F135A	Hamerly-Cresbard loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (44%)	Depth to saturated zone (0.86)	345.0	13.5%
			Balaton (5%)	Depth to saturated zone (0.22)		
F143C	Barnes-Buse-Langhei loams, 6 to 9 percent slopes	Not limited	Barnes (24%)		11.3	0.4%
			Buse (23%)			
			Langhei (18%)			
			Svea (14%)			
			Balaton (3%)			
			Lanona (3%)			

Manure and Food-Processing Waste— Summary by Map Unit — Ramsey County, North Dakota (ND071)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F144B	Barnes-Buse loams, 3 to 6 percent slopes	Not limited	Barnes (25%)		241.1	9.4%
			Buse (24%)			
			Svea (14%)			
			Balaton (10%)			
			Langhei (4%)			
			Swenoda (3%)			
F249C	Esmond-Emrick loams, sandy substratums, 3 to 9 percent slopes	Not limited	Esmond, sandy substratum (37%)		5.4	0.2%
			Emrick, sandy substratum (31%)			
			Heimdal (12%)			
			Ortonville (5%)			
F256A	Divide loam, shaly, loamy substratum, 0 to 2 percent slopes	Somewhat limited	Divide, shaly, loamy substratum (74%)	Depth to saturated zone (0.86)	0.1	0.0%
			Sverdrup, loamy substratum (6%)	Leaching (0.45)		
			Wyrene, shaly, loamy substratum (5%)	Depth to saturated zone (0.86)		
F523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	Very limited	Fluvaquents, channeled, frequently flooded (40%)	Ponding (1.00)	0.2	0.0%
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.90)		
			Lowe, frequently flooded (28%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
			Lowe, moderately saline, frequently flooded (20%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
				Salinity (0.50)		

Manure and Food-Processing Waste— Summary by Map Unit — Ramsey County, North Dakota (ND071)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Lowe, very poorly drained, frequently flooded (5%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
Subtotals for Soil Survey Area					**959.2**	**37.5%**
Totals for Area of Interest					**2,560.3**	**100.0%**

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Very limited	1,295.5	50.6%
Not limited	830.1	32.4%
Somewhat limited	434.7	17.0%
Totals for Area of Interest	**2,560.3**	**100.0%**

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

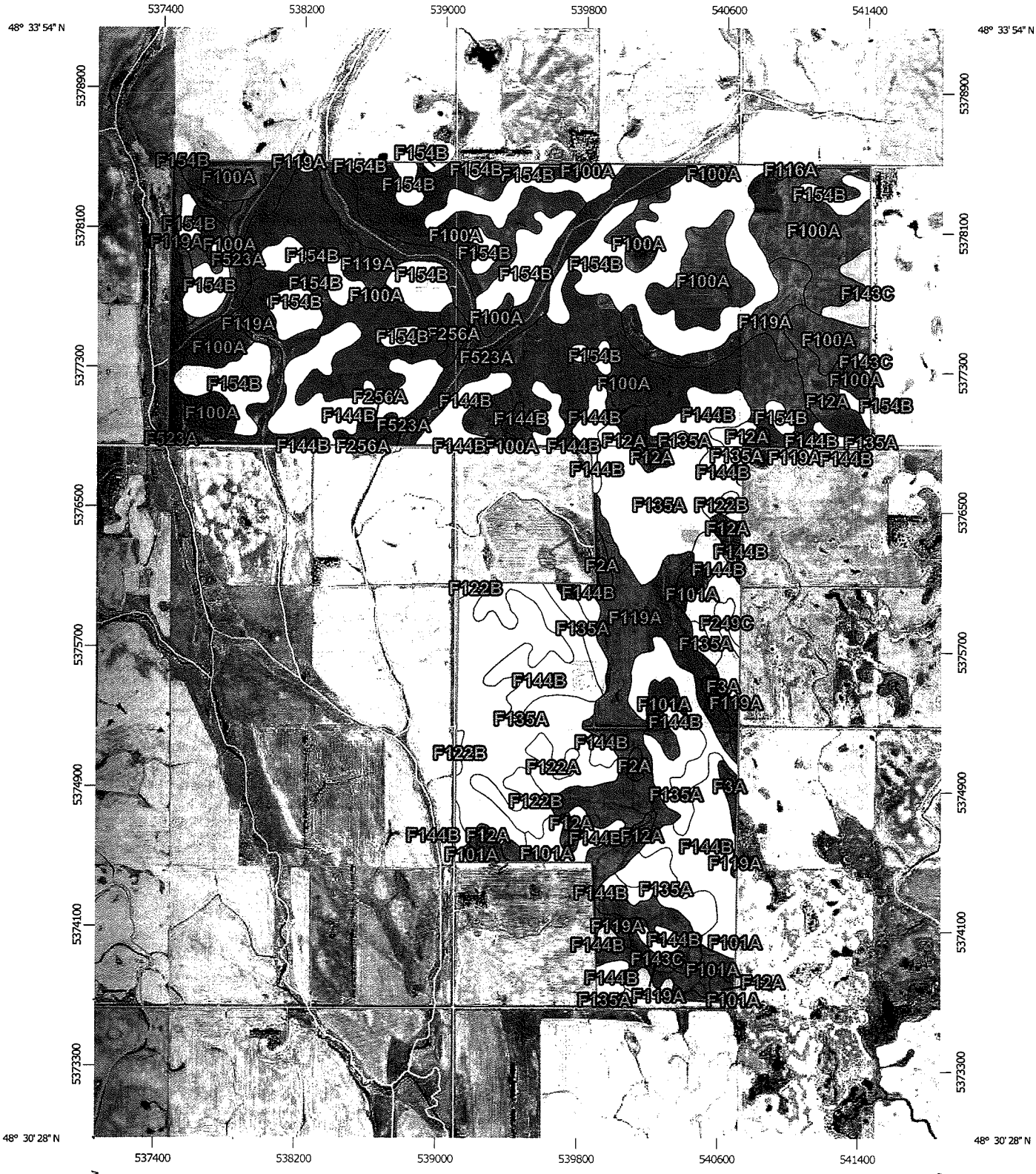
Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher


98° 29' 53" W
98° 25' 59" W
48° 33' 54" N
48° 30' 28" N
537400
538200
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5373300
F154B
F119A
F100A
F523A
F256A
F144B
F12A
F135A
F122B
F101A
F249C
F3A
F116A
F143C
F2A
F122A
Map Scale: 1:30,900 if printed on A portrait (8.5" x 11") sheet.
N
Meters
0 450 900 1800 2700
Feet
0 1500 3000 6000 9000
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Background
- Aerial Photography

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at scales ranging from 1:12,000 to 1:20,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cavalier County, North Dakota
Survey Area Data: Version 20, Sep 24, 2015

Soil Survey Area: Ramsey County, North Dakota
Survey Area Data: Version 21, Sep 25, 2015

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Oct 16, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Cavalier County, North Dakota (ND019)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
F12A	Vallers, saline-Parnell complex, 0 to 1 percent slopes	Very limited	Vallers, moderately saline (40%)	High water table (1.00)	51.0	2.0%
			Parnell (27%)	High water table (1.00)		
			Hamerly, moderately saline (11%)	High water table (1.00)		
			Tonka (7%)	High water table (1.00)		
			Manfred (5%)	High water table (1.00)		
			Southam (4%)	High water table (1.00)		
			Wyard (3%)	High water table (1.00)		
			Easby (3%)	High water table (1.00)		
F100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Hamerly (42%)	High water table (1.00)	677.3	26.5%
			Tonka (28%)	High water table (1.00)		
			Wyard (7%)	High water table (1.00)		
			Vallers, moderately saline (7%)	High water table (1.00)		
			Parnell (5%)	High water table (1.00)		
F101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Very limited	Hamerly (46%)	High water table (1.00)	1.5	0.1%
			Wyard (24%)	High water table (1.00)		
			Tonka (8%)	High water table (1.00)		
			Vallers (5%)	High water table (1.00)		
			Hamerly, moderately saline (4%)	High water table (1.00)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Cavalier County, North Dakota (ND019)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F116A	Easby clay loam, 0 to 1 percent slopes	Very limited	Easby (92%)	High water table (1.00)	4.2	0.2%
			Vallers, moderately saline (3%)	High water table (1.00)		
			Easby, very strongly saline (3%)	High water table (1.00)		
			Parnell (2%)	High water table (1.00)		
F119A	Vallers-Hamerly loams, saline, 0 to 3 percent slopes	Very limited	Vallers, moderately saline (45%)	High water table (1.00)	148.7	5.8%
			Hamerly, moderately saline (31%)	High water table (1.00)		
			Hamerly (7%)	High water table (1.00)		
			Tonka (3%)	High water table (1.00)		
			Easby (2%)	High water table (1.00)		
			Parnell (2%)	High water table (1.00)		
F135A	Hamerly-Cresbard loams, 0 to 3 percent slopes	Somewhat limited	Cresbard (41%)	High water table (0.76)	13.4	0.5%
			Balaton (5%)	High water table (0.76)		
			Cavour (2%)	High water table (0.76)		
			Barnes (2%)	High water table (0.19)		
			Svea (2%)	High water table (0.76)		
F143C	Barnes-Buse-Langhei loams, 6 to 9 percent slopes	Not limited	Barnes (24%)		16.2	0.6%
			Buse (23%)			
			Langhei (18%)			
			Renshaw (3%)			
F144B	Barnes-Buse loams, 3 to 6 percent slopes	Somewhat limited	Barnes (25%)	High water table (0.19)	141.0	5.5%
			Svea (14%)	High water table (0.76)		
			Balaton (10%)	High water table (0.76)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Cavalier County, North Dakota (ND019)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Cresbard (3%)	High water table (0.76)		
			Swenoda (3%)	High water table (0.76)		
			Sioux (2%)	High perc rate (0.22)		
F154B	Svea-Buse loams, 3 to 6 percent slopes	Somewhat limited	Svea (45%)	High water table (0.76)	376.7	14.7%
			Barnes (10%)	High water table (0.19)		
			Sioux (2%)	High perc rate (0.22)		
			Cresbard (2%)	High water table (0.76)		
F256A	Divide loam, shaly, loamy substratum, 0 to 2 percent slopes	Very limited	Divide, shaly, loamy substratum (74%)	High water table (1.00)	17.1	0.7%
			Marysland, shaly, loamy substratum (7%)	High water table (1.00)		
			Wyrene, shaly, loamy substratum (5%)	High water table (1.00)		
F523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	Very limited	Fluvaquents, channeled, frequently flooded (40%)	High water table (1.00)	153.9	6.0%
				High perc rate (0.21)		
			Lowe, frequently flooded (28%)	High water table (1.00)		
			Lowe, moderately saline, frequently flooded (20%)	High water table (1.00)		
			Lowe, very poorly drained, frequently flooded (5%)	High water table (1.00)		
			Moritz, occasionally flooded (5%)	High water table (1.00)		
Subtotals for Soil Survey Area					**1,601.1**	**62.5%**
Totals for Area of Interest					**2,560.3**	**100.0%**

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Ramsey County, North Dakota (ND071)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F2A	Tonka silt loam, 0 to 1 percent slopes	Very limited	Tonka (73%)	High water table (1.00)	8.3	0.3%
			Parnell (9%)	High water table (1.00)		
			Wyard (6%)	High water table (1.00)		
			Vallers (4%)	High water table (1.00)		
			Hamerly (3%)	High water table (1.00)		
			Manfred (3%)	High water table (1.00)		
F3A	Parnell silty clay loam, 0 to 1 percent slopes	Very limited	Parnell (64%)	High water table (1.00)	14.5	0.6%
			Vallers (10%)	High water table (1.00)		
			Vallers, moderately saline (9%)	High water table (1.00)		
			Southam (6%)	High water table (1.00)		
			Tonka (5%)	High water table (1.00)		
			Hamerly (3%)	High water table (1.00)		
F12A	Vallers, saline-Parnell complex, 0 to 1 percent slopes	Very limited	Vallers, moderately saline (40%)	High water table (1.00)	77.1	3.0%
			Parnell (27%)	High water table (1.00)		
			Hamerly, moderately saline (11%)	High water table (1.00)		
			Tonka (7%)	High water table (1.00)		
			Manfred (5%)	High water table (1.00)		
			Southam (4%)	High water table (1.00)		
			Wyard (3%)	High water table (1.00)		
			Easby (3%)	High water table (1.00)		
F100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Hamerly (42%)	High water table (1.00)	0.3	0.0%

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Ramsey County, North Dakota (ND071)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Tonka (28%)	High water table (1.00)		
			Wyard (7%)	High water table (1.00)		
			Vallers, moderately saline (7%)	High water table (1.00)		
			Parnell (5%)	High water table (1.00)		
F101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Very limited	Hamerly (46%)	High water table (1.00)	57.6	2.3%
			Wyard (24%)	High water table (1.00)		
			Tonka (8%)	High water table (1.00)		
			Vallers (5%)	High water table (1.00)		
			Hamerly, moderately saline (4%)	High water table (1.00)		
F119A	Vallers-Hamerly loams, saline, 0 to 3 percent slopes	Very limited	Vallers, moderately saline (45%)	High water table (1.00)	159.9	6.2%
			Hamerly, moderately saline (31%)	High water table (1.00)		
			Hamerly (7%)	High water table (1.00)		
			Tonka (3%)	High water table (1.00)		
			Easby (2%)	High water table (1.00)		
			Parnell (2%)	High water table (1.00)		
F122A	Svea-Cresbard loams, 0 to 3 percent slopes	Somewhat limited	Svea, saline-sodic substratum (41%)	High water table (0.76)	8.5	0.3%
			Cresbard (30%)	High water table (0.76)		
			Barnes (5%)	High water table (0.19)		
			Ferney (4%)	High water table (0.76)		
			Cavour (3%)	High water table (0.76)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Ramsey County, North Dakota (ND071)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Fordville (3%)	High water table (0.19)		
			Balaton, saline-sodic substratum (3%)	High water table (0.76)		
F122B	Barnes-Cresbard loams, 3 to 6 percent slopes	Somewhat limited	Barnes (42%)	High water table (0.19)	29.8	1.2%
			Cresbard (39%)	High water table (0.76)		
			Balaton, saline-sodic substratum (4%)	High water table (0.76)		
			Cavour (3%)	High water table (0.76)		
			Svea, saline-sodic substratum (3%)	High water table (0.76)		
F135A	Hamerly-Cresbard loams, 0 to 3 percent slopes	Somewhat limited	Cresbard (41%)	High water table (0.76)	345.0	13.5%
			Balaton (5%)	High water table (0.76)		
			Svea (2%)	High water table (0.76)		
			Cavour (2%)	High water table (0.76)		
			Barnes (2%)	High water table (0.19)		
F143C	Barnes-Buse-Langhei loams, 6 to 9 percent slopes	Not limited	Barnes (24%)		11.3	0.4%
			Buse (23%)			
			Langhei (18%)			
			Renshaw (3%)			
F144B	Barnes-Buse loams, 3 to 6 percent slopes	Somewhat limited	Barnes (25%)	High water table (0.19)	241.1	9.4%
			Svea (14%)	High water table (0.76)		
			Balaton (10%)	High water table (0.76)		
			Cresbard (3%)	High water table (0.76)		
			Swenoda (3%)	High water table (0.76)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Ramsey County, North Dakota (ND071)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Sioux (2%)	High perc rate (0.22)		
F249C	Esmond-Emrick loams, sandy substratums, 3 to 9 percent slopes	Somewhat limited	Emrick, sandy substratum (31%)	High water table (0.76)	5.4	0.2%
			Heimdal (12%)	High water table (0.19)		
			Sioux (8%)	High perc rate (0.22)		
			Ortonville (5%)	High water table (0.76)		
F256A	Divide loam, shaly, loamy substratum, 0 to 2 percent slopes	Very limited	Divide, shaly, loamy substratum (74%)	High water table (1.00)	0.1	0.0%
			Marysland, shaly, loamy substratum (7%)	High water table (1.00)		
			Wyrene, shaly, loamy substratum (5%)	High water table (1.00)		
F523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	Very limited	Fluvaquents, channeled, frequently flooded (40%)	High water table (1.00)	0.2	0.0%
				High perc rate (0.21)		
			Lowe, frequently flooded (28%)	High water table (1.00)		
			Lowe, moderately saline, frequently flooded (20%)	High water table (1.00)		
			Moritz, occasionally flooded (5%)	High water table (1.00)		
			Lowe, very poorly drained, frequently flooded (5%)	High water table (1.00)		
Subtotals for Soil Survey Area					**959.2**	**37.5%**
Totals for Area of Interest					**2,560.3**	**100.0%**

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Very limited	1,371.9	53.6%

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Somewhat limited	1,160.9	45.3%
Not limited	27.6	1.1%
Totals for Area of Interest	**2,560.3**	**100.0%**

Description

The interpretation for Agronomic Concerns, Pesticide and Nutrient Leaching evaluates limitations of a soil that increase the hazard of contaminating aquifers, springs, and local water tables.

