Understanding Air Quality and Nutrient Management at Harrison Farms

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Farm, Site, and Projects

**Farm Overview**

E & L Harrison Enterprises, Inc. is a 4000 hog finishing operation owned by Lynn and Patricia Harrison and consists of five hog finishing buildings, at three locations in Dunn and Chippewa counties northwest of Eau Claire, Wisconsin.

The Harrison family has been raising hogs since 1913, when Lynn’s grandfather moved to the area. Until the spring of 1998 their operation was farrow-to-finish. “We were farrowing six times a year in outside lots and averaging 16 to 17 piglets per sow. Farrow-to-finish operations in total confinement were averaging 20-plus piglets per sow. We weren’t competitive anymore,” Lynn says. “We had to either build a big sow set-up or change our operation.” Lynn says they had been asked to join a few sow coops, but none had come to fruition, so they started buying feeder pigs, put up total confinement finishing barns and transitioned into a finishing operation.

One of the Harrison’s properties is located near and around the Muddy Creek State Wildlife Area and Old Elk Lake, a unique and somewhat rare shallow prairie pothole lake. There is significant development pressure from nearby Eau Claire and Menomonie to subdivide the area. At the same time, the Wisconsin Department of Natural Resources (DNR) wanted to expand the Muddy Creek Wildlife Area and buy land around Old Elk Lake to protect it as a wildlife sanctuary. Lynn and Pat decided they didn’t want their farm to end up as a subdivision, so they sold the 77 acres that adjoined the lake to the DNR, as well as selling the development rights on another 350 acres that surrounds the lake.

“It’s a philosophical thing – we could have gotten a lot more money if we subdivided, but now half of the lake shore will never be developed,” Lynn says. Selling the development rights allows the Harrisons to continue farming that piece of land, using accepted best management practices which are designed to protect the environment.

Lynn and Pat are active with Wisconsin Pork Association (WPA) and the National Pork Board. Lynn served three terms on the WPA board of directors, serving as President in 1997. Lynn remained on the board as it reorganized from Wisconsin Pork Producers Association to Wisconsin Pork Association. He was elected President of the new organization in 2005. Lynn’s involvement on the National Pork Board has also been extensive, serving from 2002 – 2008. He had the honor of being elected President of the National Pork Board from July 2007 – July 2008. Lynn has been especially active within the National Pork Board Environmental Committee, that oversees checkoff funded research related to environmental issues surrounding the pork industry.

**Site Characteristics**

The general landscape of the Harrison farmland is gently sloping, with isolated moderate slopes. It varies from cropland, pastureland, and scattered woodland along riparian areas. USDA Soil Survey maps indicate that a majority of the farm has sandy loam soil characteristics. Along with their hog operation, Harrisons farm about 700 acres of corn and soybeans. They have 320 acres of this cropland under irrigation and another 250 acres of highly erodible land (HEL), which is planted on the contour with no-till equipment. They have used...
no-till crop establishment practices since 1993 and typically maintain at least 70% crop residue levels. Swine manure is stored in under-floor liquid pits at each barn and is soil injected to meet crop nutrient needs in the spring and fall. Fields generally receive manure every other year when the soil is not frozen.

Projects Conducted at Harrison Farms

1. **Air Quality Impacts**
   Air quality (emissions and odor) has been a challenge for the swine industry for decades. Through this project, the Harrison’s three hog feedlots were evaluated using facility emission data and a regulatory air quality model. The Wisconsin Ambient Air Quality Standards and U.S. Environmental Protection Agency Reference Concentrations were used to evaluate potential public nuisance and public health impacts.

2. **Best Management Practice Challenge**
   Agricultural best management practices (BMPs) are designed to protect our natural resources. Most BMPs also protect farm profits. Some farmers are reluctant to adopt BMPs because they fear a loss of profit. To address this concern, and increase the adoption of BMPs, a collaboration of private and public organizations created a program called the “BMP Challenge”. The BMP challenge provides an insurance-like product which pays producers if the adopted best management practice (either nutrient or tillage) reduces crop yield and net income. During the early phases of this regional and national initiative, the Harrisons participated in verifying the administrative and implementation protocols that were developed to run the larger program.

