I. Project Title and NPB project identification number: Implementing Mass Nutrient Balance Procedures on Swine Production Facilities, NPB Award 05-129

Principal Investigator: Richard Koelsch and Alan Sutton

Institution: University of Nebraska and Purdue University

Date Submitted: April 13, 2008

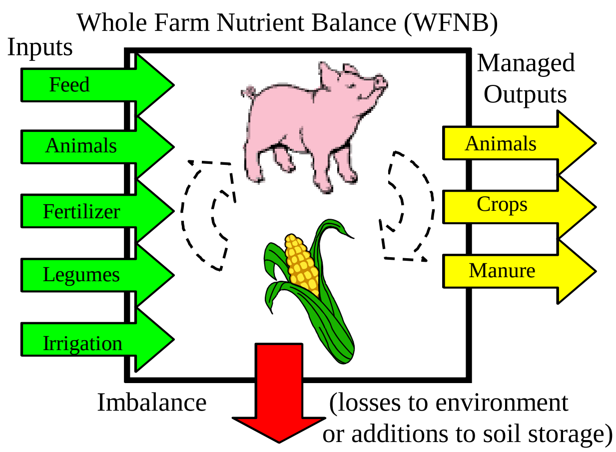
For more information contact:

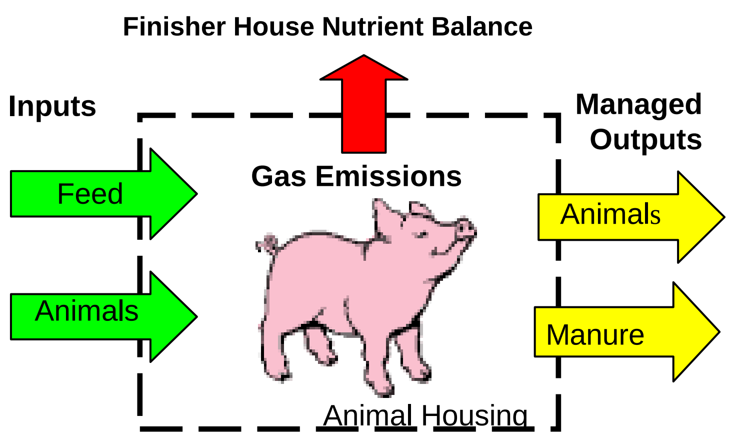
National Pork Board, P.O. Box 9114, Des Moines, Iowa USA

800-456-7675, **Fax:** 515-223-2646, **E-Mail:** porkboard@porkboard.org, **Web:** http://www.porkboard.org/

II. Industry Summary:

A Whole Farm Nutrient Balance (WFNB) is a comparison of the quantity of nutrients that enter (inputs) and exit (managed outputs) the farm gate. If there are more input nutrients than output nutrients, the difference represents a nutrient imbalance that will be either lost to the environment by both air and water pathways as or accumulated on the farm (e.g. increased soil phosphorus levels). The efficiency of nutrient utilization processes inside the farm's boundary (e.g. efficiency of utilization of manure in the cropping system) affects the quantity of nutrient inputs into the farm (e.g. fertilizer inputs). Thus, a WFNB measure is reflective of multiple internal on-farm processes and provides an overall measure of the whole farm's efficiency of nutrient use or conversely, environmental risk.





A Finisher House Nutrient Balance (FHNB) is a comparison of the quantity of nutrients that enter and exit the finishing building. The data required for a FHNB is a subset of information needed for the whole farm nutrient balance (WFNB) tool. FHNB provides three important answers: 1) a measure of the feed nutrient input/output efficiency for a pig (lbs of N or P per lb of N or P in gain), 2) a measure of total manure nutrients excreted while in the housing unit, and 3) an estimate of the losses of nutrient that can be emitted through the air. We believe that FHNB provides a means of providing a farm-specific estimate of nutrient excretion and ammonia volatilization reflective of individual farm feeding and management practices.

The purpose of this project is to collect the necessary data for creating the nutrient balances on 12 swine operations in Nebraska, Iowa, and Indiana. The project will evaluate the producer's ability to assemble the required information and the ability of these measures to enhance our understanding of the environmental performance of commercial swine farms. During year 1, participating producers will be identified and data collected to create a WFNB for 2006. In year 2, both WFNB and FHNB will be measured for participating farms and educational resources based upon this experience will be developed for the swine industry.

Based upon the year 1 experiences in which 13 commercial swine facilities participated, the following conclusions can be drawn:

- On average, the participating swine producers import 1.5 units of N and P through all farm sources for every unit of N and P that is exported in managed products. This level of efficiency is signicantly better than commonly reported values for commercial animal feeding operations (primarily dairies) reported in the literature. Several farms produced P balances very near an ideal 1 to 1 ratio.
- Feed is the dominant source of N and P arriving on farm representing 79 and 88% of all imports, respecitvely. Fertilizer represents approximately 10% or less of total nutrient imports suggesting that these farms have little opportunity to further improve their nutrient efficiency through nutrient planning (use of manure to replace fertilizer).
- The WFNB for facilities with storage only (deep pits and exterior storage) are substantially better than those observed for farms with anaerobic lagoons.
- No relationship was observed for N or P WFNB versus size of farm as measured by animal numbers. However, it was observed that as the concentration of pigs per unit of land area increased, so did the whole farm nutrient imbalance (ratio of inputs to managed outputs).
- Increasing dietary phosphorus was found to be correlated to increasing in whole farm phosphorus imbalances, suggesting the impact of diet management on environmental risk. However, no relationship was observed between dietary crude protein and whole farm nitrogen imbalance.

The second year of this project is currently underway. Producers are collecting data for completing a whole farm nutrient balance for 2007 as well as a finisher house nutrient balance.

III. Scientific Abstract:

Whole Farm Nutrient Balance (WFNB) approaches have been used to provide a measure of environmental performance (Aarts et al., 1992; Lanyon and Beegle, 1993; Klausner, 1995). Whole farm balance concepts are used as part of the Netherlands Mineral Accounting System public policy that includes compulsory mineral input and output reports from livestock farms and levies for excess imbalances (Jongbloed and Lenis, 1998). Procedures for measuring WFNB will be followed in measurements made on commercial swine facilities for 2006 and 2007. The conclusions developed based upon data from 13 for 2006 include:

- On average, the participating swine producers import 1.5 units of N and P through all farm sources for every unit of N and P that is exported in managed products. This level of efficiency is signicantly better than commonly reported values for commercial animal feeding operations (primarily dairies) reported in the literature. Several farms produced P balances very near an ideal 1 to 1 ratio.
- Feed is the dominant source of N and P arriving on farm representing 79 and 88% of all imports, respecitvely. Fertilizer represents approximately 10% or less of total nutrient imports suggesting that these farms have little opportunity to further improve their nutrient efficiency through nutrient planning (use of manure to replace fertilizer).
- The WFNB for facilities with storage only (deep pits and exterior storage) are substantially better than those observed for farms with anaerobic lagoons.
- No relationship was observed for N or P WFNB versus size of farm as measured by animal numbers. However, it was observed that as the concentration of pigs per unit of land area increased, so did the whole farm nutrient imbalance (ratio of inputs to managed outputs).

- Increasing dietary phosphorus was found to be correlated to increasing in whole farm phosphorus imbalances, suggesting the impact of diet management on environmental risk. However, no relationship was observed between dietary crude protein and whole farm nitrogen imbalance.

In addition, a finishing house nutrient balance (FHNB) using mass balance procedures for N and P will be implemented on the same farms in 2007. The FHNB will be completed for 2 turns of pigs. In addition, a WFNB will be repeated for 2007.

IV. Introduction

This proposal targeted the 2005 NPB Environmental Research Strategy #1 priority, "Conduct a model system mass balance evaluation". The year 2 proposal remains relevant to the 2007 Environmental priorities #5, "Methods for stabilizing and capturing or reclaiming nutrients", and #6, "Technically feasible and economically sustainable methods for offsite export of nutrients".

Twelve (12) swine producers from Indiana, Iowa, and Nebraska with finishing facilities will be identified to participate in a two-year effort to define the primary nitrogen and phosphorus flows entering and exiting their farm and to produce a WFNB for 2006 and 2007 and FHNB for 2007. For the WFNB measurement, farm records and on-farm measurements will be used to estimate five inputs and three outputs from the farm. For the FHNB, similar mass nutrient balance procedures will be followed for at least one finisher building on each participating swine operation. For those swine facilities where loss of nitrogen through leaching losses is considered to be negligible, mass nutrient balance procedures will be applied to estimate total nitrogen gaseous losses from the combined animal housing and manure storage. These records will be summarized for three common storage types: below barn pit, earthen and formed storages, and anaerobic lagoon.

This project will include development of an educational component designed to instruct producers on the concepts of WFNB and its application during the second year of this project. It will include a curriculum to guide a producer in the measurement of WFNB and development of a nutrient management strategy for improving nutrient balance.

This report summarizes results from year 1 including WFNB measures made on swine facilities in 2006.

V. Objectives:

<u>Phase I (2006-07)</u>

A. Construct a whole farm nutrient balance (WFNB) and a swine facility nutrient balance (SFNB) for nitrogen and phosphorus for two Consent Agreement swine facilities (*dropped at NPB request),*
B. Establish a data base of mass nutrient balance for 12 swine facilities in Nebraska, Iowa and Indiana *(originally proposed as 8 farms in Nebraska and Indiana)*.

<u>Phase II (2008)</u>

C. Evaluate the role of mass balance procedures for adjusting ammonia emissions factors for unique situations not addressed by original Consent Agreement farms *(reduced in scope due to lack of access to Consent Agreement Farms)*.
D. Utilize the data collected for WFNB to develop a new educational module for futue pork producer targeted educational initiatives *(expanded in scope*).

VI. Materials & Methods:

Objective I – A: Construct a whole farm nutrient balance (WFNB) and a swine facility nutrient balance (SFNB) for nitrogen and phosphorus for two Consent Agreement swine facilities

Based upons discussions with representatives of the National Pork Board and Al Hebert, Purdue University, it was decided that it would not be practical to intiate this effort in a timely manner. This objective was discontinued and plans were made to expand the number of producers involved in Objective I-B to offset this loss of data.