The soil features considered are saturated hydraulic conductivity and depth to seasonal high water table.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soil is limited by all of the soil features that affect the interpretation. Numerical ratings indicate the severity of individual limitations; the highest numerical rating identifies the most limiting soil feature(s) considered in the rating process. Less restrictive soil features have a lower numerical value than the maximum used to rate the soil. They are identified to provide the user with additional information about soil limitations for the specific use. Restrictive soil features also need to be considered in planning, design, installation, and management. "Not limited" (numerical value for the most restrictive feature = 0.00) indicates that the soil has features that are very favorable for the specified use. "Somewhat limited" (numerical value for the most restrictive feature = 0.01 to 0.99) indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning. "Very limited" (numerical value for the most restrictive feature = 1.00) indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special planning, or expensive installation procedures.

The results of this interpretation are not designed or intended to be used in a regulatory manner.

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

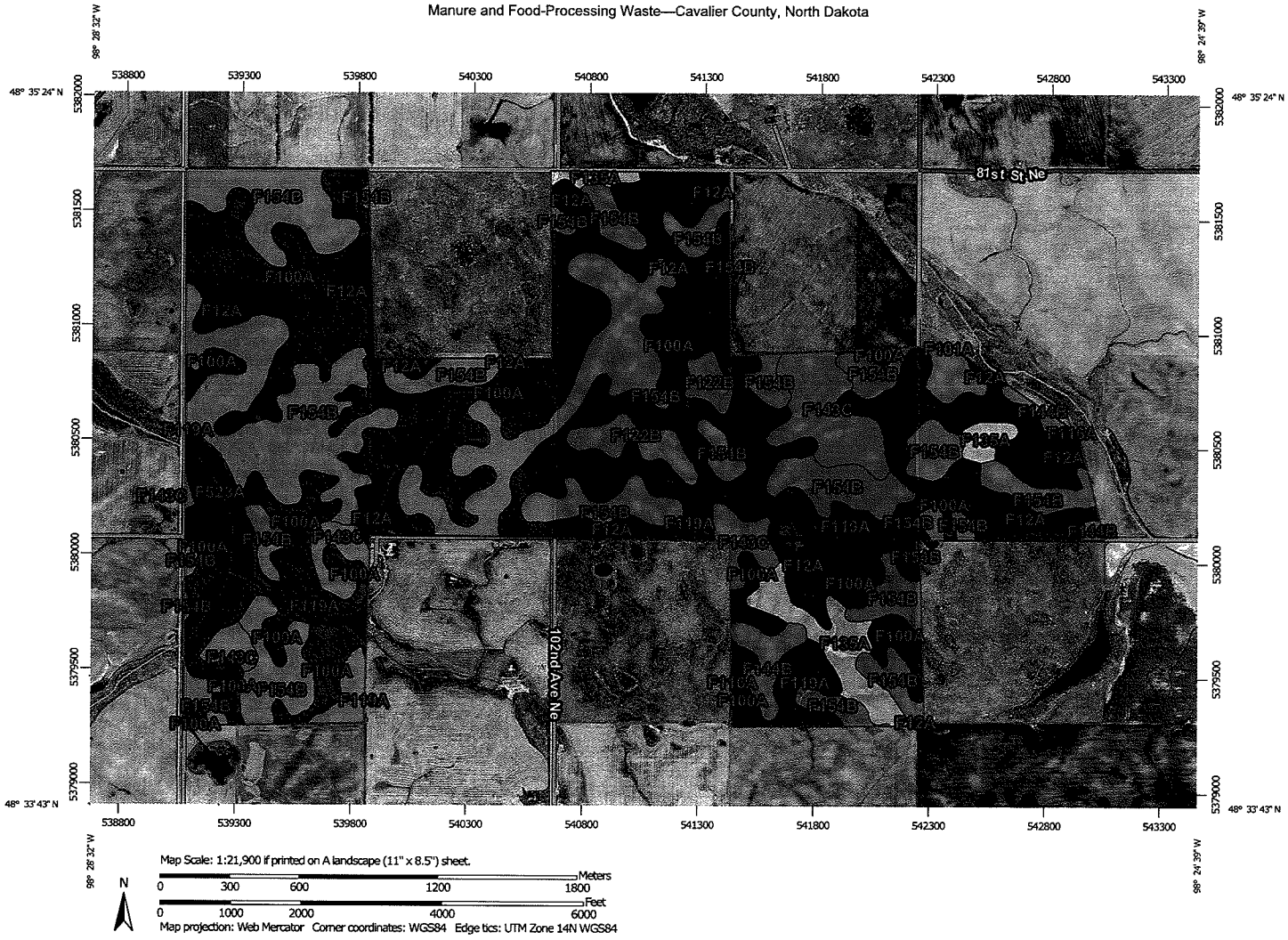
Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher


98° 28' 32" W
98° 24' 39" W
48° 35' 24" N
48° 33' 43" N
538800
539300
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542300
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5380500
5380000
5379500
5379000
81st St Ne
102nd Ave Ne
Map Scale: 1:21,900 if printed on A landscape (11" x 8.5") sheet.
N
Meters
0 300 600 1200 1800
Feet
0 1000 2000 4000 6000
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cavalier County, North Dakota
Survey Area Data: Version 20, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Oct 16, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Cavalier County, North Dakota (ND019)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F12A	Vallers, saline-Parnell complex, 0 to 1 percent slopes	Very limited	Vallers, moderately saline (40%)	Depth to saturated zone (1.00)	105.5	7.6%
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (27%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Tonka (7%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Manfred (5%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Sodium content (1.00)		
				Slow water movement (1.00)		
				Salinity (0.50)		
			Southam (4%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		

Manure and Food-Processing Waste— Summary by Map Unit — Cavalier County, North Dakota (ND019)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Salinity (0.01)		
			Wyard (3%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Easby (3%)	Depth to saturated zone (1.00)		
				Salinity (1.00)		
				Sodium content (1.00)		
				Droughty (1.00)		
				Slow water movement (0.50)		
F100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Tonka (28%)	Slow water movement (1.00)	577.9	41.4%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Wyard (7%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Vallers, moderately saline (7%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cavour (3%)	Slow water movement (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Cavalier County, North Dakota (ND019)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Sodium content (1.00)		
F101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (46%)	Depth to saturated zone (0.86)	0.3	0.0%
			Balaton (7%)	Depth to saturated zone (0.22)		
			Hamerly, moderately saline (4%)	Depth to saturated zone (0.86)		
				Salinity (0.50)		
				Sodium content (0.18)		
F116A	Easby clay loam, 0 to 1 percent slopes	Very limited	Easby (92%)	Ponding (1.00)	0.6	0.0%
				Depth to saturated zone (1.00)		
				Salinity (1.00)		
				Droughty (1.00)		
				Slow water movement (0.50)		
			Easby, very strongly saline (3%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Salinity (1.00)		
				Droughty (1.00)		
				Slow water movement (0.50)		
			Vallers, moderately saline (3%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Droughty (0.03)		
			Parnell (2%)	Slow water movement (1.00)		
				Ponding (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Cavalier County, North Dakota (ND019)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
F119A	Vallers-Hamerly loams, saline, 0 to 3 percent slopes	Very limited	Vallers, moderately saline (45%)	Depth to saturated zone (1.00)	58.5	4.2%
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Cresbard (6%)	Slow water movement (1.00)		
				Sodium content (0.32)		
			Tonka (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Easby (2%)	Depth to saturated zone (1.00)		
				Salinity (1.00)		
				Sodium content (1.00)		
				Droughty (1.00)		
				Slow water movement (0.50)		
			Parnell (2%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
F122B	Barnes-Cresbard loams, 3 to 6 percent slopes	Not limited	Barnes (42%)		26.1	1.9%

Manure and Food-Processing Waste— Summary by Map Unit — Cavalier County, North Dakota (ND019)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Balaton, saline-sodic substratum (4%)			
			Buse (4%)			
			Svea, saline-sodic substratum (3%)			
F135A	Hamerly-Cresbard loams, 0 to 3 percent slopes	Somewhat limited	Hamerly (44%)	Depth to saturated zone (0.86)	43.7	3.1%
			Balaton (5%)	Depth to saturated zone (0.22)		
F143C	Barnes-Buse-Langhei loams, 6 to 9 percent slopes	Not limited	Barnes (24%)		73.5	5.3%
			Buse (23%)			
			Langhei (18%)			
			Svea (14%)			
			Balaton (3%)			
			Lanona (3%)			
F144B	Barnes-Buse loams, 3 to 6 percent slopes	Not limited	Barnes (25%)		21.0	1.5%
			Buse (24%)			
			Svea (14%)			
			Balaton (10%)			
			Langhei (4%)			
			Swenoda (3%)			
F154B	Svea-Buse loams, 3 to 6 percent slopes	Not limited	Svea (45%)		449.7	32.2%
			Buse (33%)			
			Barnes (10%)			
F523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	Very limited	Fluvaquents, channeled, frequently flooded (40%)	Ponding (1.00)	40.0	2.9%
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.90)		
			Lowe, frequently flooded (28%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		

Manure and Food-Processing Waste— Summary by Map Unit — Cavalier County, North Dakota (ND019)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Lowe, moderately saline, frequently flooded (20%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
				Salinity (0.50)		
			Lowe, very poorly drained, frequently flooded (5%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
Totals for Area of Interest					**1,396.9**	**100.0%**

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Very limited	782.6	56.0%
Not limited	570.3	40.8%
Somewhat limited	44.0	3.2%
Totals for Area of Interest	**1,396.9**	**100.0%**

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

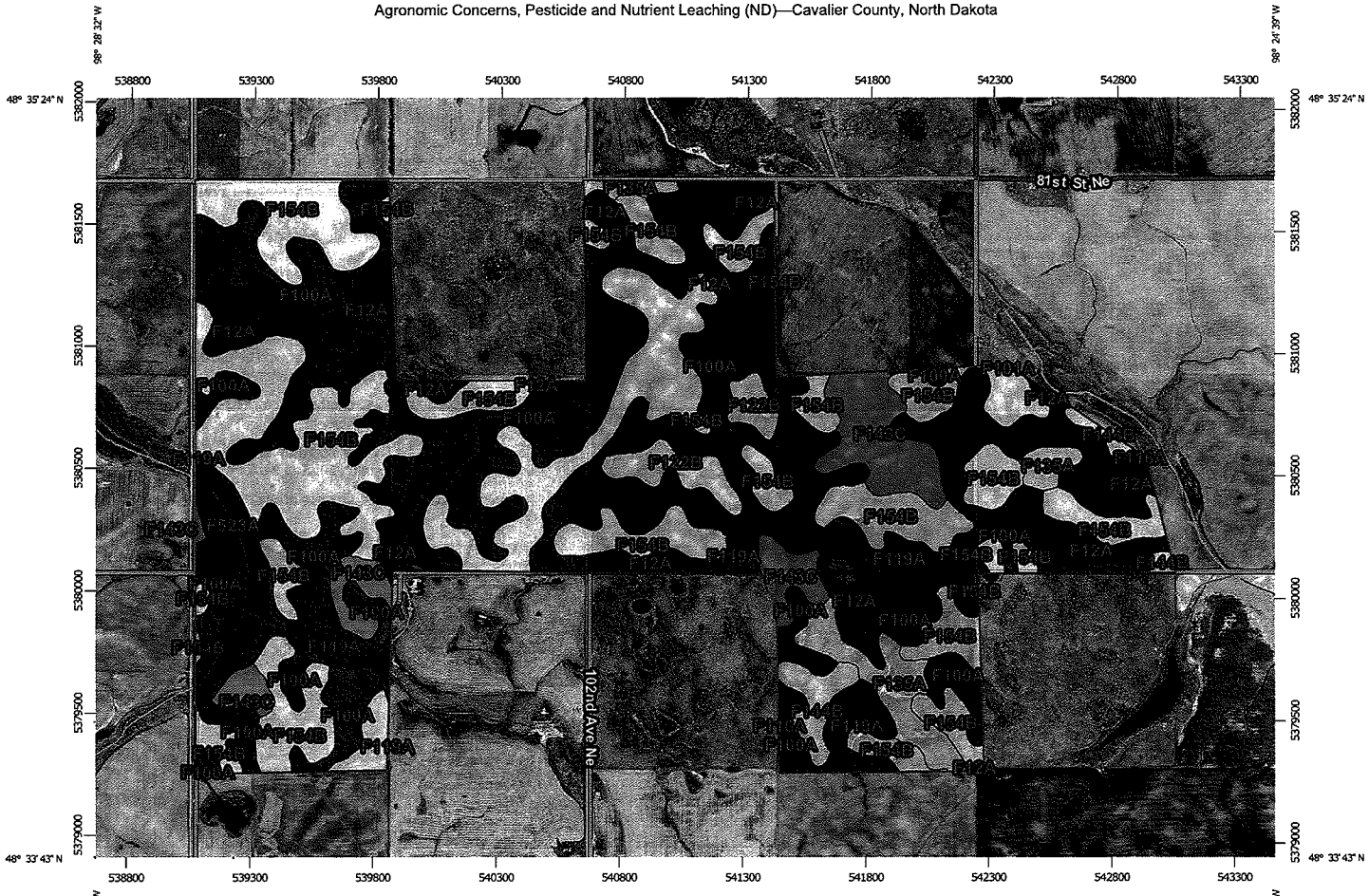
Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher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F100A
F122B
F143C
F101A
F135A
F141B
F154B
F102A
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Meters
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Feet
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Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Background
- Aerial Photography