3. **Sampling Protocol For Under Floor Swine Manure Storage Pit**
   Proper manure sampling and analysis is important when determining the nutrient content of manure, so that appropriate application rates can be identified. Typically, manure sampling is done as the pit is agitated and emptied. However, by the time analysis results from the lab are received, the manure has already been applied. The purpose of this study was to determine whether accurate, pre-agitation samples could be obtained. The study was designed to determine whether manure samples which were collected and analyzed prior to agitation accurately represent the concentration of nutrients in manure after it is agitated and applied to cropland.

**Conclusion**
Unlike most Discovery Farm locations, the Harrison farm did not have in-stream or edge-of-field water monitoring. Topography often dictates when a site will yield viable surface water monitoring data. While this location did not have an appropriate landscape for water monitoring, the fore mentioned projects provided valuable information for swine producers and the agricultural industry as a whole.
**Introduction**

Air quality and odor control are pressing environmental issues facing animal agriculture across Wisconsin and the United States. In the near future, producers will be faced with increasing pressure to comply with newly developed air quality standards. For the past several years, pork producers have been at the forefront of these issues and they understand the importance of odor and emission control. As leaders in their industry, Lynn and Patricia Harrison (E & L Harrison Enterprises, Inc.) participated in an emission/odor monitoring project with the Discovery Farms Program and Baumgartner Environics. This study evaluated their hog finishing facilities against current Wisconsin Ambient Air Quality Standards.

Ammonia, hydrogen sulfide and odor from livestock facilities can all have an adverse impact on air quality, which may affect the health and wellbeing of the people and livestock living and working in these areas. The Wisconsin livestock industry has limited quantitative data to document actual on-farm emissions associated with livestock facilities and feedlots. To improve the amount of information available, industry representatives requested that monitoring be conducted to identify the baseline levels of loss for ammonia, hydrogen sulfide and odor generated from a variety of livestock facilities.

Ammonia (a nitrogen gas) is emitted from housing facilities, manure storage areas, and from applications of manure or nitrogen fertilizer to fields. Field applications of manure that contain ammonium can have losses that remain in the air as particulate haze or re-deposited to the land. Concerns about ammonia emissions include:

1) atmospheric particulates that cause haze and stimulate human respiratory health issues; and  
2) additions of “extra” nitrogen to the ecosystem resulting in soil acidification, changes in plant speciation and water quality concerns (hypoxia).

Hydrogen sulfide is a product of the anaerobic decomposition of manure (or other organic matter). Exposure to hydrogen sulfide at 50 parts per million (ppm) can cause dizziness, headache and nausea; while exposure at levels of 1,000 ppm or more can cause death from respiratory paralysis. Occasionally workers who are in areas with extremely high concentrations of hydrogen sulfide (manure pits, transfer stations, poorly ventilated buildings, etc.) can become ill and/or die.

Odors from livestock facilities arise from a wide variety of gases and compounds, many of which exist at very low concentrations. The actual odor can be from any combination of manure, dust, decaying feed and other organic material. Odors evoke a wide range of physical and emotional reactions, both positive and negative – depending on the person.

**Project Methods**

This project was conducted by Baumgartner Environics and Discovery Farms staff at five swine finishing barns located northwest of Eau Claire, Wisconsin. Animal management within these barns is “all in – all out,” where feeder pigs are brought in at 50 lbs. and finished to 250 lbs. within a 16 week period. On the day that the air quality monitoring was conducted, each feedlot/barn had hog populations shown in Table 1.

