small farm nutrient management primer:

for un-permitted animal feeding operations

...protect water resources

safeguard operations...

...improve efficiency & productivity

practices and strategies to minimize pollution

THE UNIVERSITY OF GEORGIA COLLEGE OF AGRICULTURAL & ENVIRONMENTAL SCIENCES

NOAA

GEORGIA Coastal Management Program

P²AD

Bulletin 1293

January 2006

THE UNIVERSITY OF GEORGIA
COOPERATIVE EXTENSION
Colleges of Agricultural and Environmental Sciences & Family and Consumer Sciences

Small Farm Nutrient Management Primer:

For Un-permitted Animal Feeding Operations

Small Farm Nutrient Management Primer:
For Un-permitted Animal Feeding Operations

Editors: Thomas M. Bass and L. Mark Risse
Authors: Credited on Individual Chapters

Table of Contents:

Chapter 1
Environmental Stewardship, Water Quality and Nutrient Balance

L. Mark Risse, Biological & Agricultural Engineering Dept., University of Georgia

Producers need to be aware of the impacts that manure can have on water and air quality. However, management of manure and other byproducts of livestock and poultry production has important impacts on farm profitability, neighbor relations and protecting soil and water quality.

How Can Manure Affect the Environment?

The livestock and poultry industry is facing growing scrutiny of its environmental stewardship. While emotion and limited information on the part of the general public contribute to this concern, problems also result from a few producers who have allowed highly visible impacts to occur on the environment. These situations create a negative and often biased public view about the impact of livestock and poultry on the environment.

If not carefully managed, manure and other byproducts of animal production such as mortality can have a significant negative impact on the environment. Animal production can negatively affect surface water quality (pathogens, phosphorus, nitrogen as ammonia and nitrate, and organic matter); groundwater quality (nitrate); soil quality (soluble salts, copper, arsenic, and zinc); and air quality (odors, dust and particulate matter emissions, pests, and aerial pathogens). In fact, the U.S. Environmental Protection Agency (EPA) has identified agricultural production as the largest single contributor to water quality impairment for rivers and lakes (Table 1). For nutrients in particular, livestock and poultry manures are a major contributor of total nitrogen (N) and phosphorus (P) inputs into U.S. watersheds. In some watersheds, manure nutrient inputs are substantially greater than those associated with more traditional sources of pollution (e.g., municipalities, industry).

Table 1. Five leading sources of water quality impairment.

Rank	Rivers	Lakes	Estuaries
1	Agriculture	Agriculture	Municipal point sources
2	Municipal point sources	Urban runoff and storm sewers	Urban runoff and storm sewers
3	Urban runoff and storm sewers	Hydrologic/habitat modification	Agriculture
4	Resource extraction	Municipal point sources	Industrial point sources
5	Industrial point sources	Onsite wastewater disposal	Resource extraction
Source: EPA 1998.			

Is manure an environmental risk or benefit?

How you manage your manure can determine if it is; is it…

A source of nutrients and disease causing organisms that degrade the quality of our water for drinking and recreational use?	OR	A source of organic matter that improves the quality and productivity of our soil resources?
One of our nation's largest sources of water pollution?	OR	A source of plant nutrients that can replace commercial fertilizers saving time, energy, and money?
A source of gaseous emissions that reduces the quality of life in rural communities and contributes to possible neighbor health concerns?	OR	A means of recycling and adding carbon to the soils that contributes to a reduction in atmospheric carbon and global warming?

Manure can produce both good and bad results. The actual results often depend upon choices that you make in managing this resource.

Principles of Environmental Stewardship

As someone who manages animal manure on a livestock or poultry operation, you make the decisions that determine if manure will be a benefit or risk to the operation. Several fundamental principles of good environmental stewardship must be considered in the production of livestock and poultry.

Awareness of environmental risks

The potential impact of an individual operation on the environment varies with animal concentration, weather, terrain, soils, and a host of other conditions. You must understand these risks and manage your operation's manure to minimize them.

No point source discharge

Livestock and poultry production systems operate on the principle of "no discharge" of manure or wastewater to surface water from point sources such as animal housing, storage facilities, or treatment lagoons. Under EPA rules, the only time a discharge is allowed is in extreme rainfall events such as a 25-year, 24-hour storm (This is a defined amount of rain expected to fall in one day once every 25 years on the average). The no discharge management standard for animal manure is distinctly different from the management of human and industrial waste, which is routinely discharged into surface waters following treatment. Avoiding manure or wastewater spills directly into surface waters is essential to being a good environmental steward. Minimizing runoff from nonpoint sources (NPSs) (e.g., land application) is also central to good environmental stewardship. Making proper decisions related to timing and site selection for land application should minimize the risk of these NPS discharges.

Follow a nutrient management plan (NMP) for land application

A good stewardship program includes a plan for managing manure nutrients in crop production systems. The plan must maintain a balance between nutrient application and crop use as well as minimize the risk of runoff and leaching of nutrients. Proper nutrient management allows you to use the nutrients in manure as a resource for your operation.

Be a good neighbor

The byproducts of animal production create several potential nuisances (including odors, flies, noise, and others) in rural communities. You must be fully aware of these potential issues and the degree of concern they cause neighbors. Where reasonable technologies and management strategies are available to reduce or eliminate these nuisances, such strategies should be implemented. Where such options do not exist, producers may need to consider alternatives such as separation distances and good communication to minimize these nuisances.

Know the rules

Good stewardship requires knowledge of and compliance with current regulations established by federal, state, and local governments. Knowledge of these rules and careful planning of manure management systems to meet these requirements is essential. Good stewardship, however, goes beyond meeting the minimum requirements and includes reducing environmental risks whenever possible. While these environmental stewardship principles appear simple, they require knowledge, hard work, and commitment from everyone involved with the operation.

Understanding Water Quality Issues

While land application of manure provides many benefits, incorrect manure use can have negative impacts on water quality. Good stewards should be aware of the components of manure that are of greatest concern, their specific impact on water quality, and their common pathways to surface and groundwater.

Water Quality Contaminants

Manure contains four primary components that impact water quality: nitrogen (N), phosphorus (P), pathogens (disease-causing organisms), and organic matter. These components, their environmental risk, and typical pathways to water are summarized in Table 2.

Table 2. Summary of manure components that can impact water quality, the associated environmental risk, and most common pathway to water.

Potential Pollutant	Environmental Risk	Most Common Pathway to Water
Nitrate-N	Blue Baby Syndrome Algal blooms	Leaching to groundwater Subsurface flow to waterways
Ammonia-N	Fish kills	Surface water runoff
P	Eutrophication	Erosion and surface water runoff
Pathogens	Human health risk	Surface water runoff
Organic solids	Reduced oxygen level in water body-fish kills	Surface water runoff

Nitrogen

For growth and survival, all living things require N, the fundamental building block of protein. Livestock and poultry use only part of the protein in their feed. The remaining protein is excreted as N in manure. Some of this N is quickly transformed into ammonia-N. When manure is applied to land, the soil's aerobic environment converts common manure-N forms to nitrate-N.

Nitrate contamination of drinking water supplies (primarily a groundwater issue) can present a health hazard. Infants and pregnant women are at greatest risk. The U.S. EPA has set a maximum contaminant level of 10 parts per million (ppm) for nitrate-N in public water supplies, and this is used as a ground-water quality standard in many states.

Ammonia-N in surface water also represents an environmental risk. In most natural surface waters, low levels of ammonia-N (around 2 ppm) can cause fish kills.

Nitrogen is a very mobile element that has many different forms. Most N in manure exists in forms that are easily transported by surface runoff or shallow groundwater flow. The filtering ability of soil restricts movement of most forms to groundwater, but if sufficient oxygen is available, some forms can be transformed into nitrate-N and can leach through soils to groundwater. Some forms can also be transported through the atmosphere by volatilization and deposition processes.

Excessive nitrogen loading to surface waters can cause algal blooms. Algae or phytoplankton are microscopic, single-celled plants. Most species of algae are not harmful and are actually food sources for many forms of life. Too much algae, however, causes water quality problems. Occasionally, conditions allow algae to grow very fast or "bloom." As these blooms die and decompose, oxygen in the water is removed. The low oxygen levels inhibit aquatic life, reduce fishery production, and cause fish kills. Nutrient loading, whether from fertilizers, manure, or other waste is a leading contributor to poor water quality in ponds, rivers, lakes, and coastal waters.

Phosphorus

Phosphorus transported from agricultural land to surface waters can also promote eutrophication (abnormally high growth of algae and aquatic weeds and associated low oxygen levels in surface waters). Other common problems associated with eutrophic water bodies include less desirable recreational use, unsuitable drinking water, and increased difficulty and cost of drinking water treatment. Eutrophic surface waters may also experience massive blooms of cyanobacteria (aka blue-green algae), some of which can kill animals and pose health hazards to humans.

Since P binds readily with soil or organic matter, soil erosion is the main way P moves to surface water. Soil water also contains a small amount of dissolved P that is essential for plant uptake. Phosphorus leaching is rarely an issue unless the soils are sandy and have high water tables. However, as P levels in the soil increase, dissolved P in runoff water will also increase. Since dissolved P is readily available to algae, overloading soils with excessive amounts is a water resource concern.

Pathogens

A pathogen is typically considered any virus, bacterium, or protozoa capable of causing infection or disease in animals or humans. Two pathogens shed in animal manure, *Cryptosporidium parvum* (*C. parvum*) and *Giardia lamblia* (*Giardia*), are of greatest concern to humans. *C. parvum*, commonly referred to as "crypto," and *Giardia* are parasites that cause severe diarrhea, nausea, fever, vomiting, and fatigue in humans. The risk of infection from these organisms is much greater for the very young, the elderly, and those with weak immune systems. These pathogens pose a particular risk since they are resistant to the disinfection processes used in most water treatment plants.

Livestock and poultry shed a number of viruses and bacteria in manure. While some of these can infect humans, it is relatively unlikely that they will unless the manure has direct access to a drinking water supply. Most bacteria can be controlled with common water disinfectants such as chlorine. Where untreated water such as that from wells (no chlorine treatment) is located near animal housing or manure storage, some cases of human illnesses and deaths due to bacteria such as *Escherichia coli* (*E. coli*) have been reported.

Most pathogens, including *C. parvum* and *Giardia*, do not multiply outside a host organism so they have a limited lifetime outside a host. The viability of these organisms can range from a few days to many months, depending on a number of environmental factors such as temperature, pH, sunlight, moisture, and the amount of oxygen available. Land application and composting are two processes that commonly speed up the decay of pathogens, because they are subjected to wider ranges of temperature and pH than they normally encounter.

Pathogens are most likely transported to water supplies through surface runoff and erosion or by direct animal access to surface water. Streams and lakes used for drinking water supply and recreational purposes provide the greatest opportunity for these pathogens to be transported to humans. Animal operations located upstream of drinking water supplies or recreational areas should recognize the potential risks associated with pathogens.

Soils provide a filtering mechanism, especially for larger organisms such as protozoa and bacteria. Although it is unlikely that pathogens will reach a groundwater supply, it can happen. Proper wellhead protection and separation distances are important. There is evidence that viruses and bacteria can travel some distance through sandy soils. Research and experience have shown that water can be contaminated from tile drainage shortly after the land application of manure because drainage tiles can short-circuit natural filtration processes that normally occur in the soil.

Organic matter

Organic matter in manure, silage leachate, and milking center wastewater degrades rapidly and consumes considerable oxygen in the process. If this occurs in an aquatic environment, oxygen can be quickly depleted, resulting in fish kills and other aquatic impacts. Manure, silage leachate, and waste milk are extremely high in organic matter that can break down and use oxygen. These products can be 50 to 250 times more concentrated than raw municipal sewage (primarily because animal production does not add the large volume of fresh water used for the dilution and transport of municipal waste).

Organic matter, like pathogens, P, and ammonia, is transported to water by surface water runoff. Rarely does it leach through soils. Organic matter is unlikely to be transported in sufficient quantities to nearby surface waters unless one of the following situations occurs:

- A direct discharge from an animal barn, manure storage, open lot, or other facility is allowed to enter surface water.