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cavalier County, North Dakota
Survey Area Data: Version 20, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 9, 2010—Oct 16, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Cavalier County, North Dakota (ND019)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F12A	Vallers, saline-Parnell complex, 0 to 1 percent slopes	Very limited	Vallers, moderately saline (40%)	High water table (1.00)	105.5	7.6%
			Parnell (27%)	High water table (1.00)		
			Hamerly, moderately saline (11%)	High water table (1.00)		
			Tonka (7%)	High water table (1.00)		
			Manfred (5%)	High water table (1.00)		
			Southam (4%)	High water table (1.00)		
			Wyard (3%)	High water table (1.00)		
			Easby (3%)	High water table (1.00)		
F100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Hamerly (42%)	High water table (1.00)	577.9	41.4%
			Tonka (28%)	High water table (1.00)		
			Wyard (7%)	High water table (1.00)		
			Vallers, moderately saline (7%)	High water table (1.00)		
			Parnell (5%)	High water table (1.00)		
F101A	Hamerly-Wyard loams, 0 to 3 percent slopes	Very limited	Hamerly (46%)	High water table (1.00)	0.3	0.0%
			Wyard (24%)	High water table (1.00)		
			Tonka (8%)	High water table (1.00)		
			Vallers (5%)	High water table (1.00)		
			Hamerly, moderately saline (4%)	High water table (1.00)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Cavalier County, North Dakota (ND019)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F116A	Easby clay loam, 0 to 1 percent slopes	Very limited	Easby (92%)	High water table (1.00)	0.6	0.0%
			Easby, very strongly saline (3%)	High water table (1.00)		
			Vallers, moderately saline (3%)	High water table (1.00)		
			Parnell (2%)	High water table (1.00)		
F119A	Vallers-Hamerly loams, saline, 0 to 3 percent slopes	Very limited	Vallers, moderately saline (45%)	High water table (1.00)	58.5	4.2%
			Hamerly, moderately saline (31%)	High water table (1.00)		
			Hamerly (7%)	High water table (1.00)		
			Tonka (3%)	High water table (1.00)		
			Easby (2%)	High water table (1.00)		
			Parnell (2%)	High water table (1.00)		
F122B	Barnes-Cresbard loams, 3 to 6 percent slopes	Somewhat limited	Barnes (42%)	High water table (0.19)	26.1	1.9%
			Cresbard (39%)	High water table (0.76)		
			Balaton, saline-sodic substratum (4%)	High water table (0.76)		
			Cavour (3%)	High water table (0.76)		
			Svea, saline-sodic substratum (3%)	High water table (0.76)		
F135A	Hamerly-Cresbard loams, 0 to 3 percent slopes	Somewhat limited	Cresbard (41%)	High water table (0.76)	43.7	3.1%
			Balaton (5%)	High water table (0.76)		
			Svea (2%)	High water table (0.76)		
			Cavour (2%)	High water table (0.76)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Cavalier County, North Dakota (ND019)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Barnes (2%)	High water table (0.19)		
F143C	Barnes-Buse-Langhei loams, 6 to 9 percent slopes	Not limited	Barnes (24%)		73.5	5.3%
			Buse (23%)			
			Langhei (18%)			
			Renshaw (3%)			
F144B	Barnes-Buse loams, 3 to 6 percent slopes	Somewhat limited	Barnes (25%)	High water table (0.19)	21.0	1.5%
			Svea (14%)	High water table (0.76)		
			Balaton (10%)	High water table (0.76)		
			Cresbard (3%)	High water table (0.76)		
			Swenoda (3%)	High water table (0.76)		
			Sioux (2%)	High perc rate (0.22)		
F154B	Svea-Buse loams, 3 to 6 percent slopes	Somewhat limited	Svea (45%)	High water table (0.76)	449.7	32.2%
			Barnes (10%)	High water table (0.19)		
			Sioux (2%)	High perc rate (0.22)		
			Cresbard (2%)	High water table (0.76)		
F523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	Very limited	Fluvaquents, channeled, frequently flooded (40%)	High water table (1.00)	40.0	2.9%
				High perc rate (0.21)		
			Lowe, frequently flooded (28%)	High water table (1.00)		
			Lowe, moderately saline, frequently flooded (20%)	High water table (1.00)		
			Moritz, occasionally flooded (5%)	High water table (1.00)		
			Lowe, very poorly drained, frequently flooded (5%)	High water table (1.00)		
Totals for Area of Interest					**1,396.9**	**100.0%**

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Very limited	782.9	56.0%
Somewhat limited	540.5	38.7%
Not limited	73.5	5.3%
Totals for Area of Interest	**1,396.9**	**100.0%**

Description

The interpretation for Agronomic Concerns, Pesticide and Nutrient Leaching evaluates limitations of a soil that increase the hazard of contaminating aquifers, springs, and local water tables.

The soil features considered are saturated hydraulic conductivity and depth to seasonal high water table.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soil is limited by all of the soil features that affect the interpretation. Numerical ratings indicate the severity of individual limitations; the highest numerical rating identifies the most limiting soil feature(s) considered in the rating process. Less restrictive soil features have a lower numerical value than the maximum used to rate the soil. They are identified to provide the user with additional information about soil limitations for the specific use. Restrictive soil features also need to be considered in planning, design, installation, and management. "Not limited" (numerical value for the most restrictive feature = 0.00) indicates that the soil has features that are very favorable for the specified use. "Somewhat limited" (numerical value for the most restrictive feature = 0.01 to 0.99) indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning. "Very limited" (numerical value for the most restrictive feature = 1.00) indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special planning, or expensive installation procedures.

The results of this interpretation are not designed or intended to be used in a regulatory manner.

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

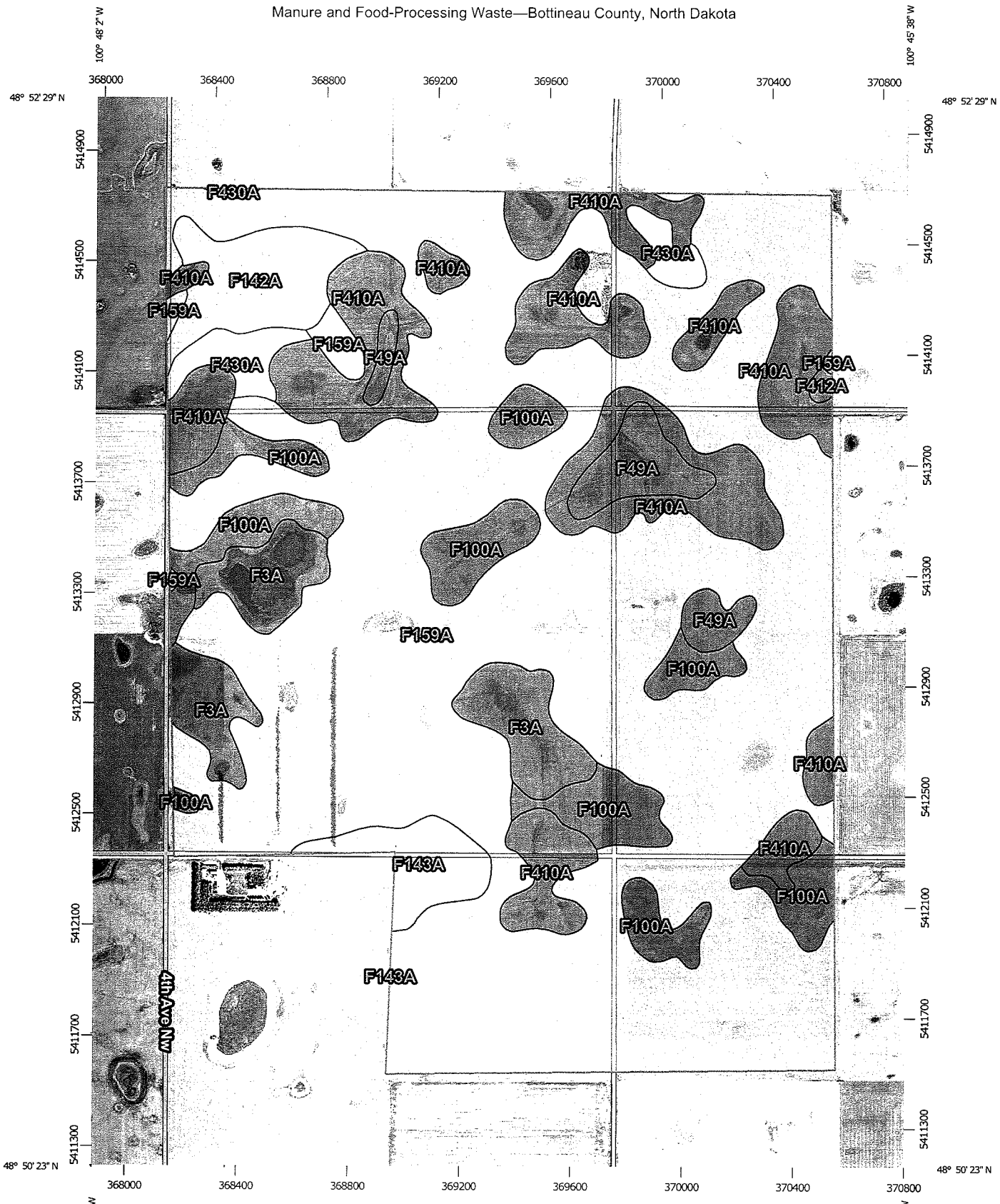
Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher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F430A
F410A
F142A
F159A
F49A
F100A
F3A
F143A
F412A
4th Ave NW
Map Scale: 1:18,800 if printed on A portrait (8.5" x 11") sheet.
Meters
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Feet
0 500 1000 2000 3000
N
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Bottineau County, North Dakota
Survey Area Data: Version 22, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 21, 2010—Sep 28, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Bottineau County, North Dakota (ND009)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
F3A	Parnell silty clay loam, 0 to 1 percent slopes	Very limited	Parnell (64%)	Slow water movement (1.00)	84.7	4.9%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Vallers (10%)	Depth to saturated zone (1.00)		
				Leaching (0.70)		
			Vallers, moderately saline (9%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Southam (6%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Tonka (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Ferney (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
				Salinity (0.50)		

Manure and Food-Processing Waste— Summary by Map Unit — Bottineau County, North Dakota (ND009)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
F49A	Fargo-Hegne silty clays, very poorly drained, 0 to 1 percent slopes	Very limited	Fargo, very poorly drained (45%)	Slow water movement (1.00)	42.0	2.4%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Hegne, very poorly drained (37%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Lindaas (8%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Dovray (7%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Hegne, moderately saline (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.50)		
F100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Tonka (28%)	Slow water movement (1.00)	134.8	7.8%
				Ponding (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Bottineau County, North Dakota (ND009)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Wyard (7%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
			Vallers, moderately saline (7%)	Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.70)		
				Sodium content (0.18)		
			Parnell (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Cavour (3%)	Slow water movement (1.00)		
				Sodium content (1.00)		
F142A	Svea loam, 0 to 3 percent slopes	Not limited	Svea (76%)		50.6	2.9%
			Barnes (3%)			
F143A	Barnes-Svea loams, 0 to 3 percent slopes	Not limited	Barnes (39%)		30.9	1.8%
			Svea (38%)			
			Buse (2%)			
F159A	Barnes-Svea-Tonka complex, 0 to 3 percent slopes	Not limited	Barnes (32%)		1,108.6	64.0%
			Svea (28%)			
			Buse (3%)			
F410A	Fargo silty clay, 0 to 1 percent slopes	Very limited	Fargo (85%)	Slow water movement (1.00)	249.9	14.4%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		

Manure and Food-Processing Waste— Summary by Map Unit — Bottineau County, North Dakota (ND009)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
			Hegne (8%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Dovray (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Aberdeen (2%)	Slow water movement (1.00)		
				Sodium content (0.18)		
			Hegne, moderately saline (2%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.50)		
F412A	Hegne silty clay, 0 to 1 percent slopes	Very limited	Hegne (74%)	Slow water movement (1.00)	2.1	0.1%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Fargo (10%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		

Manure and Food-Processing Waste— Summary by Map Unit — Bottineau County, North Dakota (ND009)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
			Hegne, moderately saline (8%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.50)		
			Dovray (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Aberdeen (3%)	Slow water movement (1.00)		
				Sodium content (0.18)		
F430A	Bearden silty clay loam, 0 to 2 percent slopes	Somewhat limited	Bearden (72%)	Depth to saturated zone (0.86)	28.1	1.6%
				Slow water movement (0.50)		
Totals for Area of Interest					**1,731.7**	**100.0%**

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	**Acres in AOI**	**Percent of AOI**
Not limited	1,190.1	68.7%
Very limited	513.5	29.7%
Somewhat limited	28.1	1.6%
Totals for Area of Interest	**1,731.7**	**100.0%**

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

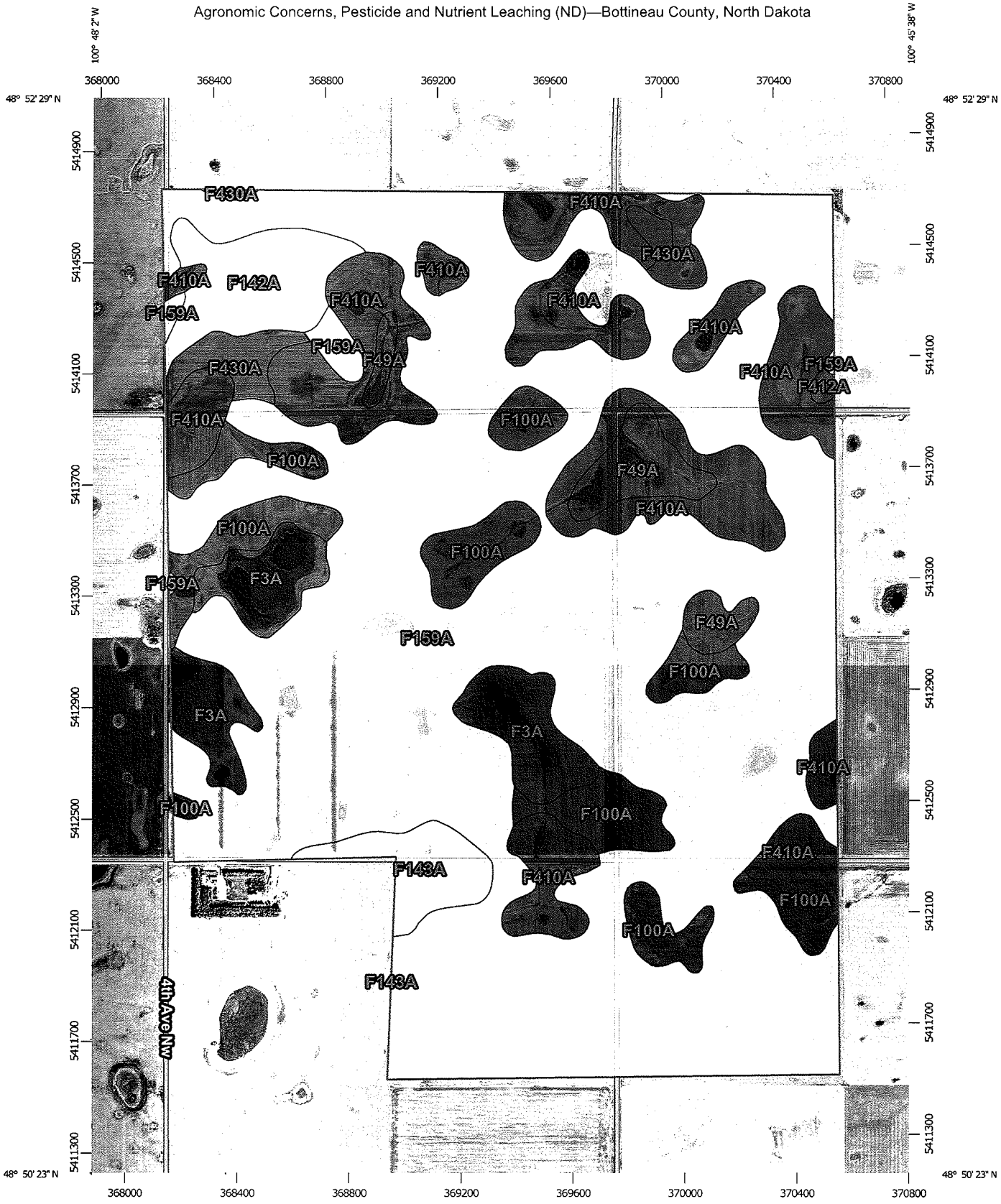
Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher



Map Scale: 1:18,800 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0 250 500 1000 1500

Feet: 0 500 1000 2000 3000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Bottineau County, North Dakota
Survey Area Data: Version 22, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 21, 2010—Sep 28, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Bottineau County, North Dakota (ND009)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F3A	Parnell silty clay loam, 0 to 1 percent slopes	Very limited	Parnell (64%)	High water table (1.00)	84.7	4.9%
			Vallers (10%)	High water table (1.00)		
			Vallers, moderately saline (9%)	High water table (1.00)		
			Southam (6%)	High water table (1.00)		
			Tonka (5%)	High water table (1.00)		
			Hamerly (3%)	High water table (1.00)		
F49A	Fargo-Hegne silty clays, very poorly drained, 0 to 1 percent slopes	Very limited	Fargo, very poorly drained (45%)	High water table (1.00)	42.0	2.4%
			Hegne, very poorly drained (37%)	High water table (1.00)		
			Lindaas (8%)	High water table (1.00)		
			Dovray (7%)	High water table (1.00)		
			Hegne, moderately saline (3%)	High water table (1.00)		
F100A	Hamerly-Tonka complex, 0 to 3 percent slopes	Very limited	Hamerly (42%)	High water table (1.00)	134.8	7.8%
			Tonka (28%)	High water table (1.00)		
			Wyard (7%)	High water table (1.00)		
			Vallers, moderately saline (7%)	High water table (1.00)		
			Parnell (5%)	High water table (1.00)		
F142A	Svea loam, 0 to 3 percent slopes	Somewhat limited	Svea (76%)	High water table (0.76)	50.6	2.9%

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Bottineau County, North Dakota (ND009)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Cresbard (6%)	High water table (0.76)		
			Barnes (3%)	High water table (0.19)		
F143A	Barnes-Svea loams, 0 to 3 percent slopes	Somewhat limited	Barnes (39%)	High water table (0.19)	30.9	1.8%
			Svea (38%)	High water table (0.76)		
			Cresbard (3%)	High water table (0.76)		
F159A	Barnes-Svea-Tonka complex, 0 to 3 percent slopes	Somewhat limited	Barnes (32%)	High water table (0.19)	1,108.6	64.0%
			Svea (28%)	High water table (0.76)		
			Cresbard (3%)	High water table (0.76)		
F410A	Fargo silty clay, 0 to 1 percent slopes	Very limited	Fargo (85%)	High water table (1.00)	249.9	14.4%
			Hegne (8%)	High water table (1.00)		
			Dovray (3%)	High water table (1.00)		
			Hegne, moderately saline (2%)	High water table (1.00)		
F412A	Hegne silty clay, 0 to 1 percent slopes	Very limited	Hegne (74%)	High water table (1.00)	2.1	0.1%
			Fargo (10%)	High water table (1.00)		
			Hegne, moderately saline (8%)	High water table (1.00)		
			Dovray (5%)	High water table (1.00)		
F430A	Bearden silty clay loam, 0 to 2 percent slopes	Very limited	Bearden (72%)	High water table (1.00)	28.1	1.6%
			Kindred (9%)	High water table (1.00)		
			Colvin, moderately saline (5%)	High water table (1.00)		
			Lindaas (4%)	High water table (1.00)		
Totals for Area of Interest					**1,731.7**	**100.0%**

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Somewhat limited	1,190.1	68.7%
Very limited	541.6	31.3%
Totals for Area of Interest	**1,731.7**	**100.0%**

Description

The interpretation for Agronomic Concerns, Pesticide and Nutrient Leaching evaluates limitations of a soil that increase the hazard of contaminating aquifers, springs, and local water tables.

The soil features considered are saturated hydraulic conductivity and depth to seasonal high water table.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soil is limited by all of the soil features that affect the interpretation. Numerical ratings indicate the severity of individual limitations; the highest numerical rating identifies the most limiting soil feature(s) considered in the rating process. Less restrictive soil features have a lower numerical value than the maximum used to rate the soil. They are identified to provide the user with additional information about soil limitations for the specific use. Restrictive soil features also need to be considered in planning, design, installation, and management. "Not limited" (numerical value for the most restrictive feature = 0.00) indicates that the soil has features that are very favorable for the specified use. "Somewhat limited" (numerical value for the most restrictive feature = 0.01 to 0.99) indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning. "Very limited" (numerical value for the most restrictive feature = 1.00) indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special planning, or expensive installation procedures.

The results of this interpretation are not designed or intended to be used in a regulatory manner.

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

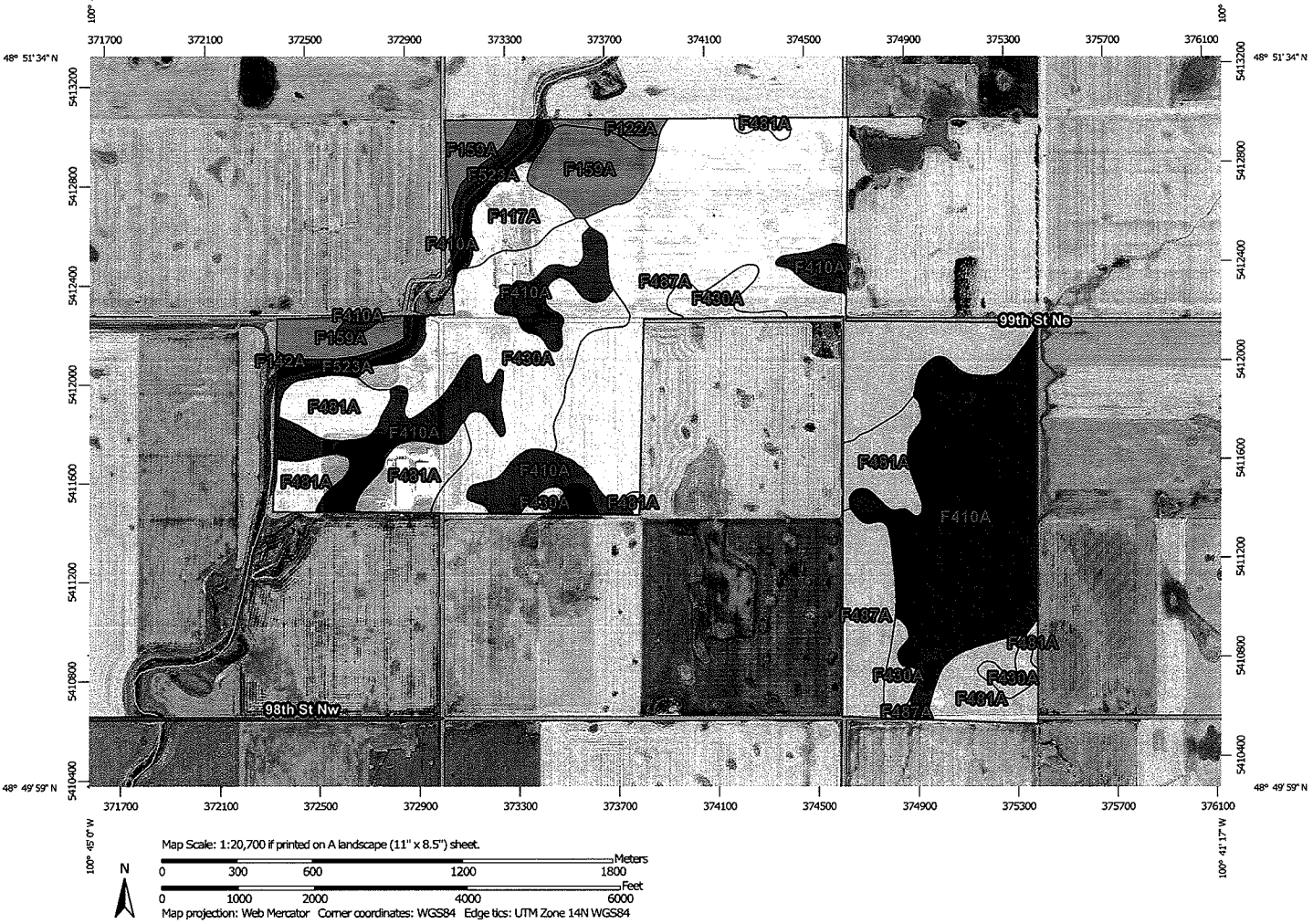
Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher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Meters
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Feet
0 1000 2000 4000 6000
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Background
- Aerial Photography

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

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Please rely on the bar scale on each map sheet for map measurements.

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Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

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This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Bottineau County, North Dakota
Survey Area Data: Version 22, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 21, 2010—Sep 28, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Bottineau County, North Dakota (ND009)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F117A	Hamerly loam, saline, 0 to 3 percent slopes	Somewhat limited	Hamerly, moderately saline (55%)	Depth to saturated zone (0.86)	23.3	2.5%
				Salinity (0.50)		
				Sodium content (0.18)		
			Hamerly (8%)	Depth to saturated zone (0.86)		
			Balaton (7%)	Depth to saturated zone (0.22)		
F122A	Svea-Cresbard loams, 0 to 3 percent slopes	Not limited	Svea, saline-sodic substratum (41%)		7.0	0.8%
			Barnes (5%)			
			Balaton, saline-sodic substratum (3%)			
F142A	Svea loam, 0 to 3 percent slopes	Not limited	Svea (76%)		0.6	0.1%
			Barnes (3%)			
F159A	Barnes-Svea-Tonka complex, 0 to 3 percent slopes	Not limited	Barnes (32%)		61.9	6.7%
			Svea (28%)			
			Buse (3%)			
F410A	Fargo silty clay, 0 to 1 percent slopes	Very limited	Fargo (85%)	Slow water movement (1.00)	257.8	28.0%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Hegne (8%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Bottineau County, North Dakota (ND009)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Leaching (0.50)		
			Dovray (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Aberdeen (2%)	Slow water movement (1.00)		
				Sodium content (0.18)		
			Hegne, moderately saline (2%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.50)		
F430A	Bearden silty clay loam, 0 to 2 percent slopes	Somewhat limited	Bearden (72%)	Depth to saturated zone (0.86)	137.1	14.9%
				Slow water movement (0.50)		
F481A	Overly silty clay loam, 0 to 2 percent slopes	Somewhat limited	Overly (59%)	Slow water movement (0.50)	110.8	12.0%
			Bearden (12%)	Depth to saturated zone (0.86)		
				Slow water movement (0.50)		
			Great Bend (11%)	Slow water movement (0.50)		
F487A	Overly-Great Bend silty clay loams, 0 to 2 percent slopes	Somewhat limited	Overly, overflow (44%)	Slow water movement (0.50)	288.7	31.4%
			Great Bend (39%)	Slow water movement (0.50)		

Manure and Food-Processing Waste— Summary by Map Unit — Bottineau County, North Dakota (ND009)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Bearden (3%)	Depth to saturated zone (0.86)		
				Slow water movement (0.50)		
F523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	Very limited	Fluvaquents, channeled, frequently flooded (40%)	Ponding (1.00)	32.4	3.5%
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.90)		
			Lowe, frequently flooded (28%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
			Lowe, moderately saline, frequently flooded (20%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
				Salinity (0.50)		
			Lowe, very poorly drained, frequently flooded (5%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
Totals for Area of Interest					**919.7**	**100.0%**

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Somewhat limited	559.9	60.9%
Very limited	290.2	31.6%
Not limited	69.5	7.6%
Totals for Area of Interest	**919.7**	**100.0%**

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

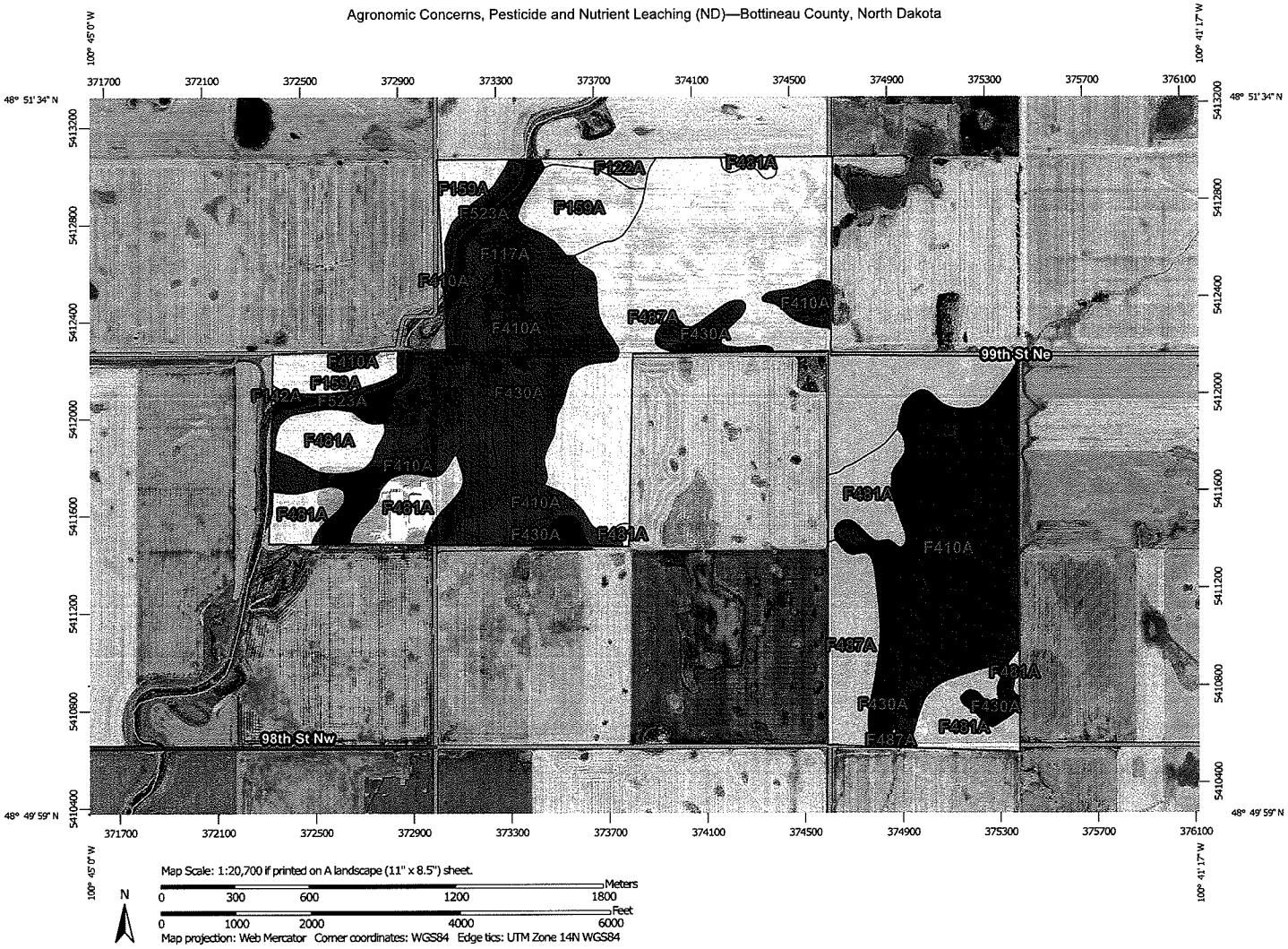
Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher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F159A
F523A
F117A
F410A
F487A
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F491A
99th St Ne
98th St Nw
Map Scale: 1:20,700 if printed on A landscape (11" x 8.5") sheet.
Meters
0 300 600 1200 1800
Feet
0 1000 2000 4000 6000
N
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Background
- Aerial Photography