The emission rates for ammonia, hydrogen sulfide and odor were determined for each barn. Ammonia was measured directly from barn exhaust fans, as well as manure pit exhaust fans using gas detection colorimetric tubes (Figure 1). Hydrogen sulfide was measured at the exhaust fans and the property lines using a Jerome 631-X Hydrogen Sulfide Analyzer (Figure 2). Odor was measured using two methods. First, by collecting a bag of air from barn exhaust fans for lab analysis by dynamic olfactometry (Figure 3). Hydrogen sulfide was measured at the exhaust fans and the property lines using a Jerome 631-X Hydrogen Sulfide Analyzer (Figure 2). Odor was measured using two methods. First, by collecting a bag of air from barn exhaust fans for lab analysis by dynamic olfactometry (Figure 3). Odor was also measured on-site using a Nasal Ranger Field Olfactometer (Figure 4). Baumgartner Environics used the U.S. Environmental Protections Agency’s CALPUFF air quality model to estimate odorous gas concentrations present at property lines and nearest neighbor residences.
Project Results

Emissions of ammonia, hydrogen sulfide, and odor are measured as the amount of gas emitted per square meter of barn floor, per time unit. These measurements are referred to as “gas flux rates,” and are provided for this study in Figures 5-7. For the purpose of comparison, each figure also shows the average emission flux rate from a number of Minnesota swine finishing barns, (Wood, S. L. et al. 2001. Odor and Gas Emissions From Animal Production Systems. 2001 ASAE Annual Meeting Paper No. 01-4043. St. Joseph, MI).

Figures 5-7 show 1-day emission and odor values for the five Harrison farm barns in this study, compared to a number of Minnesota swine finishing barns. The Harrison farm measurements show a high correlation to the number of animal units present in each barn (an animal unit is equal to 1000 pounds of animal). Table 1 shows that on the day of this study, Harrison farm-Site 2 was the most densely populated barn on the farm with 800 market weight hogs (184 AU). Similarly, Figures 5-7 show that same barn had the highest emission and odor values measured at the exhaust fans, compared to the other barns with fewer animal units in each. Emission rates of ammonia and hydrogen sulfide from all the buildings on the project farm were below the Minnesota average. The levels of odor were slightly above the Minnesota odor average. On the Harrison farm, the detectable gas concentrations and odor intensities were mostly limited to the immediate vicinity of the feedlot barns.

In summary, the sampling and modeling of air quality indicate that E & L Harrison Enterprises, Inc. hog finishing facilities are not a significant public health concern with regard to ammonia and hydrogen sulfide emissions. Odor is primarily confined to the immediate vicinity of the barns but could be detected (at non-annoying levels) at the property lines for some locations. A full report for this project, “Air Quality Impacts at Three Hog Feedlots”, was prepared by Baumgartner Environics and is available on the University of Wisconsin - Discovery Farms Program website: (http://www.uwdiscoveryfarms.org/pdf/pubsnewsres/other/harrisonBErpt.pdf).
Introduction
Agricultural best management practices (BMPs) are typically designed to protect farm profits and protect or improve the quality of natural resources (such as surface water). BMPs are associated with many agricultural management operations including soil fertility, various tillage practices, legume nitrogen crediting and manure nutrient crediting.

Growers are often reluctant to adopt and implement certain BMPs. This reluctance is linked to the belief that these practices will result in lower yields and therefore a loss in profit. This concern is not necessarily unfounded; BMPs occasionally fail. For example, cool weather conditions may delay the breakdown of organic matter which affects manure and legume nutrient availability. To “protect” against yield reductions, a grower who doubts the nutrient availability from manure or legumes might choose to apply commercial fertilizer above the recommended levels – and lose money over the long-term. Excess nutrient application can also have a negative impact on surface water and groundwater quality.