- A catastrophic failure such as an earthen storage break, broken pipeline, or continuous application by an irrigation system on the same location.
- Significant rainfall occurs immediately after the surface application of manure.
- Significant application is made on frozen, snow-covered, sloping, or saturated soils in close proximity to surface water.

Point vs. NPS pollution

Historically, "point sources" of pollution have been regulated at the state and federal level. Point source pollution is a single identifiable source of pollution such as a pipe discharging effluent from an industrial operation, a wastewater treatment plant, or a processing plant. A permit is usually required for this type of discharge because it is easy to find and regulate. "Nonpoint source" pollution is more difficult to trace to a single source because it takes place over a broad area, and the release of pollutants can occur over a variety of areas and at different times. Usually, NPS pollution occurs following rainfall when runoff carries pollutants into surface water; however, contaminated groundwater that recharges rivers and streams also can be classified as NPS pollution. Today, greater emphasis is being placed on regulating NPS pollution as state and federal agencies realize that simply regulating point sources will not result in the clean water that we all want.

Pollution pathways

The potential pollutants typically follow one or more of five possible pathways for reaching water. These pathways include:

1. **Runoff**. Runoff from open lots, land application sites, and manure or feed storage units is a common pathway for contaminant transport. Contaminants in manure can travel with surface water runoff and soil erosion. Problems associated with P, pathogens, ammonia, and organic matter are most commonly associated with runoff or erosion.
2. **Leaching**. Dissolved contaminants such as nitrate nitrogen can leach beyond a crop's root zone when the soil moisture exceeds its water-holding capacity and will eventually reach groundwater. Most contaminants in manure and other byproducts (e.g., organic matter, pathogens, and typically P) are filtered by soil and will NOT leach to groundwater. However, it is possible to overwhelm the soil's ability to restrict contaminant movement. For example, soils can allow ammonia movement of up to a few feet per year below manure storages.
3. **Macropore flow**. Most contaminants in manure can travel through soil to shallow groundwater tables or tile drains by macro-pore flow. Macro-pore flow (root holes, wormholes, and cracks due to soil drying) provides pathways for contaminants to bypass the filtering capability of soils. Sinkholes and karst topography (fractured rock) also provide opportunities for contaminants to directly reach groundwater.
4. **Wells**. Poorly constructed or maintained wells can provide a direct pathway for contaminants to reach groundwater. Abandoned wells, wells with poor well-casing designs, or wells located in close proximity to open lots or manure storage can provide a pathway for manure contaminants to move to groundwater.

5. **Ammonia volatilization and deposition**. Ammonia-N can go from a liquid to a gas in a process called volatilization. Ammonia-N volatizes from manure storage, lagoons, and open lots. Once volatilized, most ammonia is re-deposited with rainfall. It can be transported over long distances. While some areas benefit from this deposition, other areas such as large water bodies are experiencing high enough deposition that it threatens the vitality of local ecosystems. In the United States, coastal areas are often adversely affected by ammonia deposition.

Whole Farm Nutrient Management

Nutrients are transported along multiple pathways and in a variety of forms on an animal operation, but an understanding of the overall farm nutrient balance is necessary in identifying the underlying causes of nutrient-related water quality problems as well as the solutions.

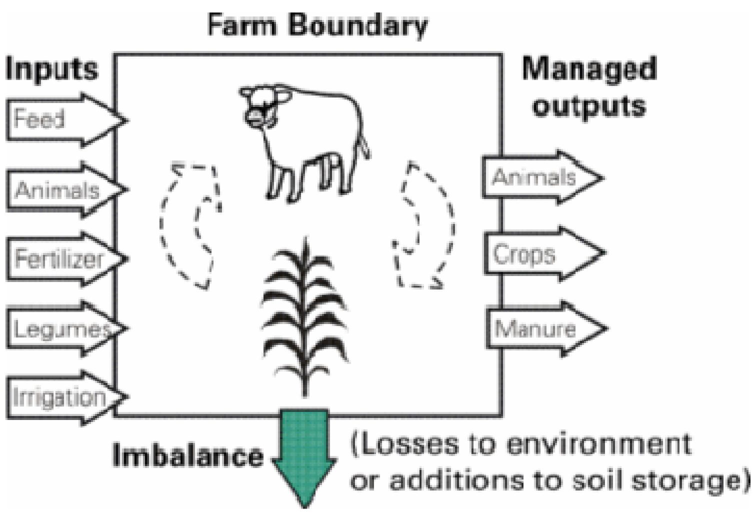


Figure 1. A whole operation nutrient balance considers all nutrient inputs, managed outputs, losses for a livestock or poultry operation.

A picture of the nutrient flow on an operation is presented in **Figure 1**. On an animal operation, nutrients arrive as purchased products (fertilizer, animal feed, and purchased animals), nitrogen fixed by legume crops, and nitrates in rain and irrigation water. Some of these "Inputs" are converted to outputs such as meat, milk, or crops while some escape into the environment. Within the operation's boundaries, there is a "Recycling" of nutrients between the animal and crop components if crops are fertilized with manure and fed to animals.

Nutrients exit an animal operation preferably as "Managed Outputs," including animals and crops sold and possibly other products moved off the operation (e.g., manure sold or given to a neighboring crop producer). Some nutrients exit the operation as losses to the environment (nitrates in groundwater, ammonia volatilized into the atmosphere, and N and P into surface water). Nutrients (especially P) also accumulate in large quantities in the soil. Although not a direct loss to the environment, a growing accumulation of nutrients in the soil adds to the risk of future environmental losses, especially through erosion.

The "Imbalance" is the difference between the Inputs and the Outputs. This Imbalance accounts for both the direct environmental loss and the accumulation of nutrients in the soil. Animal operations with an imbalance pose a greater risk to water quality. In contrast, animal operations that have achieved a balance represent a potentially sustainable production system.

The nutrient balance on an operation can often be expressed as the ratio of nutrient inputs to nutrient outputs. Ideally, your operation should be balanced for both N and P. An imbalance in N does not distinguish between the relatively harmless losses (e.g., denitrification of nitrate to N_2 gas) and the relatively harmful environmental losses (e.g., nitrate loss to water). In contrast, P losses affect water quality through increased soil P levels and greater concentration of P moving with surface runoff water. Ideally, an operation manager would want to manage an operation to maintain a P ratio near 1:1. Input-to-output P ratios on operations across the United States are commonly reported to range from less than 1:1 up to 8:1. Livestock and poultry operations with a large imbalance (1.5:1 and greater) should expect steadily increasing soil P levels that are not environmentally sustainable.

Is My Livestock/Poultry Operation in Balance?

An understanding of nutrient balance and primary source of purchased nutrients is the key to operating an animal operation in an environmentally sustainable manner. A method that most regulatory agencies require is a check of manure nutrient production vs. crop nutrient utilization. This method checks the ability of your land base to utilize the nutrients in manure. An excess of manure nutrients for crop production suggests a whole farm nutrient imbalance. This will be part of your NMP. A Whole Farm Nutrient Balance provides the "bottom line" answer to this issue. It also provides a measurement of progress made toward environmental sustainability following the implementation of changes. The producer must assemble information for animal purchases and sales, feed and grain purchases and sales, fertilizer purchases, manure sales, and possibly other contributors for a one-year period. A spreadsheet to aid the producer in conducting a whole farm nutrient balance is located at http://manure.unl.edu/Koelsch-nbalance.html.

Chapter 2
Farm and Homestead Maps

Thomas M. Bass and Julia W. Gaskin, Biological & Agricultural Engineering Dept., University of Georgia

A farm or homestead map is a valuable tool for managing and protecting the natural resources on or near your farm property. Understanding where creeks, wetlands, ponds and wells are in relation to livestock pens, barns, manure storage or septic systems is a major first step to protecting water quality on-farm and in the community. In addition, crop planning or grazing management can be made easier with a view of the available lands for these activities. In the case of an emergency, it can be valuable to have gas lines, electrical boxes or fuel storage identified on a map. Some cost-share programs require a map before implementing a new practice or building a structure. In the case of nutrient management planning a farm map is essential.

A good map for nutrient and conservation planning will include many of the following items:

- farm property lines
- land use -- cropland, pasture, forest, etc.
- farm field boundaries with field identification
- surface water locations, including streams, rivers, ponds, ditches and wetlands
- arrows showing the direction of stream or river water flow
- well locations
- buffers around sensitive areas including surface water, wetlands, wellheads, springs, rock outcrops or sinkholes
- any residences or public gathering areas
- spreadable acres
- North arrow
- date prepared
- "Prepared with assistance from (Name)"
- road names or numbers
- name of county
- legend with map symbols
- BAR SCALE on the map

Making a Base Map

How do you go about getting this information? There are several ways including: computer based maps produced by professionals like the NRCS, computer based maps downloaded from the internet on a home computer, maps hand drawn over an aerial photograph or road map, or maps drawn completely by hand. An accurate and detailed map is much more useful than one lacking detail or accuracy. Hand drawn maps will only be able to show basic details at an approximate scale.

NRCS Toolkit
The easiest way to acquire the map information needed for a NMP is to use the Natural Resources Conservation Service (NRCS) Toolkit. USDA Service Center Offices are equipped with computers and technology that can generate a map for you. A conservationist can come to your farm, and bring an electronic aerial photo of the farm with the Farm Service Agency (FSA) property lines and field lines. You can work with the conservationist to add streams, as well as other water bodies, and locate buffers. This technology is in place in several district offices and should be available throughout the state in the near future. Figure 1.

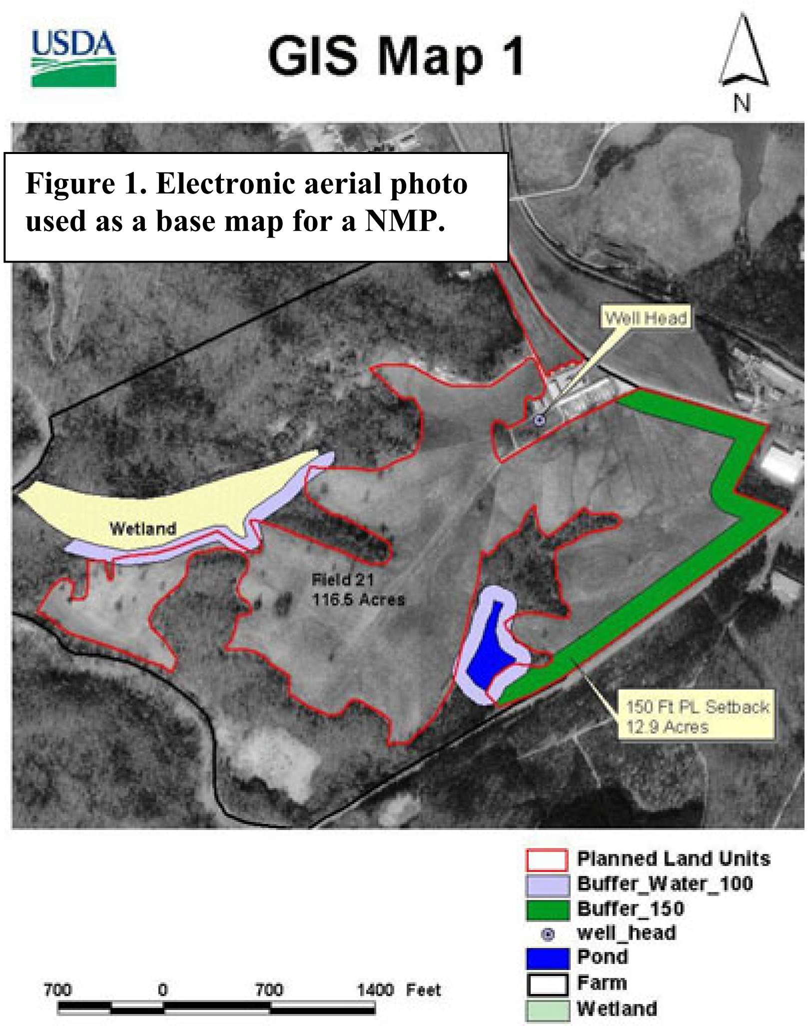


Figure 1. Electronic aerial photo used as a base map for a NMP.