Objective I – B: Establish a data base of mass nutrient balance for 12 swine facilities in Nebraska, Iowa and Indiana

Identification of cooperators: Koelsch met with Nebraska Pork Producers Association Board of Directors in July 2006 to build understanding of project intent and identify potential cooperators. Personal visits were then made to 6 Nebraska swine operation and 8 Indiana farms in August - September 2006. Visits were also made with Smithfield representatives producing a list of 7 potential swine cooperators. From this group, 4 Nebraska farms, 4 Iowa farms, and 5 Indiana farms were selected for this study. Factors considered in selection included size (representative of common facility sizes), type of manure storage (lagoon vs. outdoor storage vs. deep pit), and ability to separate animal feed use and manure application land from what might be used by other livestock (if any) managed by the producer. Judgments were also upon the degree of cooperation that might be received by individual producers.

Joe Lally completed a second visit to each of the Nebraska and Indiana sites gaining a commitment from four Nebraska farms (1 deep pit facilities, 2 outdoor storage, and 1 anaerobic lagoon) and Indiana farms (2 deep pit and 2 anaerobic lagoon). In addition, four Smithfield farms in Iowa have agreed to participate

Data Collection: Producer visits were made during December 2006 through February 2007 to collect farm specific data to create a WFNB for each of 13 farms for 2006. Data was analyzed during the spring or 2007. The project team met with all cooperators during late spring and summer of 2007, shared a draft of whole farm nutrient balance (see attachment 1) with each producer, and finalized the WFNB for all 13 farms. Issues of data accuracy and completeness were addressed during the visit and resolved. All farms have received a draft WFNB for 2006 and a final report if corrections were made similar to the report in Appendix B. The producer meetings were also used to introduce our plans for 2007 including a protocol for conducting a finishing house nutrient balance for estimating ammonia emissions (see Appendix C) We also reviewed procedures with the producers for the 2nd year of data collection.

Supporting Producer Resources: The following resources were developed to help communicate the project's purpose, outcomes, and data collection requirements to the participating producers:

- Three fact sheets introducing the concepts of WFNB and FHNB as well as addressing potential producer questions about the project were developed to be used during visits with swine producers (see Appendix A).
- A data analysis tool (Excel Spreadsheet) was modified and updated for use with WFNB measurements by this project. The tool, originally developed for the Livestock and Poultry Environmental Steward curriculum, was reviewed for accuracy, ability to adapt to swine systems, and user friendliness (potential tool for use in education products promised for phase II project). Modifications were identified and completed. One remaining change will require a review of the recent literature for the nitrogen and phosphorus retention within feeder and finishing pigs and

possible modification of those values. The current spreadsheet values are representative of the literature through 1995.

- An example report provided to producers using this spreadsheet tool is illustrated in Appendix B.
- A FHNB paper based worksheet has been developed. The previously mention WFNB spreadsheet tool has since been adapted for a FHNB measurement with some changes to the nutrient inputs and outputs sections. FHNB will be conducted for analysis of all 13 farms for two turns of pigs from data collected in 2007- 2008. In addition, a series of supporting data and record sheets were developed for use by producers who will begin collecting data. Some of these record sheets were designed to also meet both project record needs as well as records required for Concentrated Animal Feeding Operation (CAFO) regulation compliance.
- On-farm manure, water, and feed sampling expectations by swine producers have been identified and shared with producers during a summer farm visit (May - June 2007).
- Two $500 payments (February and December of 2007) were completed to 13 producers to compensate for their time investment and costs of collecting necessary samples.

VII. Results and Discussion:

A summary of the 2006 WFNB data is presented in Table 1. A review of this data reveals several observations. On average, the participating swine producers are importing 1.5 units of N and P through all farm sources (imported animals, feed, and fertilizer as well an legume fixed N and N in irrigation water) for every unit of N and P that is exported in managed products (pigs, crops, exported manure). Feed is proving the dominant source of N and P arriving on farm representing 79 and 88% of all imports. Fertilizer represents approximately 10% or less of total nutrient imports suggesting that these farms have little opportunity to further improve their nutrient efficiency through nutrient planning (use of manure to replace fertilizer). Animals, leume fixed N, and N in irrigation all proved to be fairly insignificant contributors of imported nutrients.

Type of manure storage has a significant impact on WFNB. The WFNB for facilities with storage only (deep pits and exterior storage) are substantially better than those observed for farms with anaerobic lagoons

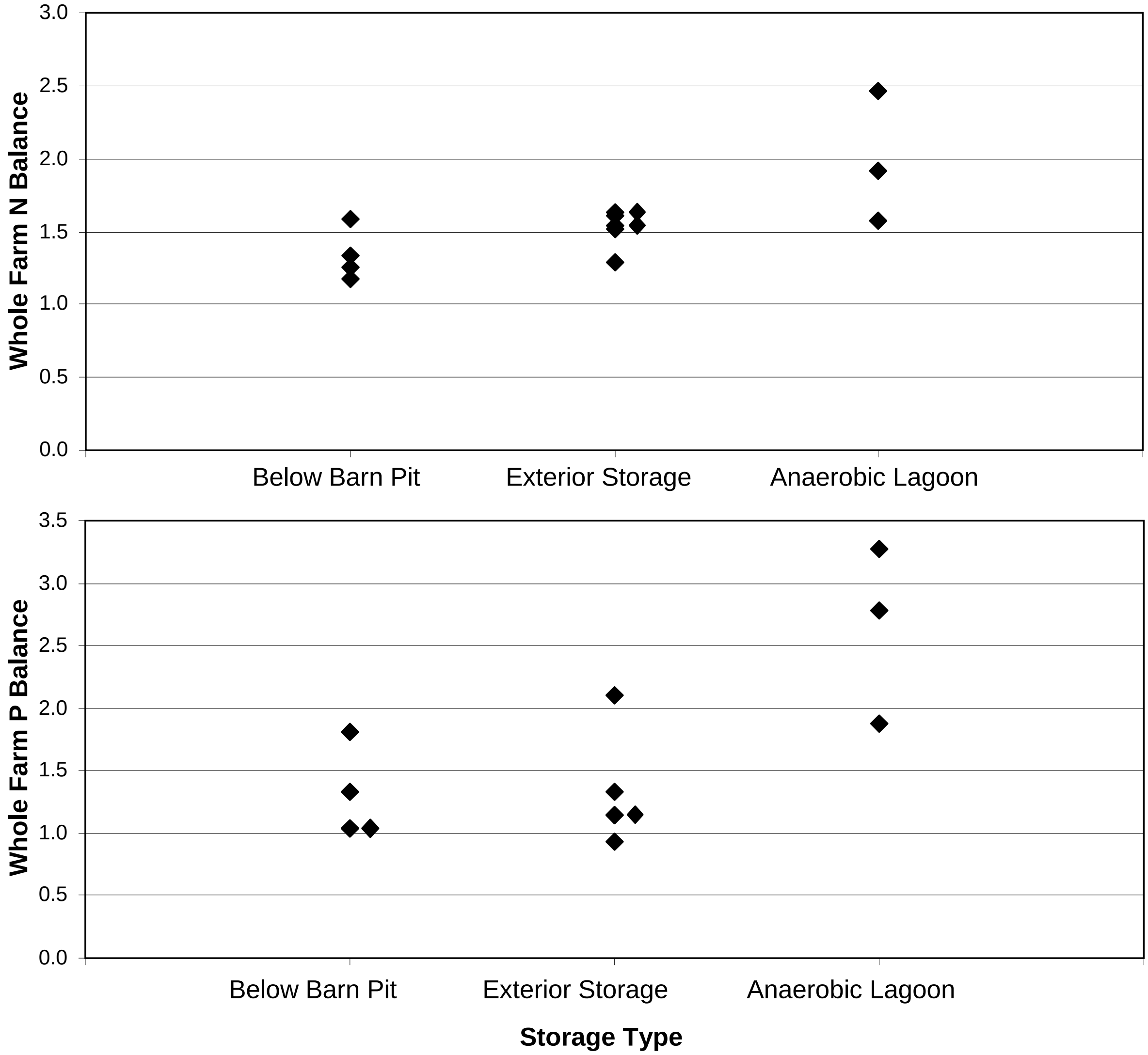


Figure 1. Whole farm nutrient balance versus storage type for 13 swine facilities in Nebraska, Iowa, and Nebraska

(Figure 1). Whole farm N and P balance for facilities with storage only produced input to managed output ratios of 1.2 - 1.6 to 1 and 0.9 – 2.2 to 1, respectively. By comparison, facilities with anaerobic lagoons were between 1.6 – 2.5 to 1 and 1.8 - 3.3 to 1 for N and P whole farm balances, respectively. This would support the advantage of storage facilities for utilizing nutrients as compared to the higher losses associated with treatment facilities. There appeared to be no difference in WFNB for facilities with below barn deep pits and facilities with exterior storage facilities. Although these results are not surprising, such compariosons do not currently exist in the literature.

The very low input to managed output ratios for many of the participating swine operations (at least those not using anaerobic lagoons) has not been observed in the literature. Previous literature results from the 1980’s and 1990’s primarily from dairy and beef operations shows very few examples of the levels of effiency seen on many of the farms in this study. This review may suggest that progress is being achieved in nutrient utilization. Particpatinge farms are commonly demonstrating low feed to gain ratios (efficient feeding programs) and little or new fertilizer purchases (efficient use of manure resources). These preliminary results support the value of voluntary and regulatory efforts to improve feed efficiency and implement crop nutrient management plans as a means of minimizing nutrient concentration in swine production.

In addition, no relationship was observed for difference in N or P WFNB versus size of farm as illustrated by the very low R^2 values (no corelation between size and WFNB ratio) and no slope to the regression line. This data is supportive of previous literature suggestiong that nutrient concentration or inefficiencies are not related to increasing farm animal numbers.