The United States Department of Agriculture (USDA) – Risk Management Agency approved a pilot crop insurance program called the “Nutrient BMP Endorsement” in 1993 for corn producers in Iowa, Minnesota, Pennsylvania, and Wisconsin. This insurance program was an optional endorsement to a farmer’s Multi-Peril Crop Insurance or Crop Revenue Coverage insurance policy for corn. This program was designed to provide protection from the financial risk which could be incurred by corn growers adopting nutrient management BMPs.

The Nutrient BMP Endorsement was a contractual agreement between an insurer and producer to follow university soil fertility recommendations including taking the nutrient credits from manure and legume crops. As a part of this contract the grower implements nutrient crediting on a field, while including a check strip of his “normal” practices. If yield losses occur because of the implemented BMPs, the insurer pays the producer for the loss.

The cost of the Nutrient BMP Endorsement was approximately $7.00 per acre, and the program was administered for USDA-Risk Management Agency by Agflex.

E & L Harrison Enterprises, Inc. worked with the Discovery Farms Program and a partner of Agflex, The IPM Institute of North America, Inc., to implement a nutrient management verification pilot project. The goal of the project was to define the implementation process for the Nutrient Management BMP Endorsement including administration, the technical aspects of field plot management, and final financial settlements – if required.

Administration
The roles, responsibilities and participation guidelines for this project were defined through a series of documents, developed by The IPM Institute of North America, Inc. and the Discovery Farms Program.

The documents included:
➢ A series of agreements between participants (Discovery Farms Program, IPM Institute, and the Harrisons) that detailed how the project would proceed.
➢ A participant application form for the nutrient BMP verification plot identifying the producer and Certified Crop Advisor contact. This form also identified the field location and specific crop management (BMP field and check strip) information.
➢ The Wisconsin Nutrient Management Verification Pilot Handbook for corn. This handbook contains definitions, program requirements and yield assessment protocols that guide the establishment and administration of the nutrient management verification pilot project.

Nutrient Management BMP Verification Plot Establishment
As a part of their involvement in the project, Harrison established a nutrient management verification plot in a field planted to corn following soybeans.

During the fall season before corn was planted, the field received 3,000 gallons of injected liquid swine manure. The Harrisons applied their traditional nutrient crediting practices and commercial nitrogen application rate on a 60 foot wide check strip.

The remaining portion of the field (120 acres) was fertilized according to University of Wisconsin soil fertility recommendations, including associated manure crediting guidelines. Phosphorus and potassium needs were adequately supplied through existing soil test levels and manure. However, Harrison’s typical nitrogen application was 15 pounds per acre higher than that indicated by following the UW soil fertility recommendation.

At harvest, the results indicated that the check strip yielded three bushels per acre higher than the BMP portion of the field (Table 1).

Table 1.

<table>
<thead>
<tr>
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<th>Check (Producer’s practice)</th>
<th>BMP (Manure crediting)</th>
</tr>
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<tbody>
<tr>
<td><strong>Supplemental Nitrogen (N)</strong></td>
<td>44.5 lbs.</td>
<td>29.7 lbs.</td>
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<tr>
<td><strong>Cost per pound (N)</strong></td>
<td>$0.2875</td>
<td>$0.2875</td>
</tr>
<tr>
<td><strong>Nitrogen cost / acre</strong></td>
<td>$12.79</td>
<td>$8.54</td>
</tr>
<tr>
<td><strong>Yield</strong></td>
<td>160 bushels/acre</td>
<td>157 bushels/acre</td>
</tr>
<tr>
<td><strong>Corn price per bushel</strong></td>
<td>$2.06</td>
<td>$2.06</td>
</tr>
<tr>
<td><strong>Cost differential (N savings vs. N yield loss)</strong></td>
<td>$0.00/acre</td>
<td>-$1.91/acre</td>
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Conclusion
Overall a payment of $229.20 was made to the Harrisons to compensate for the profit lost due to implementing the best management practice. The difference between the BMP and the Harrisons’ traditional fertility program was a lower nitrogen application rate of 15 pounds per acre, which produced a savings of $4.25/acre. However, the check strip out-yielded the BMP by three bushels per acre, which at $2.06 per bushel generated an additional $6.18 per acre. This increase in yield was offset by the increase in nitrogen cost ($4.25), but this practice still resulted in an overall increase of $1.91 greater income per acre.