Online Maps
There are several sources for maps online, two options are listed below. These maps can serve as your base from which to build a more detailed depiction of the farm and its surroundings. The aerial photographs available at some of these sites can also be used to make the base map for your NMP. After you have obtained the topographic map or aerial

photograph of your farm, you can hand draw the property boundaries, streams, fields, etc., or use computer software to add the needed features. You will have to determine the scale of the photograph by measuring a known distance on the map. More details on how to add features and determine scales follows in the photocopied maps section.

FREE:

- TerraServer USA: **http://terraserver.microsoft.com**. From the homepage, use the "advanced find" function to search for the property in question by address. If available, both a USGS topographic map and aerial photo will be offered.

FEE BASED:

- Georgia Spatial Data Infrastructure web site: **http://gis.state.ga.us/**.
- Topozone, by Maps a la carte, Inc.: **http://www.topozone.com/**.

Photocopied Maps

Maps can also be constructed from photocopies. Sources of a base map may include a detailed county road map, old FSA maps, USGS topographic maps or county soil survey maps. To complete a map the following items may be useful:

- several copies of the base map for the farm
- a copy of the county soil survey map from NRCS
- colored pencils or fine point markers
- a ruler

Important features and land uses must be added by hand using the pencils or markers.

Suitable Areas

Site suitability for manure application is largely determined by the soils and topography, although other issues may include how close a field is to public roads, public gathering areas or residences. The best sites for manure application are on level to gently sloping, deep, well-drained soils with some clay content. Areas that require extra care include:

- Soils less than 24 inches to bedrock
- Soils with water tables less than 36 inches below the soil surface
- Slopes greater than 12 to 15 percent.

Detailed information on soil maps and characteristics are available from NRCS.

Setbacks and Buffers around Sensitive Areas

Sensitive areas are things such as wellheads, streams, or wetlands that are sensitive to nutrient inputs. Setbacks are areas in which manures and nutrients are not applied. Buffers are setbacks that are managed with certain types of vegetation to help prevent nutrients and sediments from reaching surface waters.

Setbacks around wellheads will reduce the potential for groundwater contamination due to nutrients from manures, fertilizers or pesticides. Table 1 gives the distances required by law that you need to have separating wellheads from various potential contaminants. Table 2 gives recommendations for separation distances from potential contaminants.

Table 1. Minimum distances between wells and potential contaminants based on the Georgia Well Standards Act of 1985.

Distance from Well (feet)	Potential Contamination Source
10	Sewer line
50	Septic tank
100	Septic tank absorption field
150	Cesspool or seepage pit
100	Animal or fowl enclosure

Table 2. Recommended separation distances from various potential contaminants.*

Distance from Well (feet)	Potential Contamination Source
150	Waste lagoon
50	Dead animal burial pits
100	Pesticide storage, mixing & loading facilities
100	Fertilizer storage
500	Petroleum tanks

* Tyson, A. 1996. Improving Drinking Water Well Condition. Georgia Farm*A*Syst, Cooperative Extension Service Bulletin 1152-3.

Setbacks and buffers around streams, rivers, ponds and wetlands reduce the chance these surface waters will become overloaded with nutrients. Most fresh water bodies in Georgia are particularly sensitive to phosphorus. Phosphorus in runoff or in water moving through the soil into the surface water can cause excessive algae growth that creates problems for recreation and other uses. Table 3 gives some general guidelines for buffer widths. Effective buffers are highly site specific and depend on land use, slope, and vegetation. You should review any proposed buffers with NRCS or county extension personnel. Governmental rules and regulations may require specific setback and buffer widths. These take precedence over any recommended widths. A rule of thumb for buffers, that has origins in regulation, is they should be 100 feet wide for bare or sparsely vegetated land or 35 feet wide if well vegetated.

Table 3. Guidelines for surface water buffers. Do no apply animal manures within these buffers.	
Distance from Surface Waterbody *	**Feature**
At least 35 feet	Ponds, sinkholes, wetlands
At least 35 feet if buffer is well vegetated	Streams, rivers
At least 100 feet if buffer is not well vegetated	Streams, rivers
At least 35 feet	Ditches (non vegetated)

*Rules and Regulations for Water Quality Control, GA DNR-EPD, "State CAFO Rule".

Considering "Spreadable" Acreage

Setbacks and buffers needed around these sensitive areas may reduce the land available for application of manures and fertilizer. The land area within a field available for manure application should be marked on the map.   The acreage of the buffers and setbacks must be subtracted from the total acreage of the field. The use of manures in areas close to houses or public gathering places, if there is a potential for odor complaints should be limited or appropriately scheduled. These areas should also be marked on the map, and subtracted from the useable land acres if necessary. If a map is proper scale these acreage calculations can be made using the map. For hand drawn or photocopied maps without a reliable scale, the measurements should be made in the field and penciled in on the map.

Summary

You have now developed the basis for your NMP. These maps are critical for conservation, planning land application of manures, and crop rotations. You should keep them as accurate as possible.

Chapter 3
Manure Storage and Treatment Systems

John W. Worley, Biological & Agricultural Engineering Dept., University of Georgia Cooperative Extension Service

Goals/Objectives of Manure Storage and Treatment Systems

Animal waste storage and treatment systems have historically been selected and designed to efficiently use valuable fertilizer nutrients for crop production while protecting soil, air, and water quality. The primary reason to store manure is to allow the producer to land apply the manure at a time that is compatible with the climatic and cropping characteristics of the land receiving the manure. Manure nutrients can be best utilized when spread near or during the growing season of the crop. Therefore, the type of crop and method of manure application are important considerations in planning manure storage and treatment facilities.

Alternative Storage and Treatment Systems

Most swine and dairy operations and some poultry (laying hen) operations use liquid or slurry manure storage and handling systems. In fact, in Georgia, most of the systems are liquid. The discussion here will therefore focus on liquid systems. However, slurry systems will also be discussed in order to enhance understanding of the difference between the goals and management strategies of the two systems. "Dry" systems (systems where manure is handled as a solid) will also be discussed. Some systems use solids separation devices to remove some of the solids from the liquid stream. These systems are really a combination of liquid and dry systems and must be handled as such.

Liquid Storage Systems (Lagoons)

Lagoons are probably the most common form of liquid manure handling system. A lagoon is a waste treatment system as well as a storage facility for manure, and it represents the most economical means currently available of reducing the waste stream in liquid systems. A properly operating lagoon will reduce odors and convert much of the organic matter into gases which are given off to the air. Odor reduction comes as a result of purple sulfur bacteria which grow near the surface of the lagoon and convert odorous compounds (primarily hydrogen sulfide) into less offensive gases.

Lagoons reduce the amount of manure solids and nitrogen by converting organic nitrogen into nitrogen gas and ammonia. Phosphorus and potassium remain in the lagoon, but tend to settle to the bottom and are stored in the sludge. If properly designed, constructed, and managed, a lagoon will minimize seepage of nutrients into the ground below, and will present little risk of overflow into surface waters.

Advantages of lagoon storage of manure may include treatment of manure to reduce odors, and potential to handle manure with conventional pumping and irrigating equipment. Disadvantages of lagoons include the need for a large earthen structure requiring more area than simple storage and the need for solids separation or sludge removal equipment if bedding or other non-biodegradable materials are present. In addition, the effluent from a lagoon is less well balanced with crop needs, since nitrogen is released, and phosphorus and potassium remain in the lagoon.

Manure Slurry Storage Systems

Manure slurry storage systems tend to be used when the need for nutrients for crop growth in the area is high since these systems tend to maintain higher levels of nutrients (particularly nitrogen) than do lagoons. Manure storage facilities include fabricated (concrete or steel) or earthen structures. Fabricated structures may be above ground, or partially or fully below ground. Manure is usually scraped or flushed from the production buildings and may flow into these tanks by gravity or be pumped into the tank from a collection sump or reception pit. Adequate agitation is necessary to suspend solids and facilitate complete removal of the contents of these manure tanks. Fabricated tanks are usually the least costly to cover, which is sometimes desirable for odor control.

Slurry manure may also be stored in earthen structures or basins. Because storage volume can usually be obtained at less cost in an earthen basin than in a fabricated facility, these facilities are often used when manure and wastewater volumes are relatively large due to wash-water use or lot runoff. Earthen structures require a relatively high degree of planning and preliminary investigation to ensure that proper soil materials are available to create a seal and that the seal is constructed properly. These facilities are basically similar to lagoons, but much smaller since less water is added to the manure. Maintenance requirements may be greater with earthen structures due to the need for maintaining and mowing a vegetative cover on the berm area and keeping it free of weeds, trees, and shrubs. Agitation is equally important in earthen structures, and access points for agitation and pumping should be part of the design plan. Some earthen storage units are partially or completely lined with concrete and built with an access ramp so that loading and hauling equipment can enter the basin. Earthen storage structures are more difficult to cover than tanks if odor control is needed. Odor is generally a greater problem in slurry storage structures than in a properly operating lagoon, but if coverage is necessary, it is less costly in a slurry storage facility because of the smaller size.

Advantages of storing manure in the slurry form may include less volume, adaptability to tank storage, possibility of covering the manure storage facility to reduce odors, higher nutrient retention, and the potential to collect and transport hydraulically. Disadvantages may include higher odor potential (unless storage unit is covered), and odor and runoff potential if the slurry is spread without injection or incorporation.

Dry Systems and Solids Separators

Dry manure storage can be as simple as using the confinement building itself as storage, as is often done in poultry houses where three or more flocks of chickens are raised before cleaning out the building. In cases where crop needs do not coincide with the need to clean out a broiler house, a dry litter swine house, or a dairy lot; manure is often stacked either in a building or outside until it can be utilized by a crop. These stacks should always be covered to protect them against runoff in case of rain **or** the runoff should be contained and treated as a liquid waste.

When swine are raised on litter, they tend to dung in limited areas of the building, so that the litter is very non-homogeneous when removed from the building. Some loads contain almost no nutrients, and some are very concentrated. To achieve a homogeneous product, it is necessary to compost, or at least stack and mix the material from these houses. Some producers have experimented with only removing the wet areas which contain most of the nutrients and reusing the dry litter, but it is not clear if this system is sustainable because of concerns about worms and parasites transferring from one batch of pigs to the next.

Another type of "dry" storage is a settling basin used to separate solids from a liquid stream. Typically, these basins are designed to store 3 to 4 weeks of manure, with two or more basins being utilized in order to allow one basin to drain while the other one is being filled. This design allows more flexibility in timing the application of solids onto crops and pastures. These basins are lined with concrete and the runoff from them flows into a lagoon to prevent contamination of surface waters.

Mechanical solid separators are also used. These devices usually produce a dryer product than a settling basin which is better for composting or hauling to remote sites or off the farm. Their main disadvantage is that, being mechanical systems, they do break down and require periodic maintenance. They also have a cost of operation involved since they require energy to operate. The solids from these systems are typically stored on a covered concrete pad or protected to insure that runoff goes into a lagoon or storage structure.