[1]A comparison of dietary crude protein and phosphorus levels versus WFNB revealed different results for the two nutrients. No relationship was observed between dietary crude protein and whole farm nitrogen

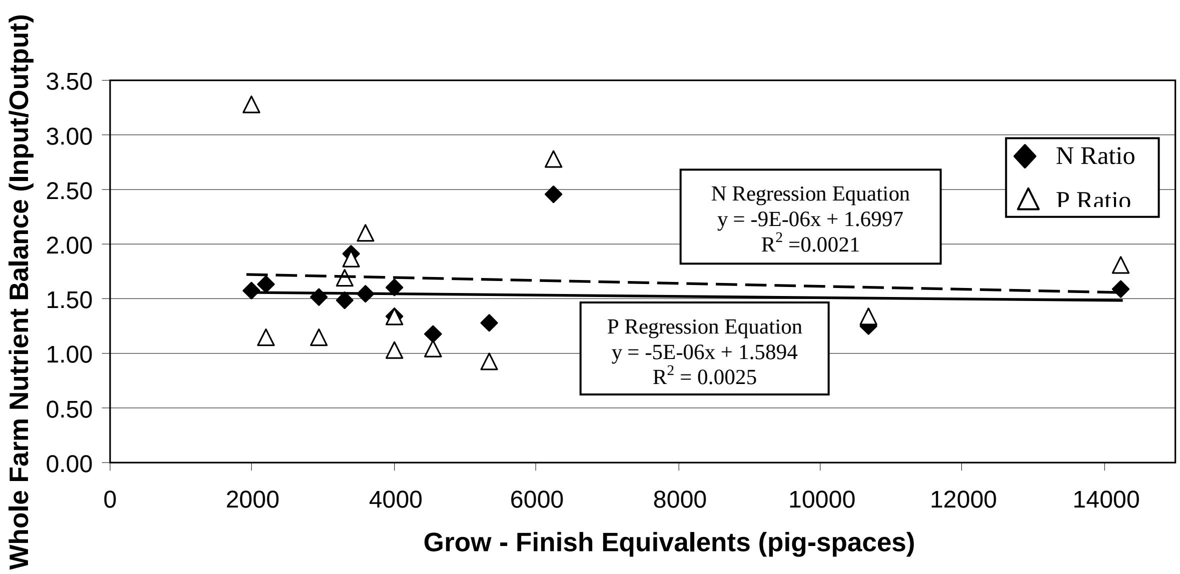
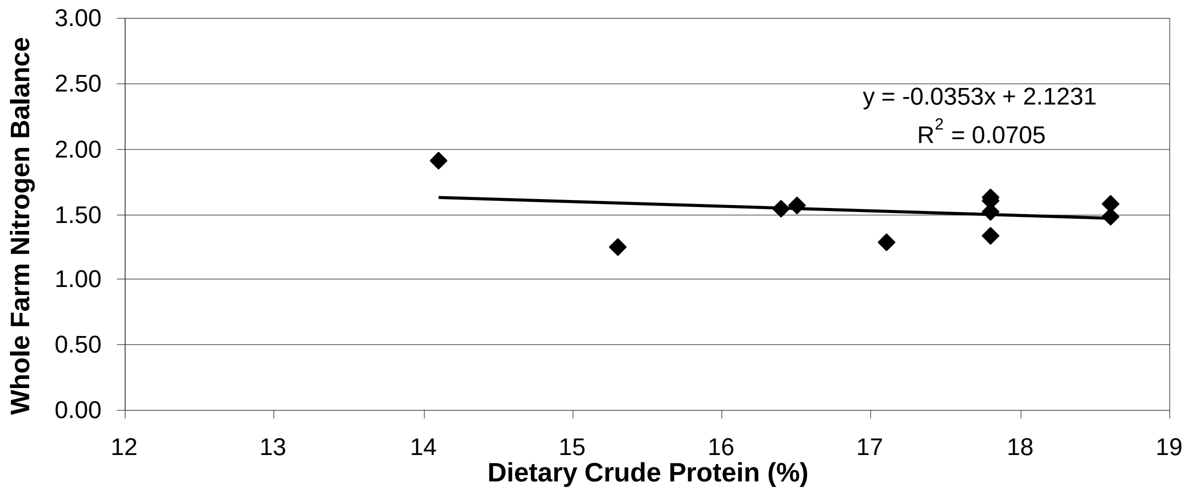


Figure 2. Whole Farm N and P Balance versus swine herd size for 13 Nebraska, Iowa, and Indiana farms.

A grow-finish equivalent was estimated for wean to finish (0.89), nursery (0.34), and sows (1.08) based upon approximately equal feed consumption for a one-year period. Equivalents were estimated on a grow-finish pig space or capacity basis.



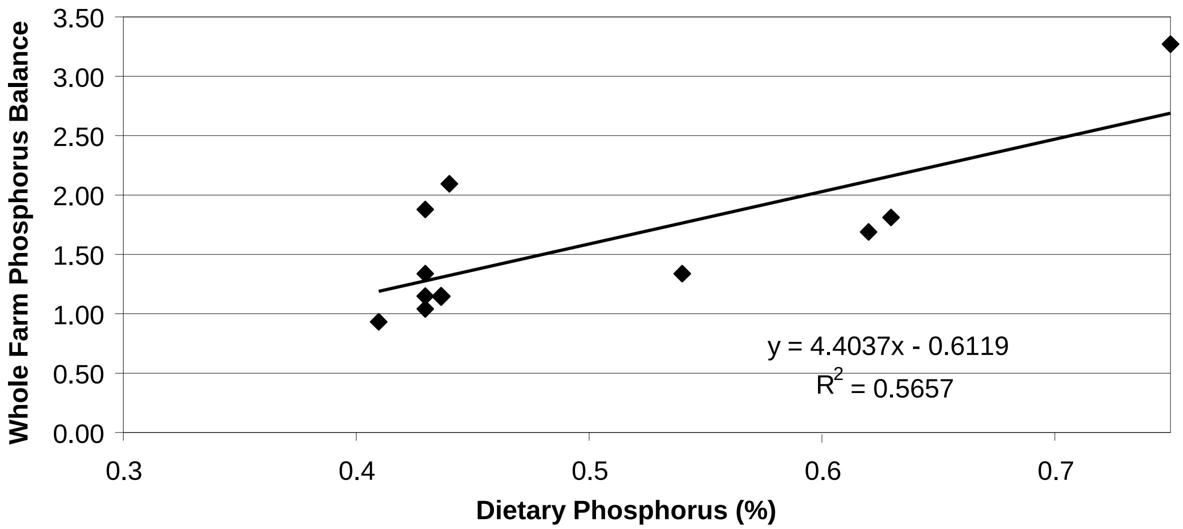


Figure 3. Whole farm nutrient balance versus concentration of crude protein (or N) and phosphorus in ration.

balance. One would expect that increasing crude protein levels would result in less efficient utilization of N within the farm. However, it appears that other factors related to efficiency of N utilization are over-whelming any dietary impacts. However, increasing dietary phosphorus partially explains increases in whole farm phosphorus balance. These data sets are limited with most of the farms reporting dietary P concentrations between 0.4 and 0.45%. However, four data points outside this range suggest increasing whole farm P imbalances as dietary P concentrations increase. A broader data set is needed to further substantiate this relationship.

The results assembled to date indicate a relationship between the concentratio of animals per unit land area and whole farm nutrient balance. The relationship between nitrogen balance and concentration was relatively strong (R^2 = 0.61). Concentration of animals per unit of land provided a poor explanation of the variation observed in P whole farm balance (R^2 = 0.14). However, the positively slope of the regression lines for both N and P balance suggests that concentration of animals per unit of land is, at least, partially responsible for the observed variation in whole farm nutrient balance. Most farms are targeting manure application to meet crop nitrogen needs and applying manure only to corn in a corn-soybean rotation. These

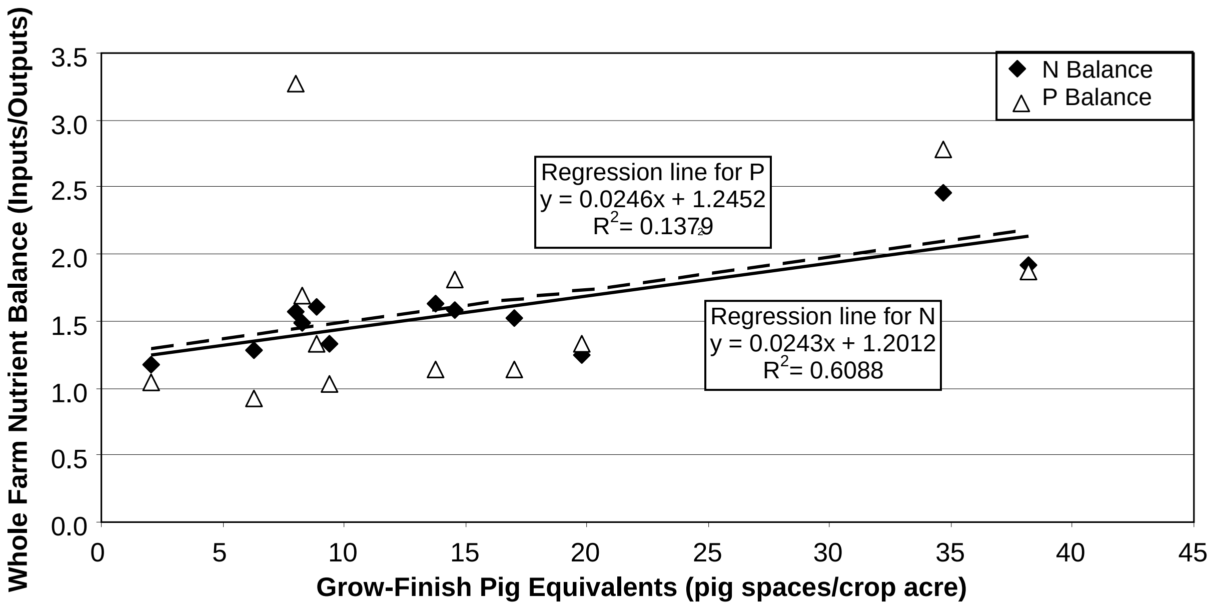


Figure 4. Relationship between concentration of pigs per unit of land area versus whole farm nutrient balance.

A grow-finish equivalent was estimated for wean to finish (0.89), nursery (0.34), and sows (1.08) based upon approximately equal feed consumption for a one-year period. Equivalents were estimated on a grow-finish pig space or capacity basis.

nitrogen based strategies for managing manure nutrients would be supportive of a stronger relationship between animal concentration and nitrogen whole farm balance. It would also appear that a concentration of 15 grow-finish pig space equivalents and less provides an opportunity for efficient use of both N and P if a storage system that efficiently recovers these nutrients is part of the manure management system.