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
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Survey Area Data: Version 22, Sep 24, 2015

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Date(s) aerial images were photographed: Aug 21, 2010—Sep 28, 2010

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Agronomic Concerns, Pesticide and Nutrient Leaching (ND)

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Bottineau County, North Dakota (ND009)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
F117A	Hamerly loam, saline, 0 to 3 percent slopes	Very limited	Hamerly, moderately saline (55%)	High water table (1.00)	23.3	2.5%
			Wyard (12%)	High water table (1.00)		
			Vallers, moderately saline (8%)	High water table (1.00)		
			Hamerly (8%)	High water table (1.00)		
			Tonka (3%)	High water table (1.00)		
F122A	Svea-Cresbard loams, 0 to 3 percent slopes	Somewhat limited	Svea, saline-sodic substratum (41%)	High water table (0.76)	7.0	0.8%
			Cresbard (30%)	High water table (0.76)		
			Barnes (5%)	High water table (0.19)		
			Ferney (4%)	High water table (0.76)		
			Cavour (3%)	High water table (0.76)		
			Fordville (3%)	High water table (0.19)		
			Balaton, saline-sodic substratum (3%)	High water table (0.76)		
F142A	Svea loam, 0 to 3 percent slopes	Somewhat limited	Svea (76%)	High water table (0.76)	0.6	0.1%
			Cresbard (6%)	High water table (0.76)		
			Barnes (3%)	High water table (0.19)		
F159A	Barnes-Svea-Tonka complex, 0 to 3 percent slopes	Somewhat limited	Barnes (32%)	High water table (0.19)	61.9	6.7%
			Svea (28%)	High water table (0.76)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Bottineau County, North Dakota (ND009)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Cresbard (3%)	High water table (0.76)		
F410A	Fargo silty clay, 0 to 1 percent slopes	Very limited	Fargo (85%)	High water table (1.00)	257.8	28.0%
			Hegne (8%)	High water table (1.00)		
			Dovray (3%)	High water table (1.00)		
			Hegne, moderately saline (2%)	High water table (1.00)		
F430A	Bearden silty clay loam, 0 to 2 percent slopes	Very limited	Bearden (72%)	High water table (1.00)	137.1	14.9%
			Kindred (9%)	High water table (1.00)		
			Colvin, moderately saline (5%)	High water table (1.00)		
			Lindaas (4%)	High water table (1.00)		
F481A	Overly silty clay loam, 0 to 2 percent slopes	Somewhat limited	Overly (59%)	High water table (0.76)	110.8	12.0%
			Great Bend (11%)	High water table (0.19)		
			Aberdeen (5%)	High water table (0.76)		
F487A	Overly-Great Bend silty clay loams, 0 to 2 percent slopes	Somewhat limited	Overly, overflow (44%)	High water table (0.76)	288.7	31.4%
			Great Bend (39%)	High water table (0.19)		
F523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	Very limited	Fluvaquents, channeled, frequently flooded (40%)	High water table (1.00)	32.4	3.5%
				High perc rate (0.21)		
			Lowe, frequently flooded (28%)	High water table (1.00)		
			Lowe, moderately saline, frequently flooded (20%)	High water table (1.00)		
			Moritz, occasionally flooded (5%)	High water table (1.00)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Bottineau County, North Dakota (ND009)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Lowe, very poorly drained, frequently flooded (5%)	High water table (1.00)		
Totals for Area of Interest					**919.7**	**100.0%**

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Somewhat limited	469.1	51.0%
Very limited	450.6	49.0%
Totals for Area of Interest	**919.7**	**100.0%**

Description

The interpretation for Agronomic Concerns, Pesticide and Nutrient Leaching evaluates limitations of a soil that increase the hazard of contaminating aquifers, springs, and local water tables.

The soil features considered are saturated hydraulic conductivity and depth to seasonal high water table.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soil is limited by all of the soil features that affect the interpretation. Numerical ratings indicate the severity of individual limitations; the highest numerical rating identifies the most limiting soil feature(s) considered in the rating process. Less restrictive soil features have a lower numerical value than the maximum used to rate the soil. They are identified to provide the user with additional information about soil limitations for the specific use. Restrictive soil features also need to be considered in planning, design, installation, and management. "Not limited" (numerical value for the most restrictive feature = 0.00) indicates that the soil has features that are very favorable for the specified use. "Somewhat limited" (numerical value for the most restrictive feature = 0.01 to 0.99) indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning. "Very limited" (numerical value for the most restrictive feature = 1.00) indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special planning, or expensive installation procedures.

The results of this interpretation are not designed or intended to be used in a regulatory manner.

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

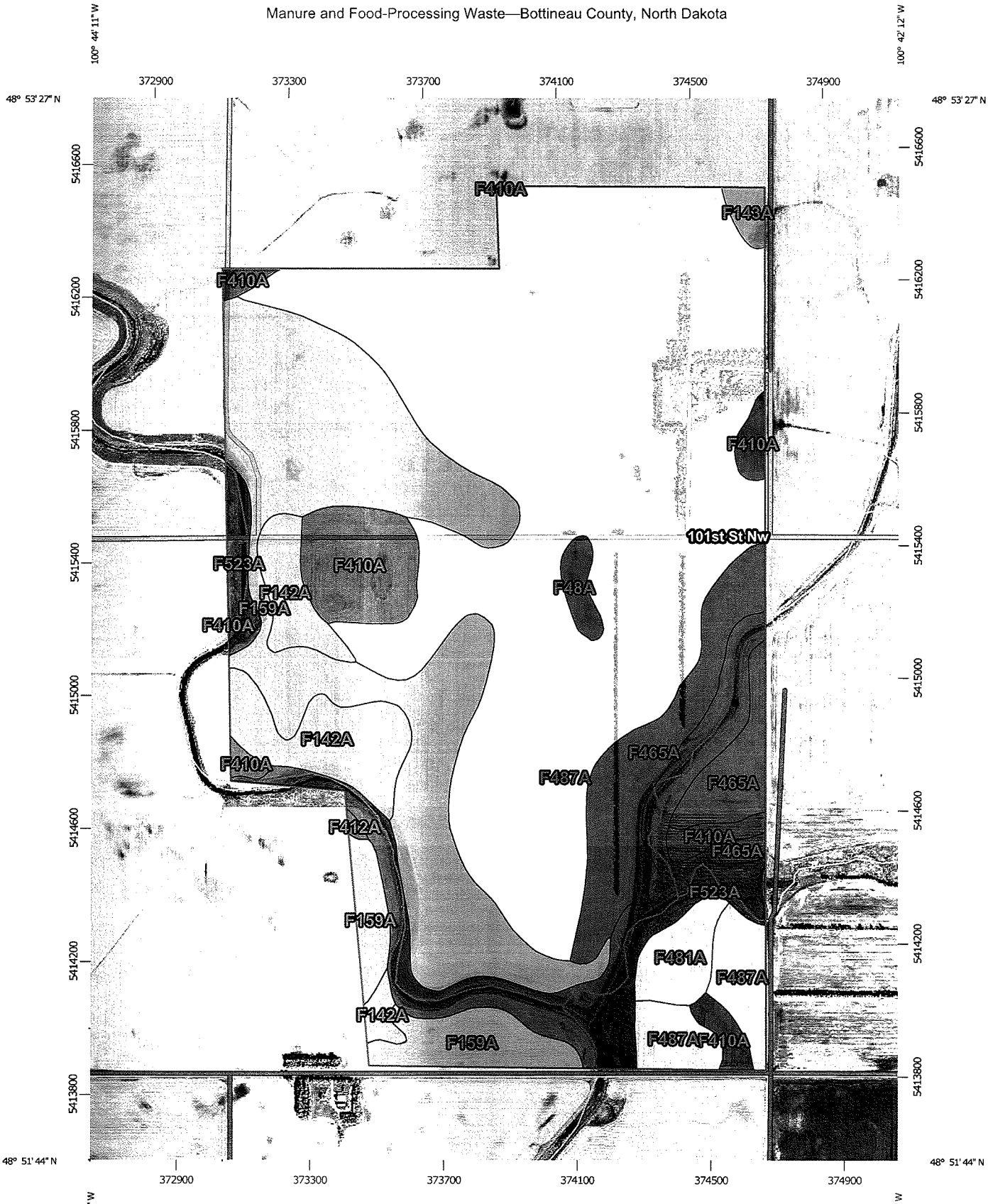
Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher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F410A
101st St Nw
F523A
F410A
F142A
F159A
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F487A
F465A
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F523A
F159A
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F159A
F487A
F410A
Map Scale: 1:15,600 if printed on A portrait (8.5" x 11") sheet.
N
Meters
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Feet
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Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Bottineau County, North Dakota
Survey Area Data: Version 22, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 21, 2010—Sep 28, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Bottineau County, North Dakota (ND009)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F48A	Lindaas silt loam, 0 to 1 percent slopes	Very limited	Lindaas (75%)	Slow water movement (1.00)	5.9	0.6%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Colvin, moderately saline (7%)	Depth to saturated zone (1.00)		
				Salinity (0.50)		
				Slow water movement (0.50)		
				Leaching (0.50)		
				Sodium content (0.32)		
			Hegne (6%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Aberdeen (3%)	Slow water movement (1.00)		
				Sodium content (0.18)		
			Kindred (3%)	Ponding (1.00)		
				Depth to saturated zone (0.86)		
F142A	Svea loam, 0 to 3 percent slopes	Not limited	Svea (76%)		47.3	5.1%
			Barnes (3%)			
F143A	Barnes-Svea loams, 0 to 3 percent slopes	Not limited	Barnes (39%)		4.3	0.5%
			Svea (38%)			
			Buse (2%)			

Manure and Food-Processing Waste— Summary by Map Unit — Bottineau County, North Dakota (ND009)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F159A	Barnes-Svea-Tonka complex, 0 to 3 percent slopes	Not limited	Barnes (32%)		205.1	22.0%
			Svea (28%)			
			Buse (3%)			
F410A	Fargo silty clay, 0 to 1 percent slopes	Very limited	Fargo (85%)	Slow water movement (1.00)	47.0	5.1%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Hegne (8%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Dovray (3%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Aberdeen (2%)	Slow water movement (1.00)		
				Sodium content (0.18)		
			Hegne, moderately saline (2%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.50)		
F412A	Hegne silty clay, 0 to 1 percent slopes	Very limited	Hegne (74%)	Slow water movement (1.00)	0.8	0.1%
				Ponding (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Bottineau County, North Dakota (ND009)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Fargo (10%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Hegne, moderately saline (8%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Salinity (0.78)		
				Leaching (0.50)		
			Dovray (5%)	Slow water movement (1.00)		
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Leaching (0.50)		
			Aberdeen (3%)	Slow water movement (1.00)		
				Sodium content (0.18)		
F465A	Aberdeen-Overly silt loams, 0 to 2 percent slopes	Very limited	Aberdeen (52%)	Slow water movement (1.00)	66.1	7.1%
				Sodium content (0.18)		
			Exline (5%)	Slow water movement (1.00)		
				Sodium content (1.00)		

Manure and Food-Processing Waste— Summary by Map Unit — Bottineau County, North Dakota (ND009)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Depth to saturated zone (0.86)		
				Salinity (0.78)		
				Runoff (0.40)		
			Nahon (4%)	Slow water movement (1.00)		
				Sodium content (1.00)		
			Colvin, moderately saline (3%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Salinity (0.50)		
				Slow water movement (0.50)		
				Leaching (0.50)		
			Perella (2%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Slow water movement (0.50)		
				Leaching (0.50)		
F481A	Overly silty clay loam, 0 to 2 percent slopes	Somewhat limited	Overly (59%)	Slow water movement (0.50)	14.1	1.5%
			Bearden (12%)	Depth to saturated zone (0.86)		
				Slow water movement (0.50)		
			Great Bend (11%)	Slow water movement (0.50)		
F487A	Overly-Great Bend silty clay loams, 0 to 2 percent slopes	Somewhat limited	Overly, overflow (44%)	Slow water movement (0.50)	454.9	48.9%
			Great Bend (39%)	Slow water movement (0.50)		

Manure and Food-Processing Waste— Summary by Map Unit — Bottineau County, North Dakota (ND009)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Bearden (3%)	Depth to saturated zone (0.86)		
				Slow water movement (0.50)		
F523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	Very limited	Fluvaquents, channeled, frequently flooded (40%)	Ponding (1.00)	84.8	9.1%
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.90)		
			Lowe, frequently flooded (28%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
			Lowe, moderately saline, frequently flooded (20%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
				Salinity (0.50)		
			Lowe, very poorly drained, frequently flooded (5%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Leaching (0.70)		
Totals for Area of Interest					**930.1**	**100.0%**

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Somewhat limited	469.0	50.4%
Not limited	256.6	27.6%
Very limited	204.5	22.0%
Totals for Area of Interest	**930.1**	**100.0%**