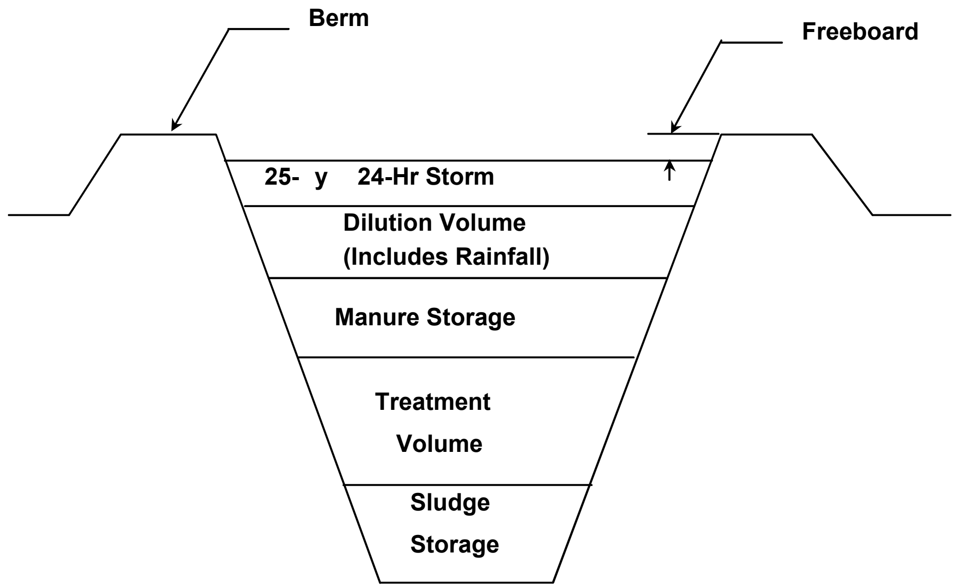
Basic Design Principles

Lagoons

A lagoon must be sized to provide adequate storage for manure, dilution water so that proper microbial digestion will occur, storage of sludge (indigestible materials that settle to the bottom), storage of rain water and wash water, and a safety margin in case of severe storms. (See Figure 1) Adequate sizing of a lagoon depends upon location, the number and size of animals using the lagoon, whether or not solids separation will be used, and how long sludge will be allowed to build up before removing. In addition, good management practices, such as loading the lagoon on a uniform basis, maintaining proper vegetation on berms, regular inspections and maintaining safe levels in the lagoon are necessary to provide safe, efficient operation.

Lagoons must be designed by a properly trained engineer (NRCS or consulting engineer). The berms (walls) must be designed to be stable under load and the lagoon must be properly lined with either a compacted clay or synthetic liner to prevent leakage into ground water. The owner/operator should understand the limitations of the system, and how the expansion of animal numbers will prevent the lagoon from operating properly. He/she should know the capacity of the lagoon, how many animals it is supposed to handle, how often it should be pumped down, and to what level it should be pumped down. Any major expansion or change in the operation of a facility would require a reassessment by the design engineer.

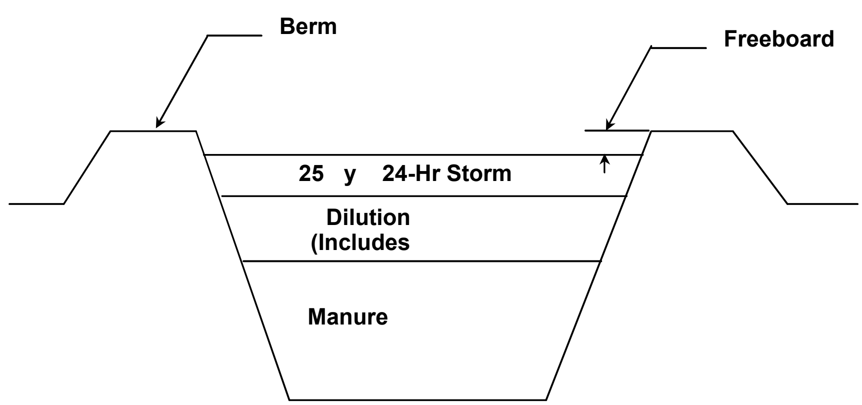
Figure 1. Lagoon diagram from previous page's description.



Manure Slurry Storage

The actual size of a manure slurry storage structure needed depends upon the same factors used in sizing a lagoon with the notable exception that no treatment volume of water must be added since microbial breakdown of manure is not desired (See Figure 2). Manure is left in a more solid state, which hinders bacterial growth. Also, sludge accumulation is not accounted for since this facility should be completely emptied one or more times per year. The design storage period plays a significant role in sizing these structures. Storage period needed depends primarily upon cropping system, climatic conditions, and labor/equipment availability. Most operations utilizing a single, full-season annual row crop or small grain crop will need at least six months manure storage to schedule land spreading around cropping operations. Experience has shown that even a full year's storage is beneficial when wet conditions may make fall application difficult and manure needs to be stored until spring.

Figure 2. A manure storage facility is smaller than a lagoon.



A manure storage facility for a given number of animals is much smaller than a lagoon for the same farm, since no storage space is needed for dilution water. However, adequate size must still be supplied for manure storage, rainwater, and a safety factor for severe storms.

As in the case of lagoons, a manure slurry storage system should be designed by an NRCS or properly trained consulting engineer, whether it is an earthen basin (Figure 2) or a concrete or steel structure. The engineer should also be consulted before any expansion or major change in the operation takes place.

Dry Systems and Solid Separators

If manure is to be stored in a building (commonly called "dry-stack houses" in the poultry industry), the building should be designed to safely handle the loads it will experience, and should be designed to withstand the corrosive atmosphere in which it will exist while manure is stored in it. Assistance on building design is available from the NRCS or the Cooperative Extension Service Plan Service. Concrete floors are recommended, but clay floors are acceptable if mortality composting is not to be done in the facility.

Storage of manure in stacks outside a building should be avoided when possible. Stacks can be covered with plastic which will protect them from leaching while in place, but when the stack is removed and spread on a field, it is almost impossible to remove all of the manure, and the remaining manure can leach into the soil. Experience has shown that the most highly contaminated areas on a poultry farm are around old stacks and at the entrance to the houses where spillage occurs when houses are cleaned out.

Settling basins for separating solids should be designed to be structurally sound and to be large enough to provide flexibility in the timing of manure application from the basin. Again, assistance can be obtained from the NRCS or Cooperative Extension Service Plan Service.

Effects on Nutrient Management

The amount of nutrients available for use on crops is affected by the method used to store manure, as well as the application method. In estimating the total amount of nutrients available for use annually, the total nutrients excreted must be adjusted for storage and application losses. When applying material from an aerobic lagoon for instance, up to 90% of the excreted nitrogen can be lost during the anaerobic treatment of the waste. This nitrogen is lost to the atmosphere primarily in the forms of nitrogen gas and ammonia. There are also losses of phosphorus and potassium, but unlike nitrogen, these nutrients accumulate in the sludge layer of the lagoon, which must eventually be removed and applied to the land unless some arrangements can be made to remove the sludge from the farm. For this reason, 90 to 95% of excreted phosphorus and potassium should be accounted for in the overall farm nutrient management plan. Five to 10% may be lost in moving the waste material (spillage when loading, leaching when stored outside, etc.) Table 1 shows estimated available nitrogen after storage losses as a percentage of total nitrogen produced for various species and storage methods.

Table 1. Estimated available nitrogen after storage losses (% of total nitrogen produced) for different systems.

Management System	Dairy	Poultry	Swine
Anaerobic Lagoon	20-35	20-30	20-30
Manure Slurry Storage	65-80		70-75
Manure Stored in Pit Beneath Slats	70-85	80-90	70-85
Manure and Bedding in Covered Storage	65-80	55-70	
Manure stored in open lot	70-85		55-70

Operation and Monitoring of Lagoons and Slurry Storages

Lagoons combine storage and treatment functions and thus are more sensitive to management inputs than are solid or slurry facilities. The establishment and maintenance of desirable microbiological populations in lagoons requires more specific procedures in the way lagoons are loaded and monitored.

Startup and loading procedures

Lagoon startup is an important factor in developing a mature lagoon that has an acceptable odor level and will perform in the expected manner over the long term. Lagoons are designed with a "treatment volume" that provides an environment for development and maintenance of a bacterial population that degrades and stabilizes manure. The size of the treatment volume is based on a volatile solids (VS) loading rate, which depends primarily upon temperature. (Volatile solids are those that can be converted to gases by bacteria.)

The proper VS loading rate is achieved only if the lagoon contains a volume of water equal to the treatment volume at startup It is very important to have sufficient water in a lagoon at startup. The treatment volume should be used as a target. Achieving this goal may require identifying a water source (pond, lake) and implementing the needed pumping procedures to transfer the desired volume of water to the lagoon. Since bacteria are more active at warmer temperatures, consideration should be given to starting a lagoon in the spring or early summer. In this way, bacteria will have a warm season to establish themselves before activity slows during the winter. Spring startup of lagoons often requires special planning of construction schedules and animal procurement.

In addition to startup, long-term loading procedures are critical to lagoon performance. A somewhat common and unfortunate practice in the livestock industry is to expand animal numbers without expanding lagoon size. This results in a proportionate increase in VS loading, and the associated problems can be expected to develop. Volatile solids loading should not be increased beyond the design loading. Alternatives to reduce VS loading (or expand animal numbers) include solids separation, construction of additional lagoon volume, or pretreatment of manure. Lagoons should also receive manure in a consistent manner (no "slug" loading). This is usually accomplished in modern production systems utilizing hydraulic transport of the manure to the lagoon. Sludge must be periodically removed from the lagoon, as a buildup of sludge also reduces treatment volume, reducing the effectiveness of bacterial treatment. Sludge should be maintained at or below the design level.

Overall Monitoring Activities

Certain activities are advisable and necessary in maintaining a manure storage structure and ensuring that it is performing as expected. Some of these activities may be required by regulation, but all are evidence of good management and stewardship regardless of regulatory requirements.

Monitoring During Pumping Activities

Experience has shown that unplanned discharges and spills most often occur with pumping activities. Sources of such unplanned discharges include burst or ruptured piping, leaking joints, operation of loading pumps past the full point of hauling equipment, and other factors. Hence, pumping activities should be closely monitored, especially in the "start-up" phase, to ensure that no spills or discharges occur. Continuous pumping systems such as drag-hose or irrigation systems can be equipped with automatic shut-off devices (which usually sense pressure) to minimize risk of discharge in the event of pipe failure.

Liners

Liners in earthen manure storage impoundments are designed and constructed to provide an adequate barrier between the potential contaminants in the impoundment and groundwater. Hence, liner integrity is extremely important in maintaining an environmentally sound manure storage facility. To the extent possible, liners should be regularly inspected for signs of damage, erosion, or other compromising factors. Wave action can cause liner erosion at the level of the liquid in the impoundment. If this condition is severe, consideration might be given to the use of riprap or similar mitigation methods to preserve liner integrity. The area around the pipes that discharge into the impoundment is also subject to erosion, especially if the pipes discharge directly onto the liner surface. A better configuration is to install inlet pipes such that they discharge into at least 4 feet of liquid, which may require a supporting structure for the end of the pipe. Concrete or rock chutes should be used with inlet pipes that discharge onto the liner surface. Agitation is also an activity that can damage liners. Care should be taken to operate agitators a sufficient distance above the liner so that liquid velocities are reduced enough to ensure that erosion does not occur. Heavy or unusual rainfall events can also erode liners, and special attention should be given to liner inspection after such storm events.

Logbooks and record keeping

Certain data and record keeping involving manure storage structures can aid in overall maintenance and management, and is also evidence of responsible operation and good record keeping. In addition to the periodic inspections, manure levels in a storage structure should be monitored and recorded. This data can illustrate the effects of excessive rainfall and lot runoff, and help in planning pump-down or other land application activities. Manure levels should be observed and recorded frequently enough to provide a “feel’ for the rate of accumulation, and pumping activities should be scheduled accordingly.

When a lagoon is pumped or other manure storage structure is emptied, the date of the activity should be recorded along with the volume or amount of manure removed, locations where the manure is spread, and the nutrient content (lab analysis) of the manure. Calibration of pumping equipment is necessary to accurately estimate amounts pumped. This information may be required by the regulatory agency for interim or year-end reports, or may be useful in the event of litigation. Example record keeping forms follow at the end of this chapter.