Several additional observationss about the process have been made by producers or their advisors including:

- The simplicity of record keeping for measuring overall farm nutrient utilization efficiency. Procedure did not require records for individual crop fields for manure use and manure nutrient concentration (except if manure was exported). Feed and animal records were generally accessible to the producer as part of current business records.
- The ability to make a quantitative comparison of the efficiency (or inefficiency) of nutrient utilization among farms. This observation was made by an advisor for four of the participating farms.
- The significant role that feed has on the overall nutrient balance of most farms. The use of or failure to use phytase was noted by several individuals as having significant impact on the overall P efficiency of the farm.
- The inability of many farms to improve nutrient efficiency further through traditional manure management planning due to fertilizer inputs having been completely eliminated in the past or representing only a minor contribution to the current inputs.

The second year of this project is currently underway. Producers are collecting data for completing a whole farm nutrient balance for 2007 as well as a finisher house nutrient balance. Joe Lally is in the middle of meeting with all producers to collect some of their data and insure that the FHNB is proceeding as planned. It is anticipated that these activities will be completed over the next three months and that preparations of the proposed educational resources will become the focus of our efforts.

Table 1. Summary of whole farm nutrient (N and P) balance for 13 participating farms.

Farm	C-1	C-2	C-3	C-4	E-1	E-2	E-3	E-4	E-5	W-1	W-2[1]	W-3	W-4	Average of All Farms	
Swine Facility	2,200 hd finisher	4,000 hd finisher	4,000 hd finisher	3,300 hd finisher	3,400 hd Farrow to finisher	6,000 wean to finish	16,000 hd wean to finish	Finish - 3,400 hd finisher	3,300 hd wean to finish	4,800 + 900 hd finisher + 500 sows	3,600 hd finisher	12,000 hd wean to finish	2,000 hd finisher		
Storage	Earthen basin	Deep pit	Concrete storage	Slurry Store	Deep Pit	Earthen basin	Deep pit	Anaerobic Lagoon	?	Anaerobic lagoon	Concrete storage	Deep pit	Anaerobic lagoon		
Land & Crops	86 ac of corn & 74 ac of soybeans	200 ac of corn & 226 ac of soybeans	185 ac corn, 149 ac oats, 118 ac soybeans	80 ac of corn & 93 ac of soybeans	1128 ac corn, 670 ac soybeans, 69 ac wheat, an 310 ac vegetables	437 ac of corn & 413 ac of soybeans	490 ac of corn & 490 ac of soybeans	89 acres of corn	200 ac of corn and 200 ac of soybeans	115 ac of corn and 65 ac of soybeans	None	540 acres of corn	130 ac soybeans and 120 ac alfalfa	Average Inputs, Outputs, and Balance	Portion of Total
Nitrogen Balance															
Animals	8,000	12,000	14,000	2,000	2,000	4,000	10,000	15,000	2,000	10,000	18,000	8,000	4,000	8,000	3%
Feed	96,000	171,000	164,000	100,000	76,000	167,000	499,000	126,000	127,000	200,000	222,000	320,000	110,000	183,000	79%
Fertilizer	0	11,000	0	0	253,000	23,000	0	16,000	0	16,000	0	0	4,000	25,000	11%
Legumes	5,000	16,000	6,000	3,000	54,000	23,000	30,000	0	12,000	6,000	0	0	21,000	14,000	6%
Irrigation	0	0	0	0	0	0	0	0	0	9,000	0	10,000	4,000	2,000	1%
Inputs	**109,000**	**211,000**	**185,000**	**105,000**	**386,000**	**217,000**	**539,000**	**157,000**	**141,000**	**241,000**	**240,000**	**339,000**	**143,000**	**232,000**	
Animals	38,000	68,000	65,000	38,000	37,000	62,000	194,000	70,000	39,000	70,000	77,000	163,000	25,000	73,000	46%
Crops	18,000	72,000	50,000	14,000	294,000	107,000	146,000	11,000	56,000	17,000	0	79,000	66,000	72,000	46%
Manure[1]	11,000	18,000	0	17,000	0	0	0	0	0	11,000	79000	28,000	0	13,000	8%
Managed Outputs	**67,000**	**158,000**	**115,000**	**69,000**	**330,000**	**169,000**	**340,000**	**82,000**	**95,000**	**98,000**	**156,000**	**271,000**	**91,000**	**157,000**	
Imbalance	**41,000**	**53,000**	**69,000**	**35,000**	**55,000**	**48,000**	**199,000**	**75,000**	**46,000**	**144,000**	**83,000**	**68,000**	**52,000**	**74,000**	
In/Out Ratio	**1.6 to 1**	**1.3 to 1**	**1.6 to 1**	**1.5 to 1**	**1.2 to 1**	**1.3 to 1**	**1.6 to 1**	**1.9 to 1**	**1.5 to 1**	**2.5 to 1**	**1.5 to 1**	**1.3 to 1**	**1.6 to 1**	**1.5to 1**	
Phosphorus Balance															
Animals	2,000	3,000	3,000	0	0	1,000	2,000	3,000	1,000	2,000	4,000	2,000	1,000	2,000	5%
Feed	15,000	26,000	25,000	15,000	16,000	25,000	105,000	24,000	27,000	45,000	38,000	70,000	31,000	36,000	88%
Fertilizer	0	0	0	0	35,000	0	0	2,000	0	2,000	0	0	4,000	3,000	7%
Inputs	**16,000**	**29,000**	**28,000**	**16,000**	**52,000**	**26,000**	**107,000**	**30,000**	**27,000**	**50,000**	**42,000**	**72,000**	**36,000**	**41,000**	
Animals	7,000	13,000	13,000	7,000	7,000	12,000	38,000	14,000	8,000	14,000	15,000	32,000	5,000	14,000	54%
Crops	2,000	10,000	8,000	2,000	43,000	16,000	21,000	2,000	8,000	2,000	0	16,000	6,000	10,000	38%
Manure[1]	4,000	5,000	0	4,000	0	0	0	0	0	2,000	6000	6,000	0	2,000	8%
Managed Outputs	**14,000**	**28,000**	**21,000**	**14,000**	**50,000**	**28,000**	**59,000**	**16,000**	**16,000**	**18,000**	**20,000**	**54,000**	**11,000**	**27,000**	
Imbalance	**3,000**	**0**	**7,000**	**2,000**	**2,000**	**-2,000**	**48,000**	**14,000**	**12,000**	**33,000**	**7,000**	**19,000**	**25,000**	**13,000**	
In/Out Ratio	**1.1 to 1**	**1.0 to 1**	**1.3 to 1**	**1.1 to 1**	**1.0 to 1**	**0.9 to 1**	**1.8 to 1**	**1.9 to 1**	**1.7 to 1**	**2.8 to 1**	**1.3 to 1**	**1.3 to 1**	**3.3 to 1**	**1.5to 1**	

[1] Considers only that manure which is exported from the farm and utilized by crop producers on land not managed by the pork producer.

Appendix A: Fact Sheets Developed to Introduce Producers to Project

Understanding Whole Farm Nutrient Balance

Rick Koelsch University of Nebraska June 29, 2006

What Is Whole Farm Nutrient Balance?

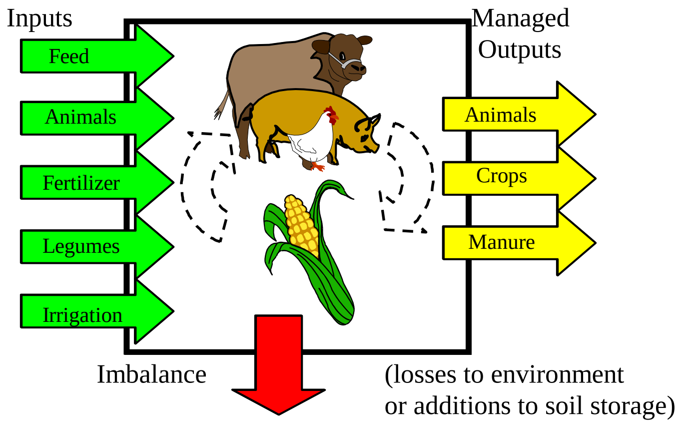
A Whole Farm Nutrient Balance (WFNB) is a comparison of the quantity of nutrients, typically nitrogen and phosphorus that enter (inputs) and exit (managed outputs) the farm gate. If there are more input nutrients than output nutrients, the difference is called a nutrient imbalance. This imbalance represents nutrients that will be lost to the environment by both air and water pathways as well as those nutrients that accumulate on the farm (e.g. increased soil phosphorus levels). The imbalance provides a measure of environmental risk.

This measure can be visualized as a "Nutrient Yardstick". This measure is analogous to an input/output rating for a car's energy efficiency (miles per gallon - MPG) or feed input/output efficiency for animal (lbs of feed per lb of gain). All of these indicators compare inputs with a useful output to define the system's performance or efficiency. A WFNB is focused on the efficiency of a "whole farms" nutrient use and provides an environmental indicator for an important animal production environmental issue (nutrients).

This balance measures only those nutrients that cross the boundary of the farm and does not directly track nutrients flows within the farm. Using the car MPG analogy, the buyer seldom is interested in the efficiencies of individual components such as the engine, transmission, or auxiliary loads. Those internal efficiencies are reflected in the overall input/output measure or MPG. Similarly, the efficiency of nutrient utilization processes inside the farm's boundary (e.g. efficiency of utilization of manure in the cropping system) affects the quantity of nutrient inputs into the farm (e.g. fertilizer inputs to the farm). Thus, a WFNB efficiency measure is reflective of multiple internal on-farm processes.

WFNB also provides an indicator of the magnitude of direct nutrient losses (e.g. ammonia into the air or nitrate in the soil) and accumulations that add to a farm's risk (e.g. phosphorus buildup in the soil). Regulatory agencies are increasingly asking questions about these losses and accumulations. WFNB provides a producer with a relatively simple method for understanding these losses and accumulations and the approximate size of these concerns.

Whole Farm Nutrient Balance *estimates nutrient use efficiency by comparing products entering (inputs) and exiting (managed outputs) the farm. Only products with an N or P component are included.*



Why is A Measure of WFNB Important?