The insurance payment was the value of the yield shortfall, minus the fertilizer savings, over the 120 enrolled acres (or $1.91/acre X 120 acres = $229.20).

Through this pilot project, a detailed set of protocol and procedures was developed which assisted in the implementation of the nutrient management verification pilot project. The project demonstrated the working details of a crop insurance endorsement program designed to provide yield risk management coverage for corn producers who adjust their nutrient management strategies to meet university recommendations.

This on-farm project was one of more than 30 that Agflex and partners conducted in five states between 2001 and 2003. The cumulative experiences of these projects led to fine tuning of administrative and technical details for the Nutrient BMP Endorsement, an optional offering to corn producers by the USDA Federal Crop Insurance Corporation. The insurance industry has since chosen to not incorporate this type of policy endorsement into their assortment of crop risk management products.

As of 2006, the Nutrient BMP Endorsement program (formerly offered as an insurance product) has been reconfigured into the Nutrient BMP Challenge (http://www.bmpchallenge.org). It is being administered by Agflex; The IPM Institute of North America, Inc.; IPM Works and American Farmland Trust. Various public and private entities fund the reconfigured project.

The Nutrient BMP Challenge is offered in Wisconsin and 12 other states as an income guarantee. This income guarantee agreement is of interest to individual corn producers, as well as public and private water quality projects that focus on nutrient management in agricultural watersheds.

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Determining Swine Manure Nutrient Content: A Comparison of Sampling Methods

Introduction
Manure is an excellent source of nitrogen, phosphorus, and potassium as well as organic matter, sulfur, and a number of micronutrients. To properly utilize manure’s nutrients as a fertilizer for crop production, producers must know two key values:

1) Application rate – knowing how much manure is applied to a field is one of the critical factors for nutrient crediting. To determine application rates, producers need to know two factors:
   ➢ the tons or gallons of manure in the spreader, and
   ➢ the amount of land covered with a load.

   One way to calibrate a spreader is to weigh the spreader when it is full and again when it is empty and subtract these weights. The difference is the amount of manure applied on the field. The final step is to measure the area where the manure was applied (length and width of the spreading pattern). Tons or gallons applied divided by area applied upon equals tons or gallons per acre. A copy of the factsheet, “Know How Much You Haul,” can be downloaded to help you calculate your spreading rates: http://ipcm.wisc.edu/LinkClick.aspx?fileticket=f99Ju5%3D&tabid=114&mid=669

2) Nutrient content – the level of nutrients in livestock manure varies by animal species, and is also influenced by the animal’s diet, the type of housing, and the type of manure handling equipment. To properly utilize these nutrients, producers need to know how many pounds of nitrogen, phosphorus, and potassium are in a given volume or weight of manure. This is expressed as pounds of nutrient per 1000 gallons for liquid manure, and pounds of nutrient per ton for solid manure. To determine these numbers producers can use “book values” or have a manure analysis performed by a laboratory.

   Book values are derived by compiling the results of many years of sample analysis conducted at certified laboratories. Book values are available for many livestock species and they are a good starting point for nutrient crediting. However, many producers want to know if the manure produced on their farm is different from the average. To determine this they take a representative sample and have a laboratory test the nutrient concentration. This is often a good decision, especially for farms that have some type of manure storage system. Because of the large variation in manure system design and handling practices, significant variations can occur from the average manure nutrient content values.

   Typically, manure samples are taken as the storage system is agitated, just prior to land application. Agitation helps provide a uniform sample, but because pit agitation and manure application occur within a relatively short time span, the laboratory analysis results are often received long after the manure has been spread. This can result in an incorrect (or at least unknown) level of nutrients being applied on the field.