Pump-down or Manure-Level Markers

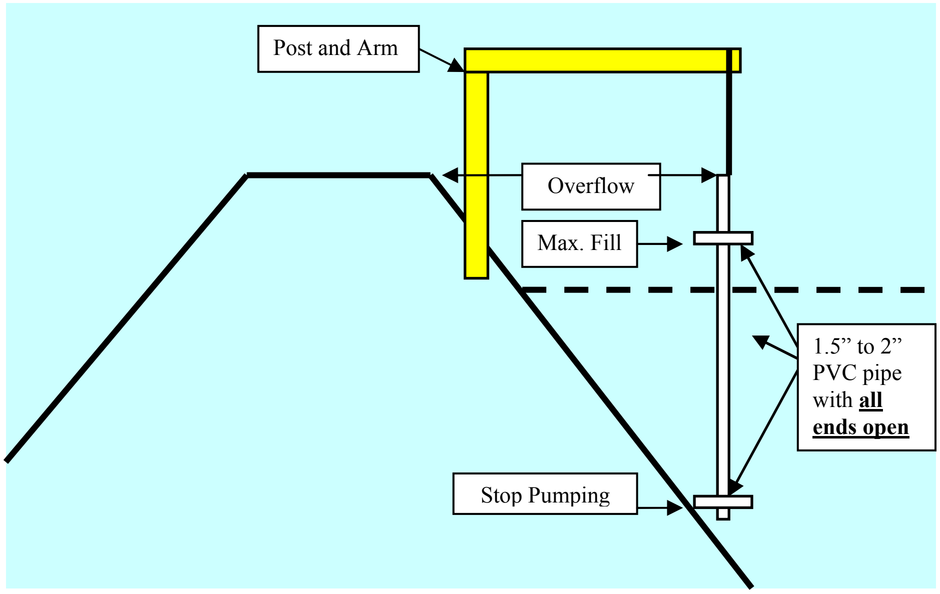
Pump-down or manure-level markers, or indicators, are a simple but important component of a manure storage facility. Such a marker enables the operator to ascertain quickly and easily the degree of fill of the manure storage facility, the point at which pumping or emptying should begin, and the point at which it should end. The presence of a durable, easily read marker gives inspection or regulatory personnel confidence that a manure storage facility is being managed properly.

Experience has shown that pump-down markers must be made of durable materials and properly installed to afford the long life needed. The operator or inspector should be able to ascertain the following information when observing a pump-down marker:

- The level at which pumping operations should begin and end
- The level at which overflow will occur
- The fraction of total storage that is currently filled

A common practice is to install steel fence posts at the upper and lower pump-down levels for earthen impoundments. While this approach provides basic information on beginning and ending pump-down, experience has shown that more knowledge is needed. Also, fence posts installed in this manner are subject to damage and displacement. A good pump-down marker will indicate the level, or elevation, of manure throughout the possible range (from lower pump-down level to overflow, or spillway) in the storage facility. A pump-down marker can be made from PVC pipe with all ends left open to allow water to flow into the pipe. One example of how this can be done is shown in Figure 3 (next page).

Figure 3. One type of pump-down marker in earthen impoundment



Weather stations

A simple weather station that indicates or records rainfall can be a useful tool in maintaining and managing a manure storage structure. Rainfall has a significant impact on open storage structures and structures serving open lots, so knowledge of rainfall amounts can be very useful. Some permits are written that provide for a “legal” discharge under certain climatic events. A weather station can aid in the documentation of such events without resorting to “off-site” data from stations that may not be descriptive of conditions at the storage facility. Recorded rainfall data is also evidence of good stewardship.

Aesthetics and appearance

Aesthetics and appearance may not be critical factors in protecting the environment or complying with environmental regulations, however, these characteristics are major factors in the perceptions formed by the general public, who may not be intimately associated or familiar with the livestock industry. Therefore, aesthetics and appearance should be given major priority for the overall benefit and viability of animal agriculture.

The general cleanliness and sanitation characteristics of a livestock enterprise are often perceived as a measure of the concern for environmental stewardship. A clean, well-landscaped production area will project a positive image for the operation. Typical items of concern for livestock production enterprises include leftover construction debris or refuse; old, unused vehicles; worn-out equipment; rusted equipment from the buildings (farrowing crates, pen dividers, feeders); torn and worn-out ventilation curtains; and loose roofing panels, etc. All livestock production operations experience animal death loss. A specific plan for managing animal mortalities should be developed and implemented. The perceptions generated by the presence of dead animals in or around the production facility are highly offensive. Additionally, poorly managed mortalities represent a very real health and disease risk to the enterprise.

Few activities undertaken by the producer are as effective as frequent mowing in conveying a positive image of livestock production. Producers who maintain “front yard quality” around the production and manure storage facilities provide a powerful first impression of pride and responsibility. Also, routine inspections for seepage, rodent burrowing, erosion, or other damage are much more effective if the areas have been mowed at regular intervals.

Control of Surface Water

As confined production units become larger, control of surface water in the production area is a primary concern. Wider, longer buildings, placed relatively close together, create high rates of discharge from roof and paved areas. Special considerations and landscaping are needed to manage this water in a manner that does not create erosion, unwanted ditches and washed-out culverts or waterways. A surface water management plan should be developed based on a design storm event, expected runoff rates, soil types and erosive velocities, and properly designed and vegetated channels for carrying surface water away from the production area. Some states may require that surface water from production areas be contained and/or checked for contaminant levels before discharge to a watercourse.

Closure of Waste Impoundments

If a lagoon or waste storage facility ceases to be used, it will need to be cleaned out at some point so that it no longer represents an environmental threat. The Natural Resources Conservation Service (NRCS) has written a Conservation Practice Standard that covers this subject. It is Code 360, Closure of Waste Impoundments. A summary of the document follows:

There are three options for managing the earthen impoundment after closure:

- ***Complete closure and fill.***
- ***Breaching the lagoon berm.***
- ***Conversion to a farm pond or irrigation storage structure.***

In either case, the first steps are the same:

1. Remove all pipes or other structures that convey waste into the structure. Pipes should be dug up and ditches refilled
2. Remove as much of the stored waste and sludge as practical. This can be done by agitating the lagoon and pumping as much material out as possible, refilling with water and repeating until most material has been removed. Alternatively, the effluent (relatively dilute liquid on top) can be pumped out, and the sludge can be removed using a slurry pump or excavation equipment.

3. All material must be land applied at agronomic rates (such that crops can utilize the nutrients).

If the lagoon is to be completely closed, it should then be filled in and the land returned to its approximate original contours. Soil should be mounded slightly in the lagoon area (5% slope) in order to allow for settling and to encourage surface water to run away from the site. Vegetation should be established on the site to prevent erosion.

If the lagoon berm is to be breached, all surface water runoff should first be diverted away from the lagoon. The breach should have sufficient side slope to prevent erosion. (Maximum 3:1 slope.) The NRCS can help with this design. It should be low enough to allow all water to flow from the structure and prevent ponding. Vegetation should be established on the entire site including the sides of the breach to prevent erosion.

If the lagoon is to be used as a farm pond, a watering source for livestock, or an irrigation storage pond, the structure should meet the requirements for these types of structures. A properly designed lagoon will probably meet those requirements without major alterations, but the NRCS should be able to provide technical assistance to assure this requirement is met. Water quality samples should be taken and submitted to assure safety before allowing livestock to drink from a converted lagoon. Dissolved oxygen (DO) levels should be higher than 3 milligrams per liter and nitrate nitrogen should be below 30 milligrams per liter.

Summary

Lagoons, manure slurry storage structures, and dry systems each have advantages and disadvantages. Lagoons reduce the nitrogen and organic matter in the waste stream by volatilizing them (converting them to gases and moving them into the air.) They also reduce the odor released compared to a slurry storage, but they are more expensive because of their larger size and must be carefully managed to maintain a healthy bacterial population. Slurry storage structures are smaller (do not include treatment volume or sludge storage), conserve more nutrients in the waste, and are easier to cover, but they tend to produce more odor if not covered. Dry systems keep manure in a concentrated form making it more transportable and less likely to flow into surface waters, but it must be handled as a solid which usually requires more labor than liquid systems which can use automated pumps. Solids separation devices remove much of the solids going into a liquid system and thus reduce the required volume for treating the waste, but they do require a financial investment and require two types of manure handling equipment (liquid and dry). Whichever type of system is used, it is important to understand that it cannot perform as designed unless it is managed properly. For a lagoon, that includes starting it about 1/3 full of water before waste is added, preferably in the spring, loading it evenly, and maintaining the level between the minimum and maximum levels. For a slurry storage, it includes cleaning it out on a regular schedule, according to crop needs, and minimizing the amount of water entering the storage. Solids separating systems must have the solid fraction removed regularly (within the flexibility provided in the design) in order to keep them operating properly, and mechanical systems must be regularly maintained to avoid break downs.

Regular inspections and records of inspections are vital to maintaining any manure storage and handling facility and to being able to prove that you are doing a good job managing your facility. Inspections should include investigations of existing or potential leaks, aesthetic appearance of facilities, and variations in odor levels. Regular monitoring and recording of lagoon levels requires the use of an easily read marker that shows **at a minimum** the overflow level, maximum storage level, and minimum pump-down level. Lagoon levels and weather forecasts should be studied so that pumping can be scheduled before it has to be done on an emergency basis. Berms should be checked for leaks, rodent burrows, erosion, and tree growth. Aesthetics include regular mowing and establishing vegetative screens where needed to present a pleasing picture to neighbors and those passing the farm.

If a lagoon is no longer used to store animal waste, it should be properly closed, including removal of all waste material. The structure can be filled in and reclaimed, the berm may be breached, or the structure can be converted for use as a farm pond. In any case all conveyances should be removed and exposed ground should be planted in a cover crop to prevent erosion. Until these steps occur, the lagoon should be managed just as it was before closure.

Monthly Manure Storage Facility Checklist

Farm:_______________________________ Facility ID:_______________________________

Inspected by:____ Date:___________________

Manure Level

Manure level today: (Distance below maximum fill level)____________ft.

Last observation: ________________ft. Date:________

Earthen Storage Facilities

Item	Low Risk	Potential Problem	Corrective Measures Taken/Planned
Are embankments well-sodded with no bare areas?	Yes	No	
Are embankments free of trees or woody shrubs?	Yes	No	
Does the berm or embankment have a consistent elevation (i.e., no low or settled areas other than the planned spillway)?	Yes	No	
Is the spillway free of erosion?	Yes	No	
Are all berms and embankments free of erosion?	Yes	No	
Is the base of the embankment free of soggy, damp areas and other evidence of seepage or leaks?	Yes	No	
Are the embankments free of burrowing or other rodent damage?	Yes	No	
Is the liner free of damage due to rainfall, wind, or wave action?	Yes	No	
Is the liner free of erosion damage around inlet/outlet pipes and agitation points?	Yes	No	
Does the lagoon contain at least the minimum volume for treatment?	Yes	No	

Concrete/Steel Tanks

Item	Low Risk	Potential Problem	Corrective Measures Taken/Planned
Are tanks free of visible cracks or structural damage in walls or foundation?	Yes	No	
Is the area around the tank free of seepage or other evidence of leakage?	Yes	No	
Is the manure loadout area free of spills or accumulations of manure?	Yes	No	
Does surface water properly drain away from the manure tank?	Yes	No	

Diversions

Item	Low Risk	Potential Problem	Corrective Measures Taken/Planned
Is roof water and field runoff diverted?	Yes	No	
Are diversion ditches adequately sized to handle runoff without overtopping?	Yes	No	
Are diversion channels vegetated and free of erosion?	Yes	No	
Is storage available in secondary containment structures if required?	Yes	No	
Is there adequate drainage of surface water around production buildings and manure storage facilities?	Yes	No	

Components

Item	Low Risk	Potential Problem	Corrective Measures Taken/Planned
Are level markers properly installed and easy to read?	Yes	No	
Are manure inlet pipes submerged and properly supported?	Yes	No	
Are drains, sewer lines, and cleanouts in good condition and operating properly?	Yes	No	
Are perimeter drains or tiles open and functioning?	Yes	No	
Are recycle pumps, valves, controls, and pressure lines operating properly?	Yes	No	

Appearance

Item	Low Risk	Potential Problem	Corrective Measures Taken/Planned
Is the manure storage site neat and recently mowed?	Yes	No	
Is the manure storage site free of refuse, debris, unused materials, and junk?	Yes	No	
Is the manure storage site screened by visual barriers, and are these barriers maintained?	Yes	No	
Is the manure storage site free of carcasses, afterbirth, or medical wastes?	Yes	No	
Is the manure storage site properly fenced and marked?	Yes	No	
Is the lagoon purple and actively bubbling?	Yes	No	
Is the manure storage surface free of excessive floating materials or vegetation growth?	Yes	No	

Chapter 4
Nutrient Budgeting with Nitrogen and Phosphorus

Leticia Sonon, Paul F. Vendrell, and Parshall Bush, Agricultural and Environmental Services Lab and Glen Harris, Department of Crop and Soil Sciences, University of Georgia

Introduction

Animal manure has long been recognized as a source of nutrients for crops. The effluent and solid waste generated from livestock operations can be used in agricultural fields to supply nutrients to crops and improve soil chemical and physical properties. Knowing the mineral contents of the manure enables the farmer to decide on the amount of manure to apply or to move off-site. By actively managing the nutrient balance on-farm and marketing or exporting manure when necessary, farms with confined animal operations can prevent future buildup of soil nutrients that may potentially move into streams and lakes.