Permitted livestock operations are being asked to provide annual reports to a permitting authority (state regulatory agency or EPA) that provide indirect indicators of nutrient plan implementation. Producers are also required to keep extensive records of planning procedures, plan implementation, sampling, and inspections. Again these records provide indirect indicators of environmental performance. Finally, all producers are required to implement the same best management practices (BMP) whether they are producing broilers in Alabama, pork in Nebraska, or milk in California. However, the effectiveness of these BMP is highly site and size specific.

WFNB provides a "potential" opportunity to set a common performance based goal for all livestock producers but allow individual producers latitude in determining how to reach that goal and a means of measuring an individual farm's progress towards that goal. Setting environmental goals based upon a WFNB measure may give a producer greater flexibility and control in achieving an environmentally sustainable animal operation. It may also provide a simpler and more accurate means of documenting environmental performance.

It must be emphasized that WFNB only has the "potential" for achieving these goals. It has been used extensively in the Netherlands but has seen only limited application in the US. It should be considered a research tool with potential for commercial application, but a tool that we do not fully understand if and how it should be applied to US livestock systems. In addition, we do not understand the implications of its use in a regulatory or public policy role.

What Decisions Might Result from Understanding WFNB?

1. A farm's WFNB can be used to evaluate alternative nutrient strategies. For example by knowing the magnitude of the fertilizer input, the potential improvement in WFNB that might result from an improved manure use plan can be forecasted. Other nutrient strategies contributing to an improved WFNB can also be evaluated including manure export, alternative cropping systems, and alternative feeding programs.
2. A farm's WFNB provides a mechanism for comparing fertilizer vs. feed inputs, typically the two largest inputs. A recognition of which input is larger provides guidance as to which of those nutrient strategies that will be most effective for reducing an imbalance.
3. An understanding of the phosphorus imbalance when combined with the total mass level of phosphorus on the farm from manure can provide an indicator of a quantity of manure that should be exported to prevent future imbalances. This can be especially valuable for farms where an imbalance is driven by purchased feeds (limited land base for growing feeds).
4. A farm's WFNB can be compared to a larger set of farms to identify the relative farm's performance.

What Information Would a Producer Be Asked to Share?

Nutrient Flow	Information Required	Producer Expectations?
	Nutrient Inputs	
Purchased Feed	Type and Quantity Protein and P concentration	Farm records of type and quantity of all purchased feeds. Book value of nutrient concentration with producer option for adjustment
Purchased Animals (or placed in finisher)	Species, # of animals, and animal weight N & P concentration	Farm records of all animal numbers and average initial weight. No producer expectation – use book values
Purchased Fertilizer	Product type and amount N and P concentration	Farm records of all purchased fertilizers and quantity. Typically a book value of nutrient concentration
	Managed Nutrient Outputs	
Crops Sold	Type and Quantity Protein and P concentration	Farm records of crops sold and quantity Book value with producer option for adjustment based upon analysis
Animals Sold	Species, # of animals, and animal weight N and P concentration	Farm records of all sold animal numbers and average sale weight. No producer expectation – use book values
Manure transferred to off farm users	Amount N and P concentration	Farm records Manure analysis

Additional Information

Additional explanation can be found at http://www.lpes.org/les_plans.html, Lesson 2, Whole Farm Nutrient Planning, and a calculator of WFNB is available at http://cnmp.unl.edu/cnmpsoftware2.html.

Understanding Finisher House Nutrient Balance

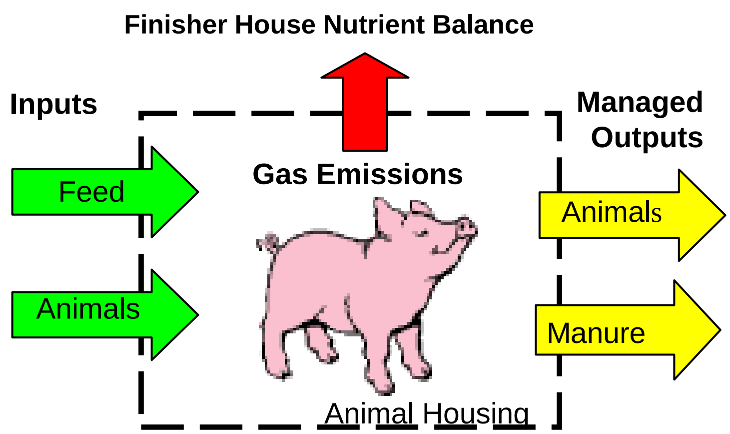
Alan Sutton Purdue University August 15, 2006

What Is Finisher House Nutrient Balance?

A Finisher House Nutrient Balance (FHNB) is simply a comparison of the quantity of nutrients, typically nitrogen and phosphorus that enter (inputs) and exit (managed outputs) the finishing building. This evaluation of nutrient flow can be calculated for grow-finish or wean-finishing housing units. The data required for a FHNB is a subset of information needed for the whole farm nutrient balance (WFNB) tool. FHNB provides three important answers: 1) a measure of the feed input/output efficiency for a pig (lbs of feed per lb of gain), 2) a measure of total manure nutrients excreted while in the housing unit, and 3) an estimate of the losses of nutrient that can be emitted through the air. Therefore the goal of using the FHNB is to document nutrient efficiency for pork production and attempt to reduce nutrient excretion and aerial emissions from the finishing housing unit.

This balance measures nutrients coming into and out of the finishing house (see diagram below). For nitrogen that is commonly transformed to gaseous forms, FHNB is an indirect, but farm-specific, estimate of ammonia emission losses. A FHNB for phosphorus, not transformed to a gaseous form, provides a farm-specific measure of manure phosphorus. Estimation of animal composition will be from previously published literature values.

Finishing House Nutrient Balance *estimates nutrient efficiency by measuring nutrient gain in pigs (managed output) per unit of feed (inputs). Manure nutrient mass is measured also. Only products with an N or P component are included.*



The reason that the finishing housing unit is important is because a majority of the excreted manure nutrients come from this part of the life cycle of pork production. Any means of reducing excreted manure nutrients will reduce the land base needed for manure nutrient utilization (e.g., reduce phosphorus buildup in soils and risk of nutrients to water sources) and reduce gaseous and odor emissions from housing facilities. A FHNB has the potential of providing more accurate and farm-specific measures of nutrient excretion and ammonia emissions and better recognize industry efforts to improve nutrient use efficiency. This will help pork production operations meet environmental stewardship requirements of regulatory agencies and provide a means to coexist with neighbor residences in the rural community.

Why is A Measure of FHNB Important?

Feed is one of the highest production costs for pork operations. Pork producers require diets that are nutritionally adequate to support optimal pig growth and health, but that is cost effective to sustain profitability for the operation. The composition of the pig rations significantly impacts the excretion of nutrients in manure and odor and gaseous emissions from swine housing facilities. With public concern about the potential impacts of production operations on air and water quality, feed composition and management is the first point source of control that may reduce environmental risks and pressures on the pork producer. It is very likely in the near future, that a permitting authority (state regulatory agency or EPA) will require producers to report air emissions from housing and/or manure storage facilities.

Most current estimating procedures assume all farms excrete manure nutrients and emit ammonia at similar rates. It is our belief that FHNB can provide data to benefit the pork producer in three areas. First, the FHNB will measure feed efficiency for the production unit with each set of pigs and the opportunity to improve feed efficiency through diet manipulation and other feed management and housing best management practices (BMP). Obviously, economic opportunities and costs will need to be considered. Second, the FHNB will accurately estimate manure nutrient mass generated for reporting to a regulatory agency, inclusion in a nutrient management plan for efficient nutrient utilization and reduced environmental risk or if there is a need for off-farm transport of the manure nutrients. Finally, FHNB will estimate of the emissions of ammonia which may need to be documented and reported to a regulatory agency. Farm-specific measurements using FHNB will recognize individual farm efforts to improve nutrient efficiency in the finishing barn resulting in lower nutrient excretion and ammonia emissions.

FHNB provides a "potential" opportunity to set a common production performance goal for all livestock producers but allow individual producers latitude in determining how to reach that goal and a means of measuring an individual farm's progress towards that goal. Setting production and environmental goals based upon a FHNB measure may give a producer greater flexibility and control in achieving a productive and an environmentally sustainable animal operation. It may also provide a simpler and more accurate means of documenting environmental performance.

The purpose of this on-farm research initiative is to evaluate the potential benefits and challenges associated with measuring FHNB. It is also our intent to gain an understanding of the FHNB levels on current swine production systems.

What Decisions Might Result from Understanding FHNB?

1. A farm's FHNB can be used to evaluate diet compositions including alternative feed resources, availability of nutrients for growth and economics. This may result in altering manure production, composition and gas emissions.
2. A farm's FHNB provides a mechanism for identifying the most effective nutrient strategies in the nutrient management plan.
3. A farm's FHNB recognizes initiatives to improve feed efficiency and the need to estimate a farm specific land base, likely smaller than required for more typical feed management practices.
4. A farm's FHNB can be compared to a larger set of farms to identify the relative farm's performance.

What Information Would a Producer Be Asked to Share?

Nutrient Flow	Information Required	Producer Expectations?
Nutrient Inputs		
Purchased Animals (or placed in finisher) – Table A	Number of animals, sex and animal weight N & P concentration	Farm records of all animal numbers and average initial weight. No producer expectation – use book values
Purchased Feed – Table D	Type and Quantity Protein and P concentration	Farm records of type and quantity of all purchased feeds. Book value of nutrient concentration with producer option for adjustment
Managed Nutrient Outputs		
Animals Sold – Table B	Number of animals, sex and animal weight N and P concentration	Farm records of all sold animal numbers and average sale weight. No producer expectation – use book values
Manure volume and analysis – Table F	Amount produced N and P concentration	Farm records (depth measurements) Manure analysis

Implementing Mass Nutrient Balance Tools on Swine Finisher Production Operations

Funding Source: National Pork Board (NPB), $40,000. NPB Contact: Allan Stokes, Director of Environmental Programs, 515-223-3447, astokes@pork.org

Purpose: We propose to apply nutrient mass balance concepts to 10 swine finishing operations to provide a more complete characterization of nitrogen and phosphorus flows on the farm. It will explore the opportunity for Whole Farm Nutrient Balance (WFNB) procedures to provide a more accurate and producer friendly tool for documenting stewardship of farm nutrient resources. It will further explore the ability of a Finisher Housing Nutrient Balance (FHNB) to compliment current efforts to estimate farm specific ammonia emissions under the Consent Agreement. Our specific objectives are:

Phase I (2006)

Construct a whole farm balance and a finisher house balance for nitrogen and phosphorus for two representative swine finishing operations selected by the Consent Agreement project and eight additional pork finishing operations in Nebraska, Iowa and Indiana based upon existing farm records for the calendar year 2006.