Description

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

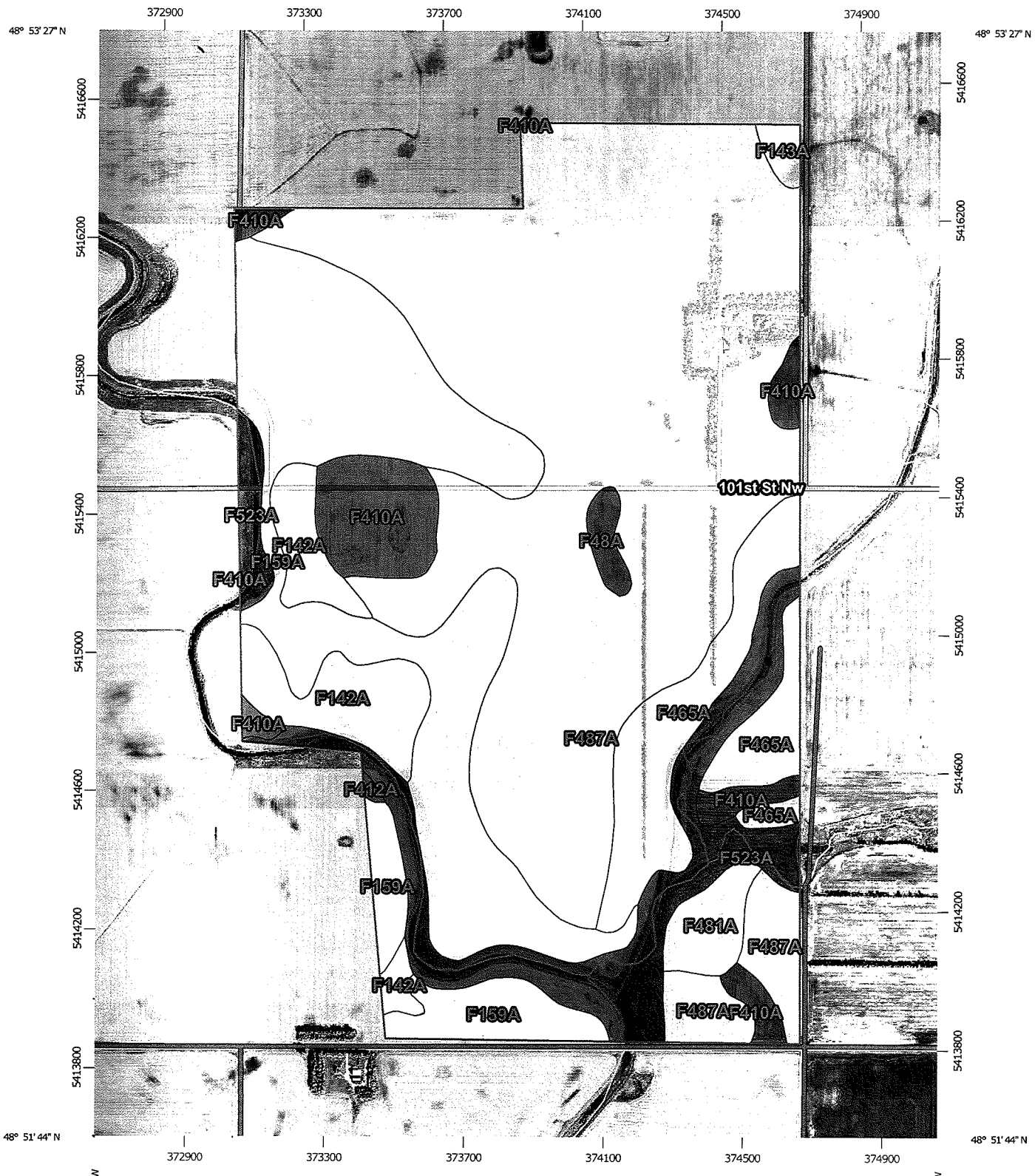
Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher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Map Scale: 1:15,600 if printed on A portrait (8.5" x 11") sheet.
Meters
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Feet
0 500 1000 2000 3000
N
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Bottineau County, North Dakota
Survey Area Data: Version 22, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 21, 2010—Sep 28, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Bottineau County, North Dakota (ND009)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F48A	Lindaas silt loam, 0 to 1 percent slopes	Very limited	Lindaas (75%)	High water table (1.00)	5.9	0.6%
			Colvin, moderately saline (7%)	High water table (1.00)		
			Hegne (6%)	High water table (1.00)		
			Bearden (3%)	High water table (1.00)		
			Kindred (3%)	High water table (1.00)		
F142A	Svea loam, 0 to 3 percent slopes	Somewhat limited	Svea (76%)	High water table (0.76)	47.3	5.1%
			Cresbard (6%)	High water table (0.76)		
			Barnes (3%)	High water table (0.19)		
F143A	Barnes-Svea loams, 0 to 3 percent slopes	Somewhat limited	Barnes (39%)	High water table (0.19)	4.3	0.5%
			Svea (38%)	High water table (0.76)		
			Cresbard (3%)	High water table (0.76)		
F159A	Barnes-Svea-Tonka complex, 0 to 3 percent slopes	Somewhat limited	Barnes (32%)	High water table (0.19)	205.1	22.0%
			Svea (28%)	High water table (0.76)		
			Cresbard (3%)	High water table (0.76)		
F410A	Fargo silty clay, 0 to 1 percent slopes	Very limited	Fargo (85%)	High water table (1.00)	47.0	5.1%
			Hegne (8%)	High water table (1.00)		
			Dovray (3%)	High water table (1.00)		
			Hegne, moderately saline (2%)	High water table (1.00)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Bottineau County, North Dakota (ND009)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
F412A	Hegne silty clay, 0 to 1 percent slopes	Very limited	Hegne (74%)	High water table (1.00)	0.8	0.1%
			Fargo (10%)	High water table (1.00)		
			Hegne, moderately saline (8%)	High water table (1.00)		
			Dovray (5%)	High water table (1.00)		
F465A	Aberdeen-Overly silt loams, 0 to 2 percent slopes	Somewhat limited	Aberdeen (52%)	High water table (0.76)	66.1	7.1%
			Overly, saline-sodic substratum (24%)	High water table (0.76)		
			Great Bend (6%)	High water table (0.19)		
			Nahon (4%)	High water table (0.76)		
F481A	Overly silty clay loam, 0 to 2 percent slopes	Somewhat limited	Overly (59%)	High water table (0.76)	14.1	1.5%
			Great Bend (11%)	High water table (0.19)		
			Aberdeen (5%)	High water table (0.76)		
F487A	Overly-Great Bend silty clay loams, 0 to 2 percent slopes	Somewhat limited	Overly, overflow (44%)	High water table (0.76)	454.9	48.9%
			Great Bend (39%)	High water table (0.19)		
F523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	Very limited	Fluvaquents, channeled, frequently flooded (40%)	High water table (1.00)	84.8	9.1%
				High perc rate (0.21)		
			Lowe, frequently flooded (28%)	High water table (1.00)		
			Lowe, moderately saline, frequently flooded (20%)	High water table (1.00)		
			Moritz, occasionally flooded (5%)	High water table (1.00)		

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Map Unit — Bottineau County, North Dakota (ND009)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Lowe, very poorly drained, frequently flooded (5%)	High water table (1.00)		
Totals for Area of Interest					**930.1**	**100.0%**

Agronomic Concerns, Pesticide and Nutrient Leaching (ND)— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Somewhat limited	791.7	85.1%
Very limited	138.4	14.9%
Totals for Area of Interest	**930.1**	**100.0%**

Description

The interpretation for Agronomic Concerns, Pesticide and Nutrient Leaching evaluates limitations of a soil that increase the hazard of contaminating aquifers, springs, and local water tables.

The soil features considered are saturated hydraulic conductivity and depth to seasonal high water table.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soil is limited by all of the soil features that affect the interpretation. Numerical ratings indicate the severity of individual limitations; the highest numerical rating identifies the most limiting soil feature(s) considered in the rating process. Less restrictive soil features have a lower numerical value than the maximum used to rate the soil. They are identified to provide the user with additional information about soil limitations for the specific use. Restrictive soil features also need to be considered in planning, design, installation, and management. "Not limited" (numerical value for the most restrictive feature = 0.00) indicates that the soil has features that are very favorable for the specified use. "Somewhat limited" (numerical value for the most restrictive feature = 0.01 to 0.99) indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning. "Very limited" (numerical value for the most restrictive feature = 1.00) indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special planning, or expensive installation procedures.

The results of this interpretation are not designed or intended to be used in a regulatory manner.

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Kent Beilke — Kent Beilke
Signature — Print Name

N½ 1 138-54 — 139 ✓
Location (Township-Section-Range) — Number of Acres

Property Owner Kent Beilke — Kent Beilke
Signature — Print Name

N½ 2 138-54 — 305 ✓
Location (Township-Section-Range) — Number of Acres

Property Owner [signature] — Keith Andersen
Signature — Print Name

Section 25, SW¼ 139N 55W — ~~147~~ 160 ✓
Location (Township-Section-Range) — Number of Acres

Property Owner [signature] — Keith Andersen
Signature — Print Name

Section ~~26~~ 36, NW¼ 139N 55W — ~~158~~ 160 ✓
Location (Township-Section-Range) — Number of Acres

764

Property Owner _____ _____
Signature — Print Name

_____ _____
Location (Township-Section-Range) — Number of Acres

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Renee Fiketjon (Signature) Renee Fiketjon (Print Name)

SW ¼ Section 20 139 N. 54 W. (Location (Township-Section-Range)) 160 (Number of Acres)

Property Owner _____ (Signature) _____ (Print Name)

_____ (Location (Township-Section-Range)) _____ (Number of Acres)

Property Owner _____ (Signature) _____ (Print Name)

_____ (Location (Township-Section-Range)) _____ (Number of Acres)

Property Owner _____ (Signature) _____ (Print Name)

_____ (Location (Township-Section-Range)) _____ (Number of Acres)

Property Owner _____ (Signature) _____ (Print Name)

_____ (Location (Township-Section-Range)) _____ (Number of Acres)

160

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Lillian VonBank — Lillian VonBank
Signature — Print Name

Section 17 N 1/2 139 N 54W — 320 Acres
Location (Township-Section-Range) — Number of Acres

Property Owner Debora Miller — Debora Miller
Signature — Print Name

Section 28 NE 1/4 141 N 54W — ~~320~~ 160
Location (Township-Section-Range) — Number of Acres

Property Owner Elaine Hagen — ELAINE HagEN
Signature POA Marilyn Rudell — Print Name

NW 1/4 35-140-54 — 160
Location (Township-Section-Range) — Number of Acres

Property Owner Sharol Martin — Sharol MarTiN
Signature POA Marilyn Rudell — Print Name

NE 1/4 35-140-54 — 160
Location (Township-Section-Range) — Number of Acres

Property Owner Donald Barnby family Trust — MARilyN Barnby
Signature POA Marilyn Rudell — Print Name

SE 1/4 27-140-54 — 160
Location (Township-Section-Range) — Number of Acres

960

Mutual Agreement to Refuse Easements

Property Owner Bradley D Paul P.O.A for David Paul
Signature Bradley D Paul
Print Name

T-139-N Sec 35 R-55-W 160 ✓
Location (Township-Section-Range) Number of Acres

Property Owner Bradley D Paul P.O.A. for David Paul
Signature Bradley D Paul
Print Name

T-139-N Sec34- R-55-W 149 ✓
Location (Township-Section-Range) Number of Acres

Property Owner Bradley D Paul P.O.A. for David Paul
Signature Bradley D Paul
Print Name

T-139-N Sec27- R-55-W 160 ✓
Location (Township-Section-Range) Number of Acres

Property Owner _____
Signature _____
Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____
Signature _____
Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

469

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Winston S. Mullen WINSTON S. MULLEN
Signature Print Name

SW¼ 14-140-55 160
Location (Township-Section-Range) Number of Acres

160

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Marvin Ries — MARVIN N. RIES
Signature — Print Name

139N. 54W Section 30 — 460
Location (Township-Section-Range) — Number of Acres

Property Owner Scott J. Hansen — Scott J. Hansen
Signature — Print Name

Howes 32 NW 1/4 (80)(80) — 160ac ✓
Location (Township-Section-Range) — Number of Acres

Property Owner [signature] — FRANK D. MULLEN
Signature — Print Name

SE 14-140-55 — 139
Location (Township-Section-Range) — Number of Acres

Property Owner Scott J. Hansen — Scott J. Hansen
Signature — Print Name

SE 1/4 Sec 26 139N 55W — 150 ✓
Location (Township-Section-Range) — Number of Acres

Property Owner Scott J. Hansen — Scott J. Hansen
Signature — Print Name

E 1/2 Sec 35 139N 55W — 300 ✓
Location (Township-Section-Range) — Number of Acres

1209

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Gretchen Martin by Peter Baasch POA — Peter Baasch
Signature — Print Name

Tower NW 1/4 35 140 - 55 — 80
Location (Township-Section-Range) — Number of Acres

Property Owner William Krause II by Peter Baasch POA — Peter Baasch
Signature — Print Name

SE 1/4 35 140-55 — 160
Location (Township-Section-Range) — Number of Acres

Property Owner William Krause by Peter Baasch POA — Peter Baasch
Signature — Print Name

SW 1/4 35 140 -55 — 160
Location (Township-Section-Range) — Number of Acres

Property Owner Scott J. Hansen — Scott J. Hansen
Signature — Print Name

SW 1/4 Sec 36 139 N 55 W — 155 ✓
Location (Township-Section-Range) — Number of Acres

555

Property Owner _____ — _____
Signature — Print Name

_____ — _____
Location (Township-Section-Range) — Number of Acres

Mutual Agreement to Refuse Easements

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SIGNED:

Property Owner _____ Mary K Kniske
Signature Print Name

140N 54W Sec 18 SE 1/4 — 160
Location (Township-Section-Range) Number of Acres

Property Owner _____ Robert A. Pierce
Signature Print Name

139N 54W Sec 12 — 27.65
Location (Township-Section-Range) Number of Acres

Property Owner _____ MARIAN KASOWSKI
Signature Print Name

140 N-54 W Section 32-SW 1/4
140N-54W section 31-SE 1/4 — 120
Location (Township-Section-Range) Number of Acres

Property Owner _____ Betty M. Fraese
Signature Print Name

139N 54W Sect 14 West half
139N 54W Sect 10 N 1/2 half — 640
Location (Township-Section-Range) Number of Acres

Property Owner _____ Corey + Kristi Hovelson
Signature Print Name

139-55 section 4 — 273
Location (Township-Section-Range) Number of Acres

1220.65

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Paul Kasowski — Paul Kasowski
Signature — Print Name

17 NW 40 of NW¼ 140N-53W — 40
Location (Township-Section-Range) — Number of Acres

Property Owner Paul Kasowski — Paul Kasowski
Signature — Print Name

Sec 35 SE 10 of SE¼ 140 N 54 W — 10
Location (Township-Section-Range) — Number of Acres

Property Owner Heidi Baasch — Heidi Baasch
Signature — Print Name

140 N 54W Sec 31 NW Corner — 18
Location (Township-Section-Range) — Number of Acres

Property Owner Randy Kasowski — Randy Kasowski
Signature — Print Name

NE¼ Sec 15 Buffalo 140-54 — 160
Location (Township-Section-Range) — Number of Acres

Property Owner Randy Kasowski — Randy Kasowski
Signature — Print Name

NW NE & SE¼ Sec 1 Buffalo 140-54 — 480
Location (Township-Section-Range) — Number of Acres

(805)

Mutual Agreement to Refuse Easements

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SIGNED:

Property Owner Cheryl Hager — Cheryl Hager
Signature — Print Name

Sec 19 SE Quarter 139 N 54 W — 160
Location (Township-Section-Range) — Number of Acres

Property Owner [signature] — Paul Kasowski
Signature — Print Name

15 SE ¼ 140 N 54 W — 160
Location (Township-Section-Range) — Number of Acres

Property Owner [signature] — Paul Kasowski
Signature — Print Name

16 SW ¼ 140 N 54 W — 160
Location (Township-Section-Range) — Number of Acres

Property Owner [signature] — Paul Kasowski
Signature — Print Name

17 SE ¼ 140 N 54 W — 160
Location (Township-Section-Range) — Number of Acres

Property Owner [signature] — Paul Kasowski
Signature — Print Name

20 SW ¼ 140 N 53 W — 160
Location (Township-Section-Range) — Number of Acres

800

Mutual Agreement to Refuse Easements

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SIGNED:

Property Owner _____ Harvey L. Coon
Signature Print Name

NE ¼ - 1 - 139 - 55 — 160
Location (Township-Section-Range) Number of Acres

Property Owner _____ Harvey L. Coon
Signature Print Name

SE ¼ - 1 - 139 - 55 — 160
Location (Township-Section-Range) Number of Acres

Property Owner _____ Richard Smith
Signature Print Name

Sec 22 SW¼
Sec 34 W½ 27 N½ (139-54) — 800
Location (Township-Section-Range) Number of Acres

Property Owner _____ Cecil P. Von Bank
Signature Print Name

139 N - 55 W 25 S½ SE ¼ — 80
Location (Township-Section-Range) Number of Acres

Property Owner _____ Janice Diemert
Signature Print Name

Sec 17 NE ¼ 140 N 55 W
Sec 8 SE ¼ 140 N 55 W — 320
Location (Township-Section-Range) Number of Acres

(153)

Mutual Agreement to Refuse Easements

Cornell

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Cathy Ernie By Consent CATHY ERNIE
Signature Print Name

NW/4 Sec 30-140n-54 42
Location (Township-Section-Range) Number of Acres

Property Owner Eddie Wilson By Consent Eddie Wilson
Signature Print Name

NW/4 Sec. 30 140n-54 48
Location (Township-Section-Range) Number of Acres

Property Owner [signature] Justin Killam
Signature Print Name

Section 24 S 1/2 141-55 300
Location (Township-Section-Range) Number of Acres

Property Owner [signature] Justin Killam
Signature Print Name

Buffalo Sec 18+17 140W-54 300
Location (Township-Section-Range) Number of Acres

Property Owner [signature] Justin Killam
Signature Print Name

Buffalo sec 8 SE/4 140-54 150
Location (Township-Section-Range) Number of Acres

840

Mutual Agreement to Refuse Easements Cornell

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner [signature] Richard Smith
Signature Print Name

NE¼ Sec 20 (141-55) 160
Location (Township-Section-Range) Number of Acres

Property Owner Judith Von Bank Judith Von Bank
Signature Print Name

Sec 22 SE¼ 141 N 55W 160
Location (Township-Section-Range) Number of Acres

Property Owner [signature] CASEY MARCKS
Signature Print Name

SE¼ 30 140N 54 155.7
Location (Township-Section-Range) Number of Acres

Property Owner [signature] CASEY MARCKS
Signature Print Name

NE¼ Sec. 30 140N-54 44
Location (Township-Section-Range) Number of Acres

Property Owner Rodney Marcks By Casey Marcks RODNEY MARCKS
Signature Print Name

NE¼ Sec. 30 - 140N-54 74
Location (Township-Section-Range) Number of Acres

393.7

Mutual Agreement to Refuse Easements

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SIGNED:

Property Owner Judith Von Bank — Judith Von Bank
Signature — Print Name

NE ¼ section 6 139 54R — 160
Location (Township-Section-Range) — Number of Acres

Property Owner Randy Coon — Randy Coon
Signature — Print Name

SW¼ - 6 - 139 - 54 — 160
Location (Township-Section-Range) — Number of Acres

Property Owner Randy Coon — Randy Coon
Signature — Print Name

SW¼ - 36 - 140 - 55 — 160
Location (Township-Section-Range) — Number of Acres

Property Owner Randy Coon — Randy Coon
Signature — Print Name

NW¼ - 1 - 139 - 55 — 160
Location (Township-Section-Range) — Number of Acres

Property Owner Marlyn Nudell — MARLYN NUDELL
Signature — Print Name

NW¼ - 26 - 140 - 54
SW¼ - 34 - 140 - 54 — 280
Location (Township-Section-Range) — Number of Acres

920

Mutual Agreement to Refuse Easements

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SIGNED:

Property Owner Lana F Rakow — Lana F. Rakow
Signature — Print Name

Section 14, NW 1/4, 47 A m West, 139N, 55W — 47.37
Location (Township-Section-Range) — Number of Acres

Property Owner Jeff Zaun — Jeff Zaun
Signature — Print Name

SW 1/4 Sec 2-139-35 — 160.00
Location (Township-Section-Range) — Number of Acres

Property Owner Jeff Zaun — Jeff Zaun
Signature — Print Name

E 1/2 Sec 10-139-55 — 320.00
Location (Township-Section-Range) — Number of Acres

Property Owner Jeff Zaun — Jeff Zaun
Signature — Print Name

NW 1/4 Sec 11-139-55 — 160
Location (Township-Section-Range) — Number of Acres

Property Owner Jeff Zaun — Jeff Zaun
Signature — Print Name

NW 1/4 Sec 14-139-55 — 100
Location (Township-Section-Range) — Number of Acres

787.37

32,487.20
Total Acres

Mutual Agreement to Refuse Easements

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SIGNED:

Property Owner Harriet Griffin Harriet Griffin
Signature Print Name

SW¼ 16-139-55 155
Location (Township-Section-Range) Number of Acres

Property Owner Harriet Griffin Harriet Griffin
Signature Print Name

NW¼ 30-139-55 156
Location (Township-Section-Range) Number of Acres

Property Owner Harriet Griffin Harriet Griffin
Signature Print Name

NE¼ 30-139-55 139
Location (Township-Section-Range) Number of Acres

450

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Mutual Agreement to Refuse Easements

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SIGNED:

Property Owner Gary Christensen GARY CHRISTENSEN
Signature Print Name

NW 1/4 - 2 - 139 - 55 80 crop / 160 total (80)
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Mutual Agreement to Refuse Easements

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SIGNED:

Property Owner Missy Poulson by: Bryn Poulson — Missy Poulson
Signature — Print Name

138N-54W-5 — 157 ✓
Location (Township-Section-Range) — Number of Acres

Property Owner _____ _____
Signature — Print Name

_____ _____
Location (Township-Section-Range) — Number of Acres

Property Owner _____ _____
Signature — Print Name

_____ _____
Location (Township-Section-Range) — Number of Acres

Property Owner _____ _____
Signature — Print Name

_____ _____
Location (Township-Section-Range) — Number of Acres

Property Owner _____ _____
Signature — Print Name

_____ _____
Location (Township-Section-Range) — Number of Acres

157

Mutual Agreement to Refuse Easements

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SIGNED:

Property Owner William E Grieve William E Grieve
Signature Print Name

Agr Township Section 32 NW33 160
Location (Township-Section-Range) Number of Acres

Property Owner Jeannine Wilcox Jeannine Wilcox
Signature Print Name

Section 32 NE¼ 141N54W
Section 31 141N54W 160 – 640
Location (Township-Section-Range) Number of Acres

960

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner [signature] Reita Mudell
Signature Print Name

Sec. 5 139-54 — 310
Location (Township-Section-Range) Number of Acres

Property Owner [signature] Reita Mudell
Signature Print Name

Sec 6 · 139-54 — 160
Location (Township-Section-Range) Number of Acres

Property Owner [signature] Reita Mudell
Signature Print Name

Sec 33 · 140-54 — 158 — 628
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Carol Beilke — Carol Beilke
Signature — Print Name

SE 1/4 32 140-54 — 154 ✓
Location (Township-Section-Range) — Number of Acres

Property Owner Carol Beilke — Carol Beilke
Signature — Print Name

SE 1/4 15 139-54 — 158 ✓
Location (Township-Section-Range) — Number of Acres

Property Owner Carol Beilke — Carol Beilke
Signature — Print Name

SE 1/4 2 138-54 — 158 ✓
Location (Township-Section-Range) — Number of Acres

Property Owner Kent Beilke — Kent Beilke
Signature — Print Name

SE 1/4 16 139-54 — 148 ✓
Location (Township-Section-Range) — Number of Acres

Property Owner Kent Beilke — Kent Beilke
Signature — Print Name

NE 1/4 21 139-54 — 158 ✓
Location (Township-Section-Range) — Number of Acres

776

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner LuElla Von Bank LuElla Von Bank
Signature Print Name

NW ¼ of Section 5, 139-54 → Howes Township, Section 5 160 acres
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

160

Mutual Agreement to Refuse Easements

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SIGNED:

Property Owner R-Za — Ryan Zaun
Signature — Print Name

139N Howes 31 54 W — 153.4 ✓
Location (Township-Section-Range) — Number of Acres
Southwest Qtr.

Property Owner _____ _____
Signature — Print Name

_____ _____
Location (Township-Section-Range) — Number of Acres

Property Owner _____ _____
Signature — Print Name

_____ _____
Location (Township-Section-Range) — Number of Acres

Property Owner _____ _____
Signature — Print Name

_____ _____
Location (Township-Section-Range) — Number of Acres

Property Owner _____ _____
Signature — Print Name

_____ _____
Location (Township-Section-Range) — Number of Acres

153.40

Mutual Agreement to Refuse Easements

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SIGNED:

Property Owner Diane M Reveling DIANE M. REVELING ✓
Signature Print Name

W 1/2 139-54 Section 15 316
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

316

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Gerald D. Marcks — GERALD D. MARCKS
Signature — Print Name

NE 1/4 - 31 - 140 - 54 — 160
Location (Township-Section-Range) — Number of Acres

Property Owner Gerald Marcks / Jacqueline L Marcks — GERALD MARCKS / JACQUELINE MARCKS
Signature — Print Name

N 1/2 of NW 1/4 32-140-54 — 80
Location (Township-Section-Range) — Number of Acres

Property Owner Jacqueline R. Marcks — JACQUELINE MARCKS
Signature — Print Name

SW 1/4 28-140-54 — 155.98
Location (Township-Section-Range) — Number of Acres

Property Owner Jacqueline L. Marcks — JACQUELINE MARCKS
Signature — Print Name

SW 1/4 -4- 139 - 54 — 160
Location (Township-Section-Range) — Number of Acres

Property Owner Jayne Robinson — JAYNE ROBINSON
Signature — By Gerald Marcks Print Name POA.

S 1/2 of NW 1/4 - 32-140-50 — 80
Location (Township-Section-Range) — Number of Acres

635.98

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner [signature] Signature — Larry Zaun Print Name

Sec 31 - E½ of SE¼ - 140-54 Location (Township-Section-Range) — 80 Number of Acres

Property Owner [signature] Signature — Larry Zaun Print Name

Sec 32 - SW¼ - 140-54 Location (Township-Section-Range) — 80 Number of Acres

Property Owner [signature] Signature — Larry Zaun Print Name

34 - NE¼ - 140-55 Location (Township-Section-Range) — 56 Number of Acres

Property Owner Good Hope Farms by [signature] Signature — Larry Zaun Print Name

SE¼ - 2 - 139-55 — 140

NE¼ - 11 - 139-55 Location (Township-Section-Range) — 140 Number of Acres

Property Owner Good Hope Farms by [signature] Signature — Larry Zaun Print Name

W½ - 13 - 139-55 — 320

NW¼ - 24 - 139-55 Location (Township-Section-Range) — 160 Number of Acres

S½ - NE¼ - 23 - 139-55 — 80

SE¼ - 23 - 139-55 — 160

1216

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Kell Boy — Signature
Kelly Boyd — Print Name

Buffalo 20 140 54 SW Qu. — Location (Township-Section-Range)
137.5 — Number of Acres

Property Owner Kell Boy — Signature
Kelly Boyd — Print Name

[redacted] Tower 13 140 55 SE¼ — Location (Township-Section-Range)
140.7 — Number of Acres

Property Owner Kell Boy — Signature
Kelly Boyd — Print Name

Tower 23 140 55 [redacted] — Location (Township-Section-Range)
539.7 — Number of Acres

Property Owner Kalvin C Boyd Kell Boy — Signature
Kalvin Boyd Kelly Boyd — Print Name

Ayr 33 141 54 NE — Location (Township-Section-Range)
161.1 — Number of Acres

Property Owner Kalvin C Boyd — Signature
Kalvin Boyd — Print Name

Ayr 34 141 54 NE — Location (Township-Section-Range)
144.1 — Number of Acres

1123.1

Mutual Agreement to Refuse Easements

Property Owner Lorrie Smith / Luell Morse — LORRIE SMITH / LUELL MORSE

Signature By Gerald Marks POA. — Print Name

SW¼ - 30 - 140 - 54 — Location (Township-Section-Range)

160 — Number of Acres

Property Owner Barbara Phillips ET AL — BARBARA PHILLIPS

Signature Gerald Marks POA — Print Name

SE¼ - 33 - 140 - 54 — Location (Township-Section-Range)

160 — Number of Acres

(320)

Property Owner _____ _____

Signature — Print Name

_____ _____

Location (Township-Section-Range) — Number of Acres

Property Owner _____ _____

Signature — Print Name

_____ _____

Location (Township-Section-Range) — Number of Acres

Property Owner _____ _____

Signature — Print Name

_____ _____

Location (Township-Section-Range) — Number of Acres

Property Owner _____ _____

Signature — Print Name

_____ _____

Location (Township-Section-Range) — Number of Acres

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Ron K. Frase — RON K. FRASE
Signature — Print Name

NE 1/4 5-139-54 — 160
Location (Township-Section-Range) — Number of Acres

Property Owner Ron K. Frase — RON K. FRASE
Signature — Print Name

E 1/2 3-139-54 — 320
Location (Township-Section-Range) — Number of Acres

Property Owner Ron K. Frase — RON K. FRASE
Signature — Print Name

S 1/2 2-139-54 — 320
Location (Township-Section-Range) — Number of Acres

Property Owner Ron K. Frase — RON K. FRASE
Signature — Print Name

NE 1/4 2-139-54 — 160
Location (Township-Section-Range) — Number of Acres

960

Property Owner _____ — _____
Signature — Print Name

_____ — _____
Location (Township-Section-Range) — Number of Acres

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Dan Sheldon — DAN SHELDON
Signature — Print Name

Section 25 W1/2 140N 54W — 107
Location (Township-Section-Range) — Number of Acres

Property Owner Arnetta Frueh — Arnetta Frueh
Signature — Print Name

Section 8 NW 10 acres of NW 1/4 — 10.3
Location (Township-Section-Range) 139N54W — Number of Acres

Property Owner Wendy Rueppke — Wendy Rueppke
Signature — Print Name

NE, SE Qtr Section 4
Sec 4, N Buffalo 140 54 — 20
Location (Township-Section-Range) — Number of Acres