Inventory of Nutrient Sources

The first step in managing nutrients generated on-site is to conduct an inventory of all nutrient sources. This requires sampling and analysis of the manure sources as well as the soils to which the manure will be applied. Manure analysis is also very important in marketing manures because it provides needed information on the manure's fertilizer value.

Manures can be quite variable in nutrient content due to differences in animal species, feed composition, bedding material, storage and handling as well as other factors. Moreover, manures should be sampled and tested near the time of application because the nutrient content can change considerably over time, particularly if stockpiled and unprotected from the weather. Therefore, growers should not base application rates on laboratory test results from previous years because nutrient concentrations can change significantly, particularly when the manure has been exposed to the environment.

Manure Sampling

The following are some manure-type specific guidelines for collecting representative samples:

<u>Solid Manure.</u> It is **not recommended** that manure be sampled in the barn or poultry house because it is very difficult to obtain a representative sample. Instead, sample manure or poultry litter after it has been removed from the poultry house or barn and placed in a pile or spreader truck during cleanout. Solid manure samples should represent the average moisture content of the manure.

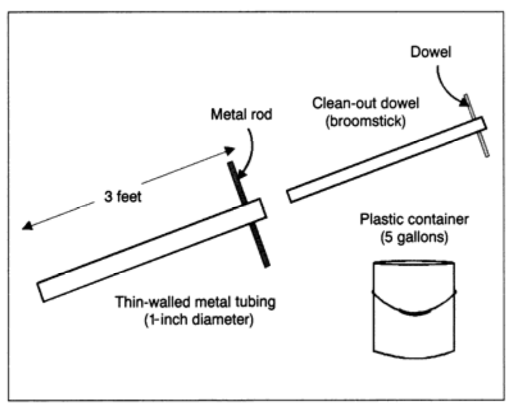


Figure 1. Solid manure sampling device.

<u>Piled manure, litter, or from a spreader truck.</u> This procedure is for manure or litter temporarily collected into piles during clean out. To obtain a representative sample, collect at

least 10 small shovels of manure or litter from the piles or from the spreaders, and combine the collected portions in a clean 5-gallon plastic bucket or wheelbarrow, and mix thoroughly. Place a one-quart portion from this mixture in a zippered plastic bag, seal it securely, and ship it to the laboratory as soon as possible. For wet manure, refrigerate the sample if it will not be shipped within one day of sampling. Samples stored for more than two days should be refrigerated. Fig. 1 shows a device for sampling solid manure.

Stockpiled manure or litter. A stockpile consists of manure or litter stored in a pile for later use. Store stockpiled manure or litter under cover on an impervious surface. The weathered exterior of uncovered waste may not accurately represent the majority of the material, since rainfall generally moves water-soluble nutrients down into the pile. Collect samples from stockpiles using the same method for piles described above except collect at a depth of 18 inches from the surface of the pile, and as close as possible to its application date.

Liquid slurry. Manure slurries that are applied from a pit or storage pond should be mixed prior to sampling. Manure should be collected from approximately eight areas around the pit or pond and mixed thoroughly in a clean, plastic container. An 8- to 10-foot section of 0.5- to 0.75-inch plastic pipe can also be used: extend the pipe into the pit with ball plug open, pull up the ball plug (or press your thumb over the end to form an air lock), and remove the pipe from the manure, releasing the air lock to deposit the manure into the plastic container.

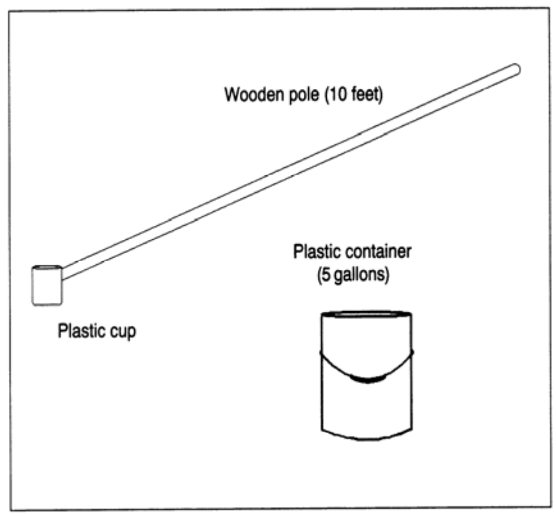


Figure 2. Liquid manure sampling device.

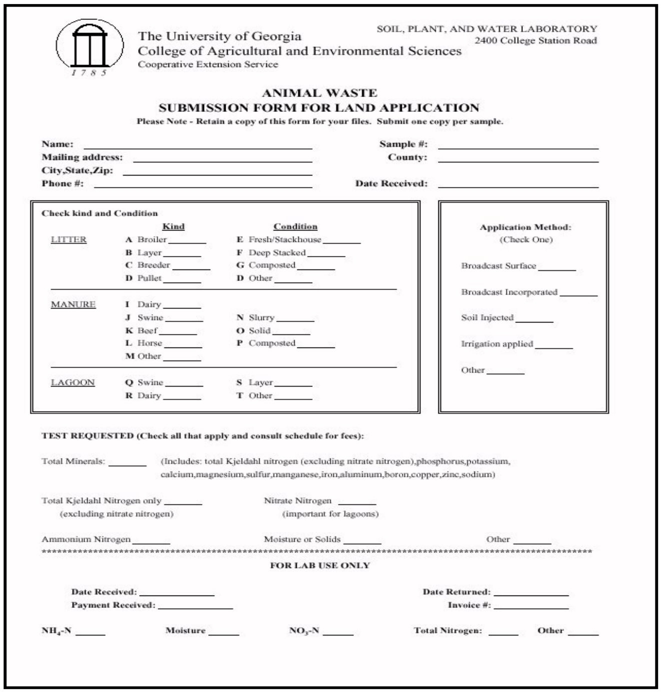
Lagoon Effluent**.** Collect one-pint effluent from 1-ft. depth at least 6 feet from the edge of the lagoon. This needs to be done from at least eight sites around the lagoon. Mix the materials in a clean, large plastic container and obtain a one-pint sub-sample for analysis. Galvanized containers should never be used for collection, mixing, or storage due to the risk of contamination from metals like zinc in the container.

Manure Analysis

The basic manure test package at the UGA Agricultural and Environmental Services Laboratories includes nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sodium (Na), sulfur (S), aluminum (Al), iron (Fe), boron (B), copper (Cu), manganese (Mn), and zinc (Zn). Other private labs may provide additional analysis.

The UGA manure sample submission form is shown in Fig. 3. This form applies to manures that are intended for land application. Poultry producers should use the form illustrated in Fig. 4, Poultry Litter/Manure Submission Form for Nutrient Management Plans.

The County Extension Office has sample submission forms and information on tests that are most often needed and can assist with shipping samples to the University of Georgia Agricultural and Environmental Services Laboratories. The amount of the total nutrients in manure that will be available to plants varies depending on the type of manure and whether it will be applied to the surface of the soil, incorporated or injected. County Extension Agents and other qualified professionals can assist with the calculation of manure nutrient availability based on when and how you will make application.



The University of Georgia
College of Agricultural and Environmental Sciences
Cooperative Extension Service

SOIL, PLANT, AND WATER LABORATORY
2400 College Station Road

ANIMAL WASTE
SUBMISSION FORM FOR LAND APPLICATION
Please Note - Retain a copy of this form for your files. Submit one copy per sample.

Name: ____________ **Sample #:** ____________
Mailing address: ____________ **County:** ____________
City,State,Zip: ____________
Phone #: ____________ **Date Received:** ____________

Check kind and Condition

	Kind	Condition
LITTER	A Broiler ____	E Fresh/Stackhouse ____
	B Layer ____	F Deep Stacked ____
	C Breeder ____	G Composted ____
	D Pullet ____	D Other ____
MANURE	I Dairy ____	
	J Swine ____	N Slurry ____
	K Beef ____	O Solid ____
	L Horse ____	P Composted ____
	M Other ____	
LAGOON	Q Swine ____	S Layer ____
	R Dairy ____	T Other ____

Application Method:
(Check One)
Broadcast Surface ____
Broadcast Incorporated ____
Soil Injected ____
Irrigation applied ____
Other ____

TEST REQUESTED (Check all that apply and consult schedule for fees):

Total Minerals: ____ (Includes: total Kjeldahl nitrogen (excluding nitrate nitrogen),phosphorus,potassium, calcium,magnesium,sulfur,manganese,iron,aluminum,boron,copper,zinc,sodium)

Total Kjeldahl Nitrogen only ____ (excluding nitrate nitrogen) Nitrate Nitrogen ____ (important for lagoons)

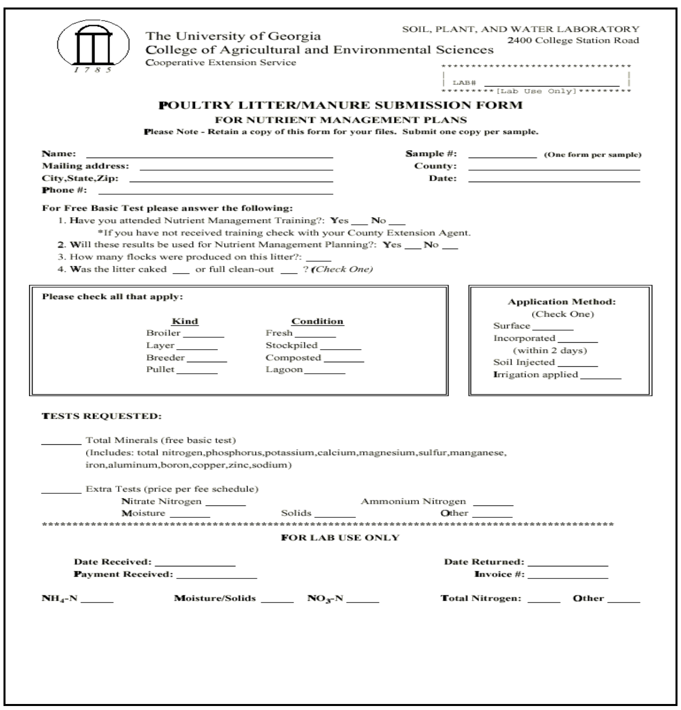
Ammonium Nitrogen ____ Moisture or Solids ____ Other ____

FOR LAB USE ONLY

Date Received: ____ **Date Returned:** ____
Payment Received: ____ **Invoice #:** ____

NH_4-N ____ **Moisture** ____ **NO_3-N** ____ **Total Nitrogen:** ____ **Other** ____

Figure 3. Sample submission form for manure intended for land application.



The University of Georgia
College of Agricultural and Environmental Sciences
Cooperative Extension Service

SOIL, PLANT, AND WATER LABORATORY
2400 College Station Road

LAB# ____ [Lab Use Only]

POULTRY LITTER/MANURE SUBMISSION FORM
FOR NUTRIENT MANAGEMENT PLANS
Please Note - Retain a copy of this form for your files. Submit one copy per sample.