Phase II (2007)

A. Construct a whole farm and a finisher house mass balance for nitrogen and phosphorus on the same farms for 2007. Review and, if appropriate, modify farm records to collect the necessary data.
B. Evaluate the role of mass balance procedures for adjusting ammonia emissions factors for unique situations not addressed by original consent agreement farms.
C. Utilize the data collected for WFNB to develop a new educational module for future pork producer targeted educational initiatives.

Why should I participate? Good stewardship in pork production requires careful management of nutrients, especially nitrogen and phosphorus. This project will evaluate two tools (WFNB and FHNB) that may provide better measures of the nutrient performance of a farm. WFNB is a comparison of the quantity of nutrients, typically nitrogen and phosphorus, that enter (inputs) and exit (managed outputs) the farm gate. If there are more input nutrients than managed output nutrients, then there is a nutrient imbalance. This imbalance represents nutrients that will be lost to the environment by both air and water pathways as well as those nutrients that accumulate on the farm (e.g. increased soil phosphorus levels). Similarly, the FHNB focuses on the nutrient inputs (feed, water and animals) and the managed outputs (animals sold and manure generated) within the finisher housing unit. The difference between inputs and managed outputs is used to calculate an imbalance. Tools such as WFNB and FHNB may provide a more direct measure of overall farm efficiency. Secondly, these two tools might prove advantageous to the producer in simplifying an increasing planning and record keeping burden. In addition, these tools may have value for current and future public policy expectations of pork producers relative to protecting water quality and managing ammonia emissions.

What will I learn? This project will provide participants an accurate measure of their farm's overall efficiency of nutrient utilization and potentially provide areas for further improvement of nutrient utilization on the farm. If the measure of finisher house nutrient balance produces an accurate measure of nutrient excretion and ammonia emissions, the study will provide an ammonia emission estimate that can be used for air quality documentation. .

How much time will I have to spend on this? The WFNB and FHNB measurement will be based strictly on farm records. Completion of this measurement may require up to four hours work with a project representative to assemble the appropriate information for a one-year period. We will ask the producer to complete this process for two separate years. If the first year measure identifies a deficiency in records (e.g. incomplete records on manure transferred off farm), we will ask the producer to maintain more complete records in this area of deficiency during 2007. Review the WFNB and FHNB documents for the necessary records.

The FHNB will also be based upon records of pigs purchased or placed in the building, pigs sold, feed consumption and manure production. We will ask the producer to maintain records of manure storage levels and assist in the collection of approximately 3 manure samples.

All sampling costs associate with this project will be paid by the project. A small stipend of $400 would be paid to the producer as compensation for invested time.

How confidential is my farms data? Confidentiality of individual farm records is essential to this project. All farm data sheets will carry only an identifying code specific to each participating farm. Joe Lally will maintain a list linking individual farms to their individual code during the project and destroy that list at the conclusion of the project. Only Joe will be allowed access to this list. All written and electronic data shared with university representatives will include only this individualized code and no farm identifying information. Purdue University and University of Nebraska will not have the capability of responding to requests for individual farm data that can be tied to an individual producer.

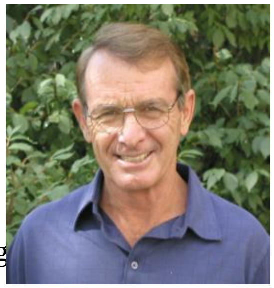
How will the results of this project be published? Our plans are to use the data to supplement educational materials targeting pork producers on the concept of whole farm nutrient balance. National Pork Board will have first opportunity for publishing these materials. In addition, the data will be the basis of a research related publication in a research journal for animal science or agricultural engineering and in annual university swine reports targeting the swine industry.

Who are the people involved? Alan Sutton (right) is a professor in the Animal Science Department at Purdue University with a focus on nutrition and animal manure management. His extension program appointment focuses on working with Indiana pork producers and advisors on manure systems and nutrient management planning. His research focuses on the interaction of animal diet to mitigate air and water quality issues.

Rick Koelsch (left) is an associate professor in the Biological Systems Engineering and Animal Science Departments at University of Nebraska. His extension program targets Nebraska livestock producers and advisors on manure management. He also contributes to national efforts to improve the connection between researchers and the end users of science based information.

Joe Lally (right) is a long time meat industry advisor with an extensive background in both independent and contract production systems. Joe's professional and personal interests remain in moving the livestock industry progressively forward while achieving profitable, sustainable operations through applied research, producer involvement and outreach with industry-led solutions.

Has this project been tried before? The concept of WFNB is used in the dairy industry in eastern US. Those studies have defined some of the critical challenges for concentrating nutrients within farms that import significant quantities of feed from outside their region. More recently, Koelsch has used this approach with cattle feedlots in Nebraska and a small group of pork producers. This concept is also the foundation for implementing nutrient public policy in the Netherlands.



How long will this project last? Late fall of 2006 through the end of 2007. Producers will be given the option at the end of 2006 to decide if they wish to continue their participation in 2007.

Will I get my farms data collected, and will comparisons be made? Each participating farm will receive a summary of the data collected for their own farm and a means of comparing their farm against the other farms involved in this study. The summary report detailing the results of all farms and the outcomes of our measurements will be shared with the producers.

What extra record keeping will be required? The two fact sheets on WFNB and FHNB describe the information required to complete those nutrient balances. It is anticipate that most producers will have most information within their existing records for these measures. After completing these measures for 2006, Joe Lally will discuss with the producer any improved record keeping needs, if appropriate.

What bio-security measures will be followed? All individual producer requirements for bio-security will be followed. Most meetings will occur in the producer's home or office. If Joe Lally would request access to the animal housing, he would, at a minimum, not been on another pork production facility within the past 48 hours (or follow the producers criteria if more stringent).

Appendix B. Sample Whole Farm Balance Report Provided to Producer

Summary of Primary Inputs and Outputs for a One-Year Period

Farm: C4 Period: 2006

Inputs: Only those inputs that come from off-farm sources

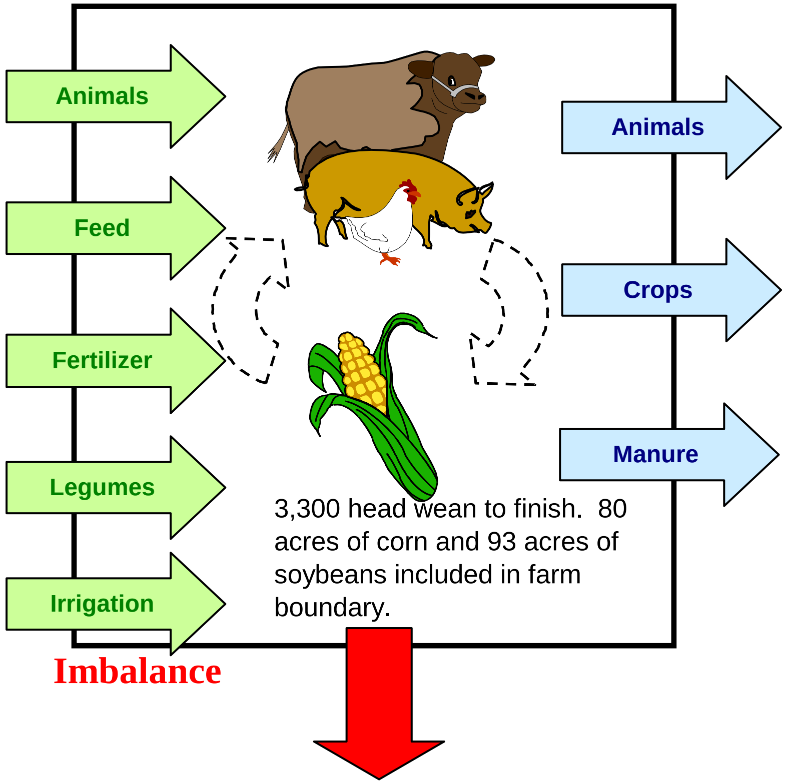
6789 pigs brought onto farm at 10 lb each. (Original data for two turns X 1.064 or 365/343)

Corn, SB Meal 44%, Dical, Lysine, and Fishmeal brought onto farm…6,042,899, 1,590,759, 99,931, 22100, 1450 lbs respectively.

No commercial fertilizer use.

63.4 acres of soybeans averaging 34 bu/ac. Soybeans do not received manure.

No irrigation



Managed Outputs: Only those products that leave the farm.

6023 pigs sold at 253 lbs, 313 culls sold at 214 lbs. 698 mortality (assumed 420 at 20 lb and 278 at 150 lb) composted - do not leave farm.

Soybeans sold (2156 bu = 63.4 ac x 34 by/ac). Corn sold (8400 bu= 80 ac x 105 bu/ac).

520,704 gallons containing 33 lbs of N and 19 lbs of P2O5 per 1000 gallons.

Whole Farm Nutrient Balance Summary

Producer Information

C4

Preparer Information

Nitrogen Balance

N Inputs (lbs / year)*

Input	lbs / year
Animals	2,000
Feed	100,000
Fertilizer	-
Legumes	3,000
Irrigation	-

TOTAL 105,000 lbs. Inputs per year

N Managed Outputs (lbs / year)*

Output	lbs / year
Animals & Animal Products	38,000
Crops	14,000
Manure & Compost	17,000

69,000 lbs. Managed Outputs per year

Input to Output Ratio: 1.5 to 1

Imbalance* 35,000 lbs/year

Phosphorus Balance

P Inputs (lbs / year)*

Input	lbs / year
Animals	-
Feed	15,000
Fertilizer	-

TOTAL 16,000 lbs. Inputs per year

P Managed Outputs (lbs / year)*

Output	lbs / year
Animals & Animal Products	7,000
Crops	2,000
Manure & Compost	4,000

14,000 lbs. Managed Outputs per year

Input to Output Ratio: 1.1 to 1

Imbalance* 2,000 lbs/year

* Corrected for changes in inventory.