Property Owner Renee Wilm — Renee Wilm
Signature — Print Name

139N 54 Sec. 26 NE¼ — 10
Location (Township-Section-Range) — Number of Acres

Property Owner Deborah Miller — Deborah Miller
Signature — Print Name

Sect. 26 NW/4 139N 55W — 160
Location (Township-Section-Range) — Number of Acres

307.3

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner [signature] BRIAN BUHR
Signature — Print Name

NW1/4 Sec 20-139-54 Howes — 160
Location (Township-Section-Range) — Number of Acres

Property Owner [signature] BRIAN BUHR
Signature — Print Name

S1/2 of the NW1/4 Sec. 6-139-54 Howes — 75
Location (Township-Section-Range) — Number of Acres

Property Owner [signature] BRIAN BUHR
Signature — Print Name

SE1/4 Sec 15-141-54 Ayr — 160
Location (Township-Section-Range) — Number of Acres

Property Owner [signature] BRIAN BUHR
Signature — Print Name

S1/2 of the NE1/4 19-141-54 Ayr — 80
Location (Township-Section-Range) — Number of Acres

Property Owner [signature] BRIAN BUHR
Signature — Print Name

(475)

Location (Township-Section-Range) — Number of Acres

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Debora Miller — Debora Miller
Signature — Print Name

E1/2 18-139-54 — 320 acres ✓
Location (Township-Section-Range) — Number of Acres

Property Owner Debora Miller — Debora Miller
Signature — Print Name

N1/2 19-139-54 — 320 acres ✓
Location (Township-Section-Range) — Number of Acres

Property Owner Debora Miller — Debora Miller
Signature — Print Name

E1/2 12-139-55 — 320 acres ✓
Location (Township-Section-Range) — Number of Acres

Property Owner Debora Miller — Debora Miller
Signature — Print Name

E1/2 13-139-55 — 320 acres ✓
Location (Township-Section-Range) — Number of Acres

Property Owner Debora Miller — Debora Miller
Signature — Print Name

N1/2 S~~H~~E1/4 11-139-55 — 80 ✓
Location (Township-Section-Range) — Number of Acres

1360

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Debora Miller — Debora Miller
Signature — Print Name

SW¼ 23-139-55 — 160 ✓
Location (Township-Section-Range) — Number of Acres

Property Owner [signature] — Craig A. Wendt
Signature — Print Name

E½ 14-139-55 — 320
Location (Township-Section-Range) — Number of Acres

Property Owner [signature] — Craig A. Wendt
Signature — Print Name

E½ 28-139-55 — 320
Location (Township-Section-Range) — Number of Acres

Property Owner [signature] — Craig A. Wendt
Signature — Print Name

E½ 29-139-55 — 320
Location (Township-Section-Range) — Number of Acres

Property Owner [signature] — Craig A. Wendt
Signature — Print Name

Section 8 E½ NW¼ 140 N 55W — 80
Location (Township-Section-Range) — Number of Acres

1200

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner William L. Jahraus William L Jahraus
Signature Print Name

SW 1/4 sec 35 Buffalo township 140 54 160
Location (Township-Section-Range) Number of Acres

Property Owner Debora Miller Debora Miller
Signature Print Name

NE 1/4 24-139-55 118
Location (Township-Section-Range) Number of Acres

278

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Kim Walter Jahraus KIM WALTER JAHRAUS
Signature MARCH 6, 2016 Print Name

SE 1/4 SECTION 35, BUFFALO TOWNSHIP 140 NORTH, RANGE 54 160
Location (Township-Section-Range) Number of Acres

SAME

Property Owner Yolonda Jane Jahraus YOLONDA JANE JAHRAUS
Signature 3-6-16 Print Name

SE 1/4 SECTION 35, BUFFALO TOWNSHIP 140 NORTH, RANGE 54 160
Location (Township-Section-Range) Number of Acres (160)

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Property Owner _____ _____
Signature Print Name

_____ _____
Location (Township-Section-Range) Number of Acres

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Orrin Brodshaug by Pete Baas POA — Peter Baasch
Signature — Print Name

Tower 26 140 55 — 640
Location (Township-Section-Range) — Number of Acres

Property Owner Orrin Brodshaug by Pete Baas POA — Peter Baasch
Signature — Print Name

Tower 25 S 1/2 140 55 — 320
Location (Township-Section-Range) — Number of Acres

Property Owner Orrin Brodshaug by Pete Baas POA — Peter Baasch
Signature — Print Name

Tower 23 140 · 55 — 59 Acres
Location (Township-Section-Range) — Number of Acres

Property Owner Pete Baas — Peter Baasch
Signature — Print Name

Tower 35 NE 1/4 140 · 55 — 160
Location (Township-Section-Range) — Number of Acres

Property Owner Antionette & William Babcock by Pete Baas POA — Peter Baasch
Signature — Print Name

Tower NW 1/4 35 140 · 55 — 80
Location (Township-Section-Range) — Number of Acres

1259

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner _____ Peter Bagsch
Signature — Print Name

Buffalo 31 W½ 31 140 N 5 HW — 280
Location (Township-Section-Range) — Number of Acres

Property Owner _____ Peter Bagsch
Signature — Print Name

Howes S½ 10 139 N 5 H W — 300
Location (Township-Section-Range) — Number of Acres

Property Owner _____ Peter Bagsch
Signature — Print Name

Howes SW¼ 11 139 N 5 H W — 160
Location (Township-Section-Range) — Number of Acres

Property Owner Marilyn Thompson by _____ POA Peter Bagsch
Signature — Print Name

Howes SE¼ 21 & NE¼ 28 139 N 5 H W — 320
Location (Township-Section-Range) — Number of Acres

Property Owner Mark Fraser by _____ POA Peter Bagsch
Signature — Print Name

Howes west ½ 33 139 N 5 H W — 320
Location (Township-Section-Range) — Number of Acres

1380

Mutual Agreement to Refuse Easements

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SIGNED:

Property Owner Gretchen Martin by Peter Baun POA Peter Baasch
Signature Print Name

Boise NE 1/4 3 Hill 139 55 W — 80
Location (Township-Section-Range) Number of Acres

Property Owner Antionette and William Babcock by Peter Baun POA Peter Baasch
Signature Print Name

Boise WE 3 1/4 Hill 139 55 W — 80
Location (Township-Section-Range) Number of Acres

Property Owner Cynthia Wangen by Peter Baun POA Peter Baasch
Signature Print Name

Boise SE 1/4 3 Hill 139 55 W — 154
Location (Township-Section-Range) Number of Acres

Property Owner ~~Section 21 Hill 139 55~~ Peter Baun Peter Baasch
Signature Print Name

SW 1/4 21 Hill 139 55W — 160
Location (Township-Section-Range) Number of Acres

Property Owner Peter Baun Peter Baasch
Signature Print Name

NE 1/4 33 Hill 139 55 W — 130
NW Location (Township-Section-Range) Number of Acres

604

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Alan + Kim Webster (Signature) Alan + Kim Webster (Print Name)

Sec. 8 N ½ 139 N 54W (Location (Township-Section-Range)) 275.10 (Number of Acres)

Property Owner Brenda Nygard (Signature) Brenda Nygard (Print Name)

Sec 28 NW ¼ 139N 54W (Location (Township-Section-Range)) 160 (Number of Acres)

Property Owner Brenda Nygard (Signature) Brenda Nygard (Print Name)

Sec 26 E ½ 139N 54W (Location (Township-Section-Range)) 180 (Number of Acres)

Property Owner Brenda Nygard (Signature) Brenda Nygard (Print Name)

Sec 25 NW ¼ 139W 54W (Location (Township-Section-Range)) 160 (Number of Acres)

Property Owner Naomi Mougey (Signature) Naomi Mougey (Print Name)

Section 28 SW ¼ 139W 54W (Location (Township-Section-Range)) 160 (Number of Acres)

935.1

Mutual Agreement to Refuse Easements

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SIGNED:

Property Owner Bradley D Paul (Signature) Bradley D Paul (Print Name)

T-139-N SEC 16 R-55-W (Location (Township-Section-Range)) 80 (Number of Acres)

Property Owner Bradley D Paul (Signature) Bradley D Paul (Print Name)

T-139-N Sec 26 - R-55-W (Location (Township-Section-Range)) 80 (Number of Acres)

Property Owner Bradley D Paul (Signature) Bradley D Paul (Print Name)

T-139-N Sec 27 - R-55-W (Location (Township-Section-Range)) 11 (Number of Acres)

Property Owner _____ (Signature) _____ (Print Name)

_____ (Location (Township-Section-Range)) _____ (Number of Acres)

17

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Gregory M. Sproul _____ Gregory M. Sproul
Signature Print Name

Property Owner Robin M. Sproul _____ Robin M. Sproul
3-8-2016 Signature Print Name

19 140N 054W — 454.2
Location (Township-Section-Range) Number of Acres

Property Owner Gregory M. Sproul _____ Gregory M. Sproul
Signature Print Name

Property Owner Robin M. Sproul _____ Robin M. Sproul
3-8-2016 Signature Print Name

24 140N 055W — 303.9
Location (Township-Section-Range) Number of Acres

Property Owner Gregory M. Sproul _____ Gregory M. Sproul
Signature Print Name

Property Owner Robin M. Sproul _____ Robin M. Sproul
3-8-2016 Signature Print Name

8 140N 054W — 135.6
Location (Township-Section-Range) Number of Acres

Property Owner Gregory M. Sproul _____ Gregory M. Sproul
Signature Print Name

Property Owner Robin M. Sproul _____ Robin M. Sproul
3-8-2016 Signature Print Name

18 140N 054W — 139.9
Location (Township-Section-Range) Number of Acres

1033.6

Mutual Agreement to Refuse Easements

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SIGNED:

Property Owner Lee K Fraase — LEE K. FRAASE
Signature — Print Name

W½ sec. 3 139-54 — 320
Location (Township-Section-Range) — Number of Acres

Property Owner Lee K Fraase — LEE K. FRAASE
Signature — Print Name

NW¼ sec. 2 139-54 — 160
Location (Township-Section-Range) — Number of Acres

Property Owner Lee K Fraase — LEE K. FRAASE
Signature — Print Name

SE¼ sec. 34 140-54 — 160
Location (Township-Section-Range) — Number of Acres

Property Owner Lee K Fraase — LEE K. FRAASE
Signature — Print Name

SW¼ sec. 36 140-54 — 160
Location (Township-Section-Range) — Number of Acres

Property Owner Dale Zaun — Dale Zaun
Signature — Print Name

Section 34 SE¼ 139N 55W — 160
Location (Township-Section-Range) — Number of Acres

960

Mutual Agreement to Refuse Easements

Property Owner Ruby Kasowski — Randy Kasowski
Signature — Print Name

W½ of SE¼ Sec. 6 Whitehall 140-53 — 400
Location (Township-Section-Range) — Number of Acres

Property Owner Ruby Kasowski — Randy Kasowski
Signature — Print Name

N½ Sec. 17 less west 40 — 280
Location (Township-Section-Range) — Number of Acres
Whitehall Twn 140-53

Property Owner Larry Zaun — Larry Zaun
Signature — Print Name

E80 - NW¼ - 30-139-54 — 80
Location (Township-Section-Range) — Number of Acres

Property Owner Penny Zaun by Larry Zaun — Larry Zaun
Signature — Print Name

NW¼ - 31-139-54 — 160
Location (Township-Section-Range) — Number of Acres

Property Owner Thomas Jorgensen — Thomas Jorgensen
Signature — Print Name

Section 32 NW¼ 139N 55W — 160
Location (Township-Section-Range) — Number of Acres

Property Owner Thomas Jorgensen — Thomas Jorgensen
Signature — Print Name

Section 30 SE¼ 139N 55W — 160
Location (Township-Section-Range) — Number of Acres

1240

Mutual Agreement to Refuse Easements

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SIGNED:

Property Owner Brent Buhr — Brent Buhr
Signature — Print Name

SW 1/4 Sec 32-141-54 Ayr — 150 ✓
Location (Township-Section-Range) — Number of Acres

Property Owner Brent Buhr — Brent Buhr
Signature — Print Name

NE 1/4 Sec 20-141-54 Ayr — 160 ✓
Location (Township-Section-Range) — Number of Acres

Property Owner Brent Buhr — Brent Buhr
Signature — Print Name

SW 1/4 Sec 15-141-54 Ayr — 160 ✓
Location (Township-Section-Range) — Number of Acres

Property Owner Brent Buhr — Brent Buhr
Signature — Print Name

N 1/2 of the NE 1/4 19-141-54 Ayr — 80 ✓
Location (Township-Section-Range) — Number of Acres

Property Owner Brent Buhr — Brent Buhr
Signature — Print Name

N 1/2 of the NW 1/4 6-139-54 Howes — 75
Location (Township-Section-Range) — Number of Acres

625

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner Darrell Holm — Darrell Holm
Signature — Print Name

Section 25, ½ of NE¼ 139N 55W — 80 A. ✓
Location (Township-Section-Range) — Number of Acres

Property Owner Alfred J. Von Bank — ALFRED VON BANK
Signature — Print Name

Section 19 ½ SW¼ 139N 54W — 80 A. ✓
Location (Township-Section-Range) — Number of Acres

Property Owner _____ — _____
Signature — Print Name

160

_____ — _____
Location (Township-Section-Range) — Number of Acres

Property Owner _____ — _____
Signature — Print Name

_____ — _____
Location (Township-Section-Range) — Number of Acres

Property Owner _____ — _____
Signature — Print Name

_____ — _____
Location (Township-Section-Range) — Number of Acres

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner _____, Trustee — Camille Schaetzel, Trustee

Signature — Print Name

SW ¼ -1-139-55 — 160

Location (Township-Section-Range) — Number of Acres

Property Owner _____ — _____

Signature — Print Name

NE ¼ -15-139-55 — 160

Location (Township-Section-Range) — Number of Acres

Property Owner _____ — _____

Signature — Print Name

W ½ -18-139-54 — 320

Location (Township-Section-Range) — Number of Acres

Property Owner _____ — _____

Signature — Print Name

_____ — _____

Location (Township-Section-Range) — Number of Acres

640

Mutual Agreement to Refuse Easements

Whereas the undersigned landowners of property in and around Buffalo, Hill, Howes, Tower, and Wheatland Townships are aware that Rolling Greens Family Farms and its affiliates are attempting to secure easements to apply effluent and or solids to agricultural land in and around the above referenced Townships, we pledge to withhold the grant of any easement to Rolling Green Family Farms, its subsidiaries or affiliates for the purposes of (1) application of effluent, waste, or manure, or (2) to install a pipeline across or upon our land.

SIGNED:

Property Owner_____ _____
Signature — Print Name

SW ¼ -1-139-55 — 160
Location (Township-Section-Range) — Number of Acres

Property Owner_____ _____
Signature — Print Name

NE ¼ -15-139-55 — 160
Location (Township-Section-Range) — Number of Acres

Property Owner [signature] — Paul R Schaefer
Signature — Print Name

W ½ -18-139-54 — 320
Location (Township-Section-Range) — Number of Acres

Property Owner_____ _____
Signature — Print Name

_____ _____
Location (Township-Section-Range) — Number of Acres