Name: ____________ **Sample #:** ____ **(One form per sample)**
Mailing address: ____________ **County:** ____________
City,State,Zip: ____________ **Date:** ____________
Phone #: ____________

For Free Basic Test please answer the following:
1. Have you attended Nutrient Management Training?: Yes ___ No ___
   *If you have not received training check with your County Extension Agent.
2. Will these results be used for Nutrient Management Planning?: Yes ___ No ___
3. How many flocks were produced on this litter?: ____
4. Was the litter caked ___ or full clean-out ___ ? *(Check One)*

Please check all that apply:

Kind	Condition
Broiler ____	Fresh ____
Layer ____	Stockpiled ____
Breeder ____	Composted ____
Pullet ____	Lagoon ____

Application Method:
(Check One)
Surface ____
Incorporated ____
(within 2 days)
Soil Injected ____
Irrigation applied ____

TESTS REQUESTED:

____ Total Minerals (free basic test)
(Includes: total nitrogen,phosphorus,potassium,calcium,magnesium,sulfur,manganese, iron,aluminum,boron,copper,zinc,sodium)

____ Extra Tests (price per fee schedule)
Nitrate Nitrogen ____ Ammonium Nitrogen ____
Moisture ____ Solids ____ Other ____

FOR LAB USE ONLY

Date Received: ____ **Date Returned:** ____
Payment Received: ____ **Invoice #:** ____

NH_4-N ____ **Moisture/Solids** ____ **NO_3-N** ____ **Total Nitrogen:** ____ **Other** ____

Figure 4. UGA sample submission form for poultry litter/manure for NMPs.

Soil Testing

Soil testing tells you the fertility status of the soil and how much, if any, additional nutrients are needed for the particular crop. It is through soil testing that one can detect nutrient deficiencies or over applications of nutrients, especially phosphorus (P). Soil testing can track the build-up of P and assist with management decisions to utilize high phosphorus animal waste on soils with lower soil test P. Soil testing can also monitor any build-up of zinc, which could possibly increase to toxic levels (for sensitive crops like peanuts) from long-term and heavy applications of poultry litter.

Soil Sampling and Analysis

When: Soils should be tested annually. Fall is a good time to take samples, but samples can be taken at any time of the year. To make good comparisons from year to year it is important to sample at approximately the same time each year.

Where: Areas within a field that have obviously different soil type, drainage, crop growth, or slope characteristics should be sampled separately. Collect in zigzag pattern within a sub-area (Fig. 5). Avoid areas where fertilizer or lime was stockpiled as well as areas around old house or barn locations.

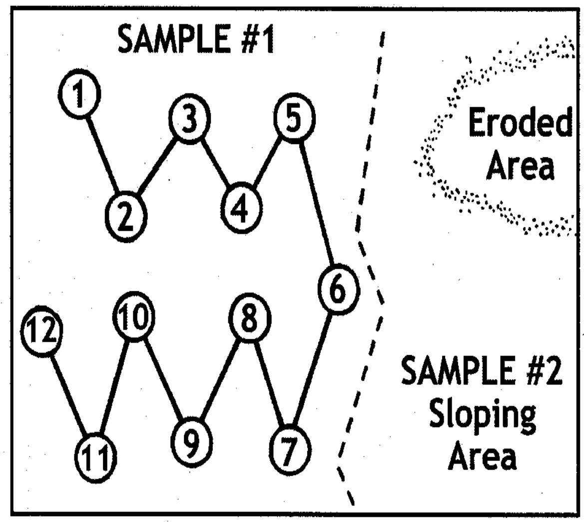


Figure 5. Zigzag pattern of soil sampling .

How: From plowed fields take the sample to 6 inches or to plow depth. No-till fields or pastures should be sampled to 4-inches depth (Fig. 6). From each area to be sampled take 10 to 20 cores at random, place in clean, plastic container and thoroughly mix. Remove about a pint of the composite soil for submission to the laboratory. Be sure to clearly mark each sample so that you know which field and area of field it represents.

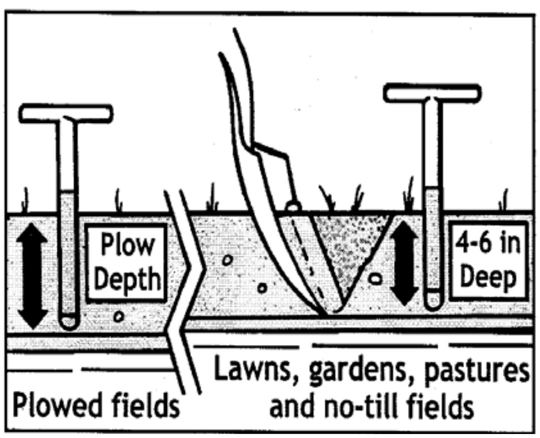


Figure 6. Soil sampling depths for plowed fields (6 inches or plow depth) and no-till or pastures (4 inches).

Nutrient Budgeting

Understanding the sources of nutrients is critical in identifying management strategy for reducing nutrient losses and achieving an environmentally sustainable operation. It is necessary to account for nutrients coming from all sources such as livestock manure or credits from legumes, or from off the farm, such as purchased fertilizer or irrigation water.

Developing nutrient budgets as a management tool for farmers has the potential to effectively reduce excess levels of nutrients on the farm and decrease nutrient inputs. This allows the farmer to compare all the sources of nutrients and nutrient needs of the crops. Nutrient budgeting can serve a number of different purposes. The most common purpose will be to determine the proper nutrient application rates for a given field using real numbers for crop needs and nutrients in manure. Nutrient budgeting can also be used as a planning tool at the farm level to determine if adequate land is available for using all of the farm's manure in the cropping system planned. Finally, nutrient budgeting can be used as an educational tool to calculate application rates based on various "simulated" scenarios, for example, how much manure one can apply given a particular soil test phosphorous level.

There are three steps required in developing a nutrient budget:

1) Determine crop nutrient requirements. This is accomplished by knowing the nutrient requirement of the crop and accounting for the residual nutrients in the field that will receive the manure. The field's fertility is determined through soil testing. The fertilizer recommendation given in the soil test report is based on a calibration of the soil test results and the nutrient requirement of the crop to be grown. These calibrations have been developed previously from field research in Georgia's soils and climate.

2) Determine nutrients supplied by manure. The animal manure is analyzed to determine the nutrient content of the manure. As with soil sampling, taking a representative sample is important to get an accurate estimate of the nutrient content of the manure (please refer to the guidelines above in collecting samples). Using "book values" to estimate nutrient content of manure should be avoided whenever possible because of high variability between manures as discussed earlier in this chapter. Manure samples may be submitted to a reputable laboratory for analysis.

3) Balancing crop nutrient needs with nutrients supplied by manure. The third and final step in calculating a nutrient budget for animal manures is to simply match the nutrient needs of the crop to be grown in step 1 (based on a soil test) with the nutrient content of the manure determined in step 2. For example, if 60 pounds of nitrogen per acre is recommended for a crop, and the manure analysis indicates it contains 30 lb available nitrogen per ton, then two tons of manure per acre would be recommended.

Nitrogen-based vs. Phosphorus -based manure application

Nitrogen (N) and phosphorus (P) are the major plant nutrients found in manures that can contaminate the environment if too much is applied. Therefore, application rates for manure, litter, or lagoon effluent must not exceed the field's capacity to minimize nitrogen and phosphorus transport from the field to surface waters. It should also be noted that manures have a poor N:P ratio relative to plant needs; this is further explained below.

When applying manures to cropland, there are two strategies that can be followed:

1) N-based approach where manure is applied at rates that meet the crop's need for nitrogen
2) P-based approach where manure is applied to satisfy the crop's need for phosphorus

The N-based approach is the most common strategy for utilizing manure to meet the N requirement of crops. Manure application rates are calculated to provide N to crops because most crops require more N than P. In many cases, N-based nutrient management plans are employed to supply just the right amount of N for optimum crop production, while avoiding excessive N applications that may cause nitrate leaching into groundwater. This strategy, however, usually results in the addition of P in excess of the nutrient needs of the crops. This leads to increases in available P in the soil

The P-strategy, on the other hand, results in less P application, just enough to meet the needs of the crops. Additional N is needed to meet the needs of the crop, which is usually provided using commercial fertilizers. Legumes are an exception because they can manufacture their own nitrogen through N-fixation from the atmosphere. Thus, recent environmental concerns have focused more on excessive phosphorus applications from manures and its adverse effect on surface water quality. Because of concern for P in runoff to sensitive water resources, many nutrient management plans now are based on P. The P-based plan, however, is not currently required but it will be considered in the future. Overall, P-based application for manures should be used where there is high risk for water contamination by excess P through runoff.

A tool to identify fields, which have the potential for P pollution is the P index. The P index will help farmers identify areas and adjust manure application rates and other management practices to minimize P losses from agricultural areas and alleviate P pollution of water bodies.

Off-site use of manures

Aside from using the manures for crop production on-farm, farmers can sell their manures to other farmers to generate additional income. This would be a necessary option in situations where the supply of manures exceeds the needs of the crops on that farm. Sale of manure to other farmers is more likely when manure application is based on a P-strategy where a larger area is required to spread a given volume of manure compared to when the application is N-based. Moving the manure to a site where it is needed will minimize the risk of water pollution. Nutrient testing of manure for export and sale is required by state law. This analysis should be provided to the person taking the litter just like you would expect to get a fertilizer tag or analysis if purchasing chemical fertilizer. By actively managing the nutrient balance on-farm and marketing or exporting manure when necessary, confined animal operations can achieve a relative level of nutrient sustainability that should prevent future buildup of soil nutrients like phosphorus.

Chapter 5
Land Application Procedures and Equipment

L. Mark Risse and T. M. Bass, University of Georgia, and Ron Sheffield, University of Idaho

Introduction

The nature of modern animal agriculture, with its highly concentrated production facilities has raised serious questions about the effects of animal manure on the quality of our soil, water, atmosphere, and food supply. The soil is a very effective manure treatment system if manure is applied at the proper rate, time, and location. Since manure is a valuable organic fertilizer, operators who need the nutrient resource in manure tend to use it better, even those who are using land application as a waste disposal practice can do it in an environmentally sound manner provided they know the impacts of their practices.

Land application planning is a two-part process. The first step involves the process of determining the amount of manure to apply, developing a general cropping plan, and estimating the number of acres needed to properly land apply the manure. The second step deals with the implementation of this plan including knowledge of how, when, and where this manure will be applied. It covers such things as the planned times for manure applications, manure application methods, best management practices (BMPs), and records of manure applications and crop yields. Often these factors can have as much or more impact on the environment than the application amount.

Selecting Land Application Sites

Site selection is one of the major factors that directly affect an operation's success. Spend the time up front selecting the best sites for land application of manure so that future, potentially expensive environmental problems and adverse public relations can be avoided. Even though a site may look good initially, its use may result in problems that could easily have been avoided by choosing another site.

One of the most important criteria in site selection is finding a site where the soils are suitable for the crops that are intended to be grown. The goal of land application is to use the manure nutrients in crop production. If the soil does not sustain crop production, then the nutrients will probably end up in the surface or groundwater. Sometimes certain areas of land application fields do not sustain vegetation. In these areas, soil testing is an essential diagnostic tool for determining what the problem is and developing solutions for correcting the problem. You may need to consider different crops or tillage systems that will sustain vegetative growth. Remember, if the intended crop is not growing, then the nutrients are going some place else.

The soil texture and other physical characteristics are also very important. Ideally, the soils at the site would not be too sandy. The clays and organic matter in soils help hold the nutrients and metals found in the manure, thereby preventing their movement to the groundwater and maximizing the potential for plant uptake. Sandy soils are prone to groundwater contamination while heavy clay soils tend to create more runoff and surface water impacts. To prevent nitrogen (N) from leaching to groundwater, limit N applications on sandy soil and avoid soils with high water tables, tile drains, or controlled drainage. A deep soil (greater than 12 inches) that has good separation from bedrock is preferred. Shallow soils tend to produce more runoff and will not hold the nutrients in place for crop utilization.

Since phosphorus (P) is usually applied in excess of plant needs in manure land application systems, sites with low soil test P are preferred. To receive the most value from your manure, apply high-P manure to fields with the lowest soil test P levels. Economically, it also makes sense to haul the highest nutrient content manure to the farthest fields and apply the lowest nutrient content manure to the closest fields. For lagoon systems, this would usually result in irrigating the closest fields with collected runoff water and lagoon effluent and hauling sludge to fields farther away.

Animal manure should not reach surface waters or wetlands by runoff, drift, manmade conveyances (such as pipes or ditches), or direct discharge during land application. For regulated operations, EPA requirements call for a 100-ft setback or a 35-ft vegetated buffer between any application area and surface waters. Therefore, sites with least potential for surface water runoff reaching streams would be better suited for land application systems. Sites that have a deep groundwater table are also preferred. This can reduce the risk of groundwater contamination. Tile-drained systems artificially lower the water table by draining the soil. These systems are therefore more prone to nutrients seeping into the shallow groundwater and ending up in surface water.

Slopes steeper than 6% should also be avoided unless there is sufficient crop residue to prevent runoff, or unless manure is injected or incorporated into the soil. Sites that are too steep will have greater losses to runoff, will have more soil erosion, and often have shallower topsoil. In general, flatter slopes have better soils for land application and make the maintenance of a crop easier.

Odor associated with land application is unavoidable so isolated sites are better that those near neighbors or in the public view. Always check with local city and county officials for applicable regulations on zoning, health, and building codes to ensure that the site can legally have manure applied to it. Buffer or set-back restrictions can significantly reduce available land for manure application. Buffers are designed to minimize the potential for impacts to adjacent homeowners as well as to the environment. Having trees or other visual barriers around the site will also help you to avoid odor complaints. In addition, it is crucial to consider the direction of the prevailing wind in relation to the site and residential development in the area.

Obviously, not every site is perfect for manure applications, but knowing the limitations of potential sites is important. Evaluating the environmental suitability of your fields is one method you can use to identify those fields where manure application is most appropriate. Table 6-1 will allow you to measure the relative "risk" to the environment of various land application sites. Evaluations such as these can be done on each field and included as part of your nutrient management plan (NMP). Assessments such as Table 1 (next page) can also help you determine which fields to use if several alternatives are available.

Table 1. Field assessment for manure application.

Category	Points	Field # ____
1. Planned crop (check one)		
a. Continuous corn or corn not following legume	10	
b. Second-year corn following legume	8	
c. First-year corn following legume	1	
d. First-year corn following nonforage legume	8	
e. Nonforage legume	2	
f. Small grains (for grain)	6	
g. Small grain with seeding (removed as grain)	2	
h. Small grain with seeding (removed as hay or silage)	4	
i. Prior to direct seeding legume forage	8	
j. Topdress (good legume stand)	1	
k. Topdress (fair legume stand)	2	
l. Topdress (poor legume stand)	3	
m. Grass pasture or other nonlegumes	6	________
2. Soil test P (check one for each category)		
a. > 200 lbs/acre	1	
b. 100-200 lbs/acre	3	
c. 30-100 lbs/acre	5	
d. < 30 lbs/acre	10	
3. Site/soil limitations (check one for each category)		
a. Surface or groundwater proximity		
1. Applied and incorporated within 10-year floodplain or within 200 feet of surface water or groundwater access	1	
2. Application above these restrictions	5	
b. Slope		
1. > 12%	1	
2. 6%-12%; > 12% (incorporated, contoured, or terraced)	3	
3. 2%-6 %; 6%-12% (incorporated, contoured, or terraced)	5	
4. < 2%; <6% (incorporated, contoured, or terraced)	10	
c. Soil texture		
1. Sands, loamy sands	1	
2. Sandy loams, loams/sands, loamy sands	3	
3. Other soils	5	
d. Depth to bedrock, inches		
1. 0–10	0	
2. 10–20	1	
3. > 20	5	
4. Odor and Public Access Concerns (check one)		
a. Field along public road or near many houses without visual screening/buffer	0	
b. Field along public road or near many house with visual screen or buffer	3	
c. Field is isolated from non-farm neighbors and public view	5	+ ________
5. Total Points (Higher field score = higher priority for land application)		= ________

Timing of Manure Applications

Crop growth rates and application conditions are not uniform throughout the year. Likewise, crop nutrient requirement is not uniform among various crops. All nutrient sources should be applied at times that will maximize crop use and minimize loss. Ideally, manure nutrients should be applied to an actively growing crop or within 30 days of planting a crop. If crops for human consumption are grown, manure should not be applied within three weeks of harvest. Some common crops grown to use nutrients in manure are shown in Table 2. A cropping system with a variety of crops offers the most flexibility for manure application over many parts of the year.

Table 2. Crops useful for manure utilization and their maximum uptake period in the southeastern United States.[1]

Crop	Uptake Period[2]
Corn (grain) Corn (silage) Sorghum (grain)	Apr-July
Small grains (grain) Small grains (hay, pasture)	Feb-Apr
Soybean	July-Sept
Cotton	June-Aug
Bermudagrass (hay, pasture)	Apr-Sept
Tall fescue (hay, pasture)	Feb-Apr and Sept-Nov
Alfalfa (hay) Millet (hay, silage)	May–Aug
Annual ryegrass (hay, silage, pasture)	Feb-Apr and Sept-Oct

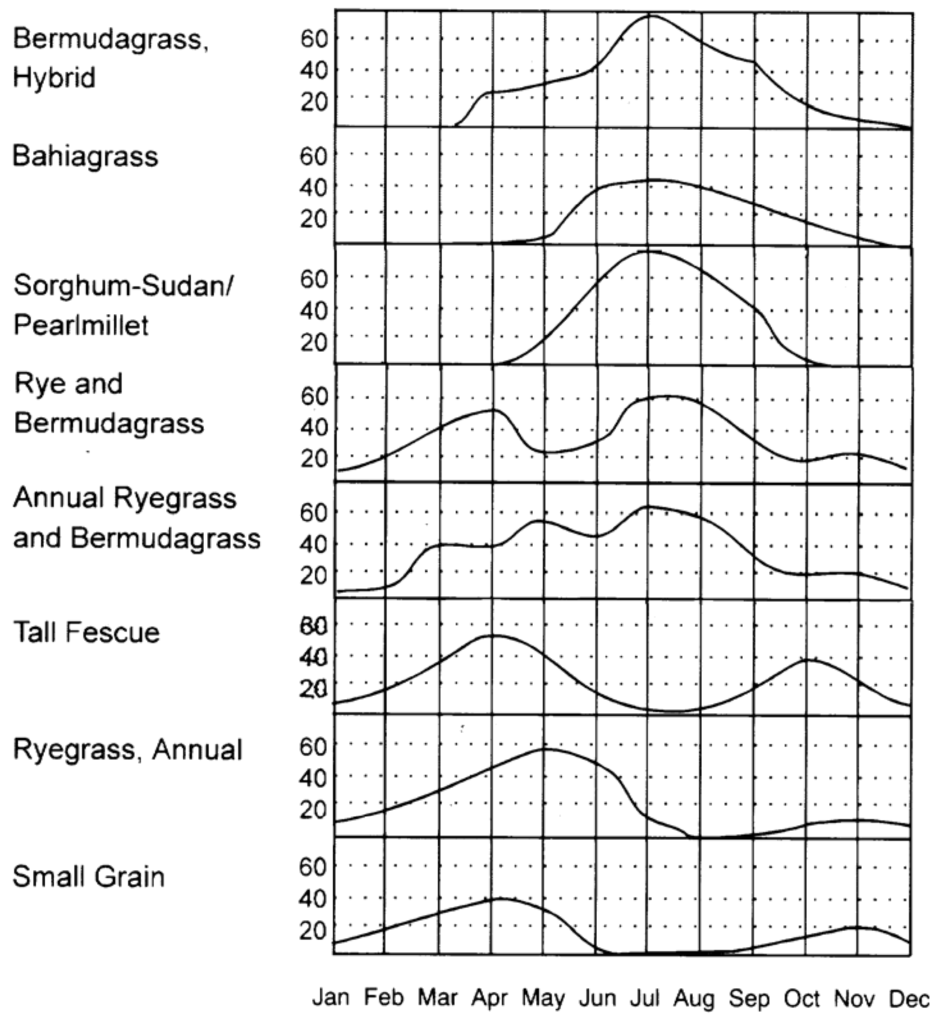
[1]Relevant crop growth periods for your local area should be substituted in this table.
[2]Application should occur no more than 30 days before planting or green up of perennial forages.

As seen in Figure 1, there are several months during the year when most crops are dormant. For example, bermudagrass is dormant in January and February, and growth is "slow" during March, November, and December. These would be periods prone to nutrient losses when manure application would not be recommended. The risk of encountering an emergency situation can be significantly reduced by utilizing a cropping system that provides the flexibility of extending the application season throughout most of the year. For example, if bermudagrass is overseeded with rye in the winter, you have a cropping system in place that can accept some manure almost all the time.

Manure should not be applied to saturated soils, during rainfall events, or when the soil surface is frozen. Timing is most important for nutrients applied to soils with a high leaching potential. Applying N to a sandy soil when there is no crop to remove it will almost certainly result in loss of N to the shallow groundwater. Manure with the highest N content should be applied in the spring to take advantage of lower temperatures. You must also plan for significant wet weather periods if you live in an area that normally receives abundant rainfall in certain months.

In some cases, manure storage capacity dictates the frequency of manure applications. Insufficient manure storage capacity will require frequent applications and year-round cropping systems, while larger storage volumes may facilitate less frequent applications to a single crop. Many storage structures are designed for 180 to 270 days of temporary storage, which means that an actively growing crop must be present in both summer and winter. Because manure production and storage capacity determine the maximum amount of time between manure applications, these factors strongly influence crop selection and land requirements.

Figure 1. Growth rate of selected forage crops. Growth is expressed as pounds of forage produced per day per acre.



Application Methods and Equipment

Different application equipment offers advantages and disadvantages over other equipment. While most operators do not have the luxury of being able to select among several types of equipment, it is important to be aware of the limitations your equipment may have on your system. Table 3 (page 7) lists the environmental performance of common application equipment. The criteria for these comparisons is given below.

Application uniformity

To manage manure nutrients as a resource, your application equipment must provide uniform and controllable applications. Uneven distribution of nutrients results in reduced crop production where application is deficient and in increased nutrient losses where nutrients exceed crop requirements.

Timeliness of application

The ability to move large quantities of manure during short periods of time is critical. Limited times of opportunity exist for the application of manure to meet crop nutrient needs and minimize nutrient loss. Investments and planning decisions that enhance the operation's capacity to move manure or that store manure in closer proximity to application sites will facilitate improved timing of manure applications.

Conservation of N

The ammonium fraction of manure, which could represent more than half of the potentially available N, is lost by long-term, open lot storage of manure, anaerobic lagoons, and surface spreading of manure. Systems that conserve ammonium N and provide nutrients more in balance with crop needs increase the economic value of manure.

Odor nuisances

Odor nuisances are the primary driving factor behind more restrictive local zoning laws for agriculture. Manure application systems that provide you with more flexibility in application timing and location can reduce odor nuisances. Application systems that minimize odor deserve consideration and preference when neighbors live close to application sites.

Soil compaction

Manure spreaders are heavy. The manure in a 3,000-gallon liquid manure tank weighs more than 12 tons. In addition, manure is often applied at times of the year, late fall and early spring, when high soil moisture levels and the potential for compaction are common. Soil compaction can reduce yields and increase surface water runoff.

Table 3. Environmental rating of various manure application systems.

	Uniformity of Application	Conservation of Ammonium*	Odor	Compaction	Timeliness of Manure Application
Solid Systems					
Box spreader: tractor pulled					poor
Box spreader: truck mounted	poor				fair
Flail-type spreader		very poor	fair	fair	
Side-discharge spreader					poor
Spinner