I. LIVESTOCK AND POULTRY PRODUCTS

I. A. Animal Inputs: For a one year period, indicate the number of animals purchased and their average live purchase weight (include custom fed animals).

Livestock or Poultry Group		Number of Animals Purchased	Average Purchase Weight (lbs)	Nitrogen		Phosphorus	
				Fraction	Total Weight (1,000 lbs)	Fraction	Total Weight (1,000 lbs)
Ex.: Beef Cattle (< 1,000 lbs)		*3,000*	*600*	*0.027*	*48.6*	*0.0073*	*13.1*
1.	Swine (<100lbs)	6,789	10	0.025	1.7	0.0056	0.4
2.							
3.							
4.							
5.							
TOTAL					**1.7**		**0.4**

I. B. Animal Outputs: For a one year period, indicate the number of animals sold or shipped off farm and average live weight (include custom fed animals, culls, and mortality).

Livestock or Poultry Group		Number of Animals Sold	Average Sell Weight (lbs)	Nitrogen		Phosphorus	
				Fraction	Total Weight (1,000 lbs)	Fraction	Total Weight (1,000 lbs)
1.	Swine (100 to 300 lbs)	6,023	253	0.024	37	0.0047	7
2.	Swine (100 to 300 lbs)	313	214	0.024	2	0.0047	0
3.							
4.							
5.							
TOTAL					**38**		**7**

I. C. Animal Products Output: For a one year period, indicate the quanity of animal products sold.

Animal Product		Pounds Sold	Fraction Crude Protein*	Nitrogen		Phosphorus	
				Fraction	Total Wt. (1,000 lbs)	Fraction	Total Wt. (1,000 lbs)
1.	Milk			0.005		0.0010	
2.	Eggs			0.019		0.0020	
3.	Wool			0.120		0.0001	
TOTAL					-		-

* If crude protein is known, enter your value. Table assumes 3.2% and 12% crude protein in milk and eggs, respectively.

I. D. Change in Animal Inventory: (beginning vs. end of year). For those livestock groups that have changed in numbers fed from the beginning to the end of the year, indicate that change in inventory below.

Livestock or Poultry Group		1-Jan		31-Dec		Nitrogen		Phosphorus	
		Number of Animals	Average Weight (lbs)	Number of Animals	Average Weight (lbs)	N Fraction	Total Weight (1000 lbs)	P Fraction	Total Weight (1000 lbs)
Example: Cattle		*1,500*	*925*	*1,700*	*925*	*0.027*	*5*	*0.0073*	*1*
1.									
2.									
3.									
4.									
5.									
				Total for Decreasing Inventory			-		-
				Total for Increasing Inventory			-		-

II. FEEDS, FORAGES, GRAINS, AND OTHER CROPS

II.A. Inputs: For a one year period, enter all grain, supplement, forage, bedding, and minerals purchased. Amount purchased and nutrient content must both be entered on same moisture basis, either "Wet or Dry Weight Basis".

	All Purchased Feeds				Nitrogen			Phosphorus		
	List Feeds, Forages, Grains or Supplements Purchased or Brought Onto Farm	Wet or Dry Weight Basis*	Amount Purchased	Units	Fraction Crude Protein: Your Value	Fraction Crude Protein: Book Value	Total N (1,000 lbs)	Fraction Phosphorus: Your Value	Fraction Phosphorus: Book Value	Total P (1000 lbs)
	Example: Soybean meal - 44%	*Wet*	*1,000,000*			*0.440*	*71*		*0.0063*	*6*
1.	Total Feed	Wet	3,520,900	lbs	0.178	-	100	0.0043	-	15
2.						-			-	
3.						-			-	
4.						-			-	
5.						-			-	
6.						-			-	
7.						-			-	
	TOTAL						100			15

* If feed intake and nutrient concentration is entered on an "As Fed" or "Wet Weight Basis" basis, enter "Wet"
If feed intake and nutrient concentration is entered on a "Dry Weight Basis", enter a "Dry". 0

II.B. Outputs: For the same one year period, indicate all grain, supplement, hay, silage, bedding, and minerals sold.

	All Feeds, Grains, or Forages Sold				Nitrogen			Phosphorus		
	List Feeds, Forages, Grains or Supplements Sold or Transferred Off-Farm	Wet or Dry Weight Basis*	Amount Sold	Units	Fraction Crude Protein: Your Value	Fraction Crude Protein: Book Value	Total N (1,000 lbs)	Fraction Phosphorus: Your Value	Fraction Phosphorus: Book Value	Total P (1000 lbs)
1.	Corn Dry Grain 56 lb/bu	Wet	8,400	bu.		0.086	6		0.0027	1
2.	Soybean Whole	Wet	2,156	bu.		0.363	8		0.0059	1
3.						-			-	
4.						-			-	
5.						-			-	
6.						-			-	
7.						-			-	
	TOTAL						14			2

II.C. Change in Inventory: (beginning vs end of year). If any previously mentioned crop or feed stored on-farm has changed in inventory, indicate that change below.

	All Feeds, Grains, or Forages Sold				Nitrogen			Phosphorus		
	List Feeds, Forages, Grains or Supplements Sold or Transferred Off-Farm	Wet or Dry Weight Basis*	Inventory	Units	Fraction Crude Protein: Your Value	Fraction Crude Protein: Book Value	Total N (1,000 lbs)	Fraction Phosphorus: Your Value	Fraction Phosphorus: Book Value	Total P (1000 lbs)
	January 1 Inventory									
1.						-	-		-	-
2.						-	-		-	-
3.						-	-		-	-
	December 31 Inventory									
1.		-		-		-	-		-	-
2.		-		-		-	-		-	-
3.		-		-		-	-		-	-
			Total for Decreasing Inventory				-			-
			Total for Increasing Inventory				-			-

III. FERTILIZER, MANURE, AND OTHER CROP NUTRIENT PRODUCTS

III.A. **Fertilizer Inputs:** (dry, liquid, anhydrous, etc). For a one year period, enter all fertilizer purchases from off-farm suppliers, quantity purchased, and nitrogen and phosphorus content. Phosphorus should be entered as % P, not % P_20_5. To convert from

Fertilizer Inputs				Nutrient Content			Total Inputs	
Fertilizer, manure, or compost purchased or brought onto farm.		Amount Purchased	Units	N	P	Units of Measure	Total N	Total P
							(1,000 lbs)	
Example: Anhydrous Ammonia		*50*	tons	*0.82*	-	fraction	*82*	-
1.								
2.								
3.								
4.								
5.								
6.								
7.								
	TOTAL						-	-

III.B. **Managed Outputs:** For a one year period, list all fertilizers, manures or composts sold, traded, or given away and your best estimate of the quanity involved. Again, phosphorus should be reported as % P, not % P_20_5. To convert from P_20_5 to P, divide P_2

Manure and Other Nutrient Outputs				Nutrient Content			Total Outputs	
Fertilizer, manure, or compost sold, traded or given away to off-farm users.		Amount	Units	N	P	Units of Measure	Total N	Total P
							(1,000 lbs)	
Example: Manure		*500*	tons	*0.0075*	*0.0050*	fraction	*8*	*5*
1.	Manure	521	1000 gal	33.0000	8.5600	lbs/1,000 gal	17	4
2.								
3.								
4.								
5.								
6.								
7.								
	TOTAL						**17**	**4**

III.C. **Change in Inventory:** (beginning vs. end of year). If the inventory of any previously mentioned product has changed from the beginnning to the end of the year, indicated that change below. Again, phosphorus should be reported as % P, not % P_20_5. To con

Fertilizer Inventory:					Nutrient Content			Total Outputs	
Fertilizer, manure, or compost Item		Jan. 1 inventory	Dec. 31 inventory	Units	N	P	Units of Measure	Total N	Total P
								(1,000 lbs)	
1.									
2.									
3.									
4.									
5.									
6.									
		Total for Decreasing Inventory						-	-
		Total for Increasing Inventory						-	-

IV. MISCELLANEOUS NITROGEN SOURCES

IV.A. Inputs as Legume Fixed Nitrogen: For all legumes not manured within the past two years, indicate crop grown, acres grown, yield, and crude protein content (wet weight basis).

	Legume Crop Data				Nitrogen		
	Non-Manured Legume Crops	Acres not manured	Average yield	Units	Fraction Crude Protein** Your Value	Book Value	Total Nitrogen (1,000 lbs)
	1st year hay (> 90% Legumes)	100	4	tons/ac		0.15	5.8
1.	Soybeans	63	34	bu/ac		0.36	2.8
2.							
3.							
4.							
5.							
6.							
	TOTAL						**2.8**

** Enter crude protein content on a wet weight basis (or as fed).

IV.B. Inputs as Nitrogen in Irrigation Water: List all irrigation wells, quantity of fresh water pumped, and nitrate-N concentration, if known. Do not include effluent from a lagoon or feedlot runoff control pond.

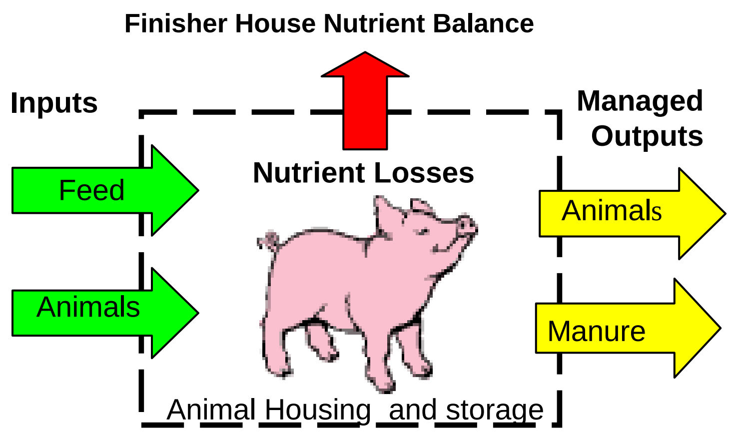
	Well Data						Nitrogen
	Well	PPM Nitrate-N	Amount Pumped Ac-inches	OR	Flow Rate (gpm)	Annual Use (hrs/yr)	Total Nitrogen (lbs)
	Example: Home Well	*15*	*1700*				*5.8*
1.							
2.							
3.							
4.							
5.							
6.							
7.							
8.							
9.							
10.							
TOTAL							-

Appendix C. Measurement Protocols for a Finisher House Nutrient Balance

Alan Sutton, Rick Koelsch, Joe Lally

What Is Finisher House Nutrient Balance?

A Finisher House Nutrient Balance (FHNB) is simply a comparison of the quantity of nutrients, typically nitrogen and phosphorus that enter (inputs) and exit (managed outputs) the finishing building. This evaluation of nutrient flow can be calculated for grow-finish or wean-finishing housing units. The critical information needed is defined in Table 1.



Finishing House Nutrient Balance *estimates nutrient efficiency by measuring nutrient gain in pigs (managed output) per unit of feed (inputs). Manure nutrient mass is measured also. Only products with an N or P component are included.*

Our whole farm nutrient balance measures for participating farms in 2006 reveals that records are generally excellent for measuring feed inputs and animal inputs and outputs. This protocol will suggest some refinements but little or no change for most farms.

Measurement of manure volume and obtaining a representative sample of manure nutrient concentration is our greatest challenge for a measurement of Finish House Nutrient Balance. Our best opportunity for a farm specific measure of manure volume is by measuring a change in storage depth (e.g. over a period of one cycle of pigs). Our best time for measuring manure nutrient concentration is during a period of agitation (if practiced) and pump-out. Another option for measuring manure nutrient concentration is near the end of a cycle of pigs if a representative sample of manure for all depths can be collected. This protocol will focus on records and measures needed for estimating the manure output arrow.

Nutrient Flow	Information Required	Producer Expectations?
	Nutrient Inputs	
Feed Entering Barn	Type and Quantity Protein and P concentration	Farm records of type and quantity of all purchased feeds. Book value of nutrient concentration with producer option for adjustment by feed sampling & analysis
Purchased Animals (or placed in finisher)	Number of animals, sex and animal weight N & P concentration	Farm records of all animal numbers and average initial weight. No producer expectation – use book values
	Managed Nutrient Outputs	
Animals Sold	Number of animals, sex and animal weight N and P concentration	Farm records of all sold animal numbers and average sale weight. No producer expectation – use book values
Manure volume and analysis	Amount produced N and P concentration	Farm records (depth measurements) Manure analysis
	Nutrient Losses	
	Nutrient Losses = Nutrient Inputs - Managed Nutrient Outputs (N - Primarily ammonia emissions) (P – Primarily settled solids not recovered during pump-out)	

Manure Volume

Measurement Period: One-year

Measurement Needed: Recording of manure storage depth a) weekly and b) before and after each pump out event for one year period.

Individual farm manure volume can be estimated by two methods:

1. Estimate of decrease in storage depth during each pump out period when applying manure to crop land.
2. Estimate an increase in storage depth vs. time (preferably over a full finishing cycle for one group of pigs).

We ask that you maintain a record of weekly storage depth plus depths before and after all pump out periods for a one year period of time. Please start this record keeping by May 1 if you do not already maintain these records. Attached you will find two sample records that may be used for this purpose. If you have a comparable record that provides similar information, please continue to use your own record if we can have a photocopy of your records.

The attached sample records are designed to meet record keeping requirements for facilities with an NPDES permit and can be used for some of the information requested by the Annual NPDES Report made to EPA or your state regulatory agency. NPDES permits typically require recording of liquid level weekly, change in level with each pump out event, and on-site precipitation. We hope that a record that meets regulatory requirements as well as our project information needs is valuable.

Manure Concentration

Measurement Period: One-year

Number of samples: 4 manure samples over next year, two per pump out event preferred.

Sample Size: ¾ quart in a one quart plastic sample container.

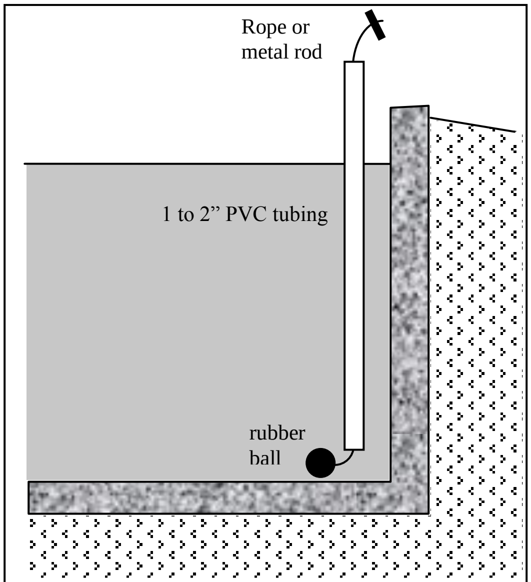
Protocol (for samples collected during agitation and/or pump-out event - preferred):

1. Sample will be collected either a) during or following agitation from the pump or representative locations where manure is well mixed or b) from the pump during the pump out event or c) from the slurry tank immediately after loading.
2. Six sub-samples (approximately one pint each) will be collected and aggregated to produce a composite sample (3/4 quart) to be sent to the lab. If collected from a storage, each sub-sample will be collected from a different location where manure appears to be well mixed. If collected from a pump, sub-samples will be collected over time with at least 15 minutes between each sub-sample. If collected from a recently filled slurry tank, each sub-sample will be collected from a different load. All sub-samples will be collected within a one-day period.
3. If sub-samples are collected over more than a one-hour period, the combined sub-samples should be stored in a cooler on ice, preferably in an air tight container.
4. Stir the combined sub-samples until a uniform mixture is obtained and pull a final ¾ quart sample while the liquid

Sampling during agitation or pumping commonly produces the most representative sample. For irrigation systems, sample before diluting with fresh water.

is still swirling. Place in a plastic quart container leaving some head space. Using electrical or duct tape, seal the cap to the container.

5. Label the container with the date, farm name, manure source ID (e.g. Building 3 deep pit), manager's name, address, and phone number.



Sampling device to collect a representative manure sample when manure varies with depth.

6. If the sample cannot be shipped to a lab the same day, then freeze and ship the sample when appropriate.

If samples are to be collected in advance of agitation and pumping, a reasonably good sample can be collected from below barn pits and exterior concrete and steel storages using a sampling device similar to the one illustrated to the left. A similar protocol would be followed as above with the exception of collecting the six sub-samples from the full depth of the storage at six distributed locations around the storage. We ask that you involve Joe Lally in a review of your procedure's ability to produce a representative sample.

Feed Sample Measurements

Measurement Period: One cycle of pigs

Number of samples: 4 samples from 4 different feeding phases representing the largest volume of feed inputs for one group of pigs.

Sample size required: 1 pound minimum.

Protocol:

1. Collect 6 sub-samples of the same type of feed (about 1 cup each) from six different feeders at different locations in the barn. Scrape to the side the feed on the surface and collect a grab sample from below the surface.
2. Mix the sub-samples and reduce sample size if necessary (one pound minimum sample size).
3. Place in a two-quart zip lock freezer bag, exclude air and seal tightly.
4. Label the container with the date, farm name, feed program ID (e.g. Phase 3 pigs- 130 to 170 lb pigs), manager's name, address, and phone number.
5. Ship to lab of your choice.

This set of samples will be used as a check of the feed analysis shared for your purchased feeds, typically from the feed supplier. <u>If the feed sample records you are sharing with us are collected from on-farm, then a new set of samples are not necessary</u>. We would ask that you follow the above protocol for one cycle of pigs.

Feed Entering Barn

Measurement Period: Two turns of pigs

Measurement Needed: Total quantity of feed entering barn

We need to know the total quantity of feed entering the barn. We do not need to know individual feed ingredients. Combining total quantity and nutrient concentrations allows us to calculate total nitrogen and phosphorus entering the barn as feed. Generally, the records we have received to date have been excellent for our needs.

Please note that Whole Farm Nutrient Balance requires an estimate of only "Purchased" feeds originating from off-farm sources. Finishing House Nutrient Balance requires an estimate of all feeds entering the barn including both "Home Grown" and "Purchased" feeds. For many of you, no home grown feeds are added to the ration on-farm and the quantity of feed for the Whole Farm Nutrient Balance and the Finishing House Nutrient Balance are the same. Please make sure we know when this assumption is not correct.

Animals Purchased and Sold

Measurement Period: Two turns of pigs

Measurement Needed:

1) Number of weaning or feeder pigs entering the animal housing and their average weight
2) Number of finish pigs existing the barn and their average weight
3) Number of mortality, approximate date of death, and their average weight, if available. If not we will assume an average of entering and exiting weights.
4) Are mortality disposed of on-farm or picked up for rendering (important to whole farm balance only)
5) From the slaughter sheet, Average Dressing Percent" and "Average Fat Free Lean Percent" at final weight. This is helpful for estimating animal protein (and nitrogen) content.

Attached you will find a sample record for your consideration. <u>If you are collecting similar information with your current records, the attached record is not necessary.</u> These same records will most likely be used for both Whole Farm Nutrient Balance and Finishing House Nutrient Balance.

Water Sample

There is a remote chance that drinking and cleanup water may be a source of significant nitrogen. We would ask that you collect one sample of water allowing us to estimate nitrogen addition to the barn based upon typical water use. If this appears to be significant, we may visit with you about additional measurements.

Number of samples: One sample during your current cycle of pigs

Protocol

1) Take the sample close to the pump, before the water goes through a treatment system.
2) Do not take the sample from a swing-type faucet. Inspect the faucet for leaks. Select another faucet if there is leaking. (This is a consideration if you use the sample to check for bacteria contamination)
3) Disinfect the faucet with bleach or a flame (for checking bacteria contamination).
4) Run the water three minutes to clear the line.
5) Take the sample midstream. Do not allow your hands to touch the insides of the collection bottle, the opening or inside of the cap.
6) If needed, store the sample in the refrigerator before taking to the lab.

Submit the sample within 48 hours of collection. If practical, transport the sample in a cooler or ship in an insulated container (box packed with newspaper or packing peanuts).