   E & L Harrison Enterprises, Inc. asked Discovery Farms to help with a study to develop a sampling protocol for swine operations with under floor liquid manure storage pits. The goal was to provide a more timely manure analysis so that proper application rates could be determined prior to spreading. The project’s purpose was to determine whether manure samples which were collected and analyzed prior to agitating, accurately represented the concentration of nutrients in manure after it is agitated and applied to the field. This sampling method attempts to detect the manure nutrient content from the whole pit profile depth approximately two weeks before agitating and emptying the manure pit.

Project Methods
Swine manure was sampled from concrete pits, beneath confinement feeding floors from four finishing barns during spring 2002, fall 2002, and spring 2003. During the study period the samples were collected from each pit...
using two different methods:

1) Vertical pit profile: A sample was taken to capture a profile of the full pit depth, two weeks prior to pit agitation, using a sampling tube. The tube was a homemade, 10-ft. long, 1.5-in. diameter PVC pipe with a rope and ball stopper. The tube is pushed vertically into the manure as close to the bottom as possible (tube length should be representative of the depth of the pit). Once in place and filled, the ball is pulled up to seal the tube so that the sample is drawn from the entire depth of the pit. The nutrient concentration information for this sampling method is referred to as “profile” in Figure 1. Manure samples were analyzed for nutrient content at the UW-Soil and Forage Analysis Laboratory, Marshfield, WI.

Project Results
Over the three season sample period, nine sets of “agitated” liquid manure samples (top-middle-bottom) were collected and analyzed. The results of these samples have been averaged and are displayed in Figure 1. During the same sample period, seven “profile” liquid swine manure samples were taken, analyzed and similarly compiled.

Figure 1 shows the results of the average manure analysis for the two sampling methods. This figure also shows the book values for liquid swine manure which are provided by the University of Wisconsin. As indicated in the figure, the two sampling methods produced results which are remarkably similar. The “agitated samples” were two pounds higher in nitrogen and potassium than the “profile samples” and two pounds lower in phosphorus. While the sample set is not large enough to draw statistical conclusions, the inference is that for swine producers who want some guidance in determining acceptable application rates, the profile sampling technique can provide a representative sample. On this operation and during this sampling period, the nitrogen and phosphorus levels were both higher than book value, while the potassium concentrations were both lower than book value.

Conclusion
These results clearly indicate that on confinement swine operations, sampling a below barn manure pit, using the “profile” technique two weeks prior to agitation and hauling provides reasonable nutrient concentrations for nutrient crediting. Profile sampling can produce nutrient content results similar to those achieved from sampling during pit agitation and hauling. The profile manure sampling method will get lab results to producers in a timely manner and allow them to more accurately credit their manure nutrient applications for crop production.

Thank you from Harrisons to: Big Gain Inc. • Value Implement • W. O. Larson Companies • Direct Oil Company • Crossroads Ag • Tractor Central • JH Larson Company • Chippewa Veterinary Clinic • Pioneer Hybrids • Meyer Bros. Grain • Bremer Insurance • Menomonie Farmers Union Coop • Common Sense Ag • Xcel Energy • CHS • Equity Cooperative • Swoboda Implement • Bremer Bank • Bauer Built Inc. • Holiday • Minder, Gross & Steving-Roe, LLP • Osborne Industries • Lester Buildings

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These briefs summarize on-farm research conducted on the Lynn and Patricia Harrison farm (E & L Enterprises, Inc), Elk Mound, WI. Project results are presented in 4 fact sheets. The series includes: Farm site and projects; Swine facility emission & odor monitoring; Harrison best management practice verification project; and Determining swine manure nutrient content: a comparison of sampling methods. Fact sheets, briefs and presentations are available from the UW-Discovery Farms Office, PO Box 429, Pigeon Falls, WI 54760, 715-983-5668 or at our website: www.uwdiscoveryfarms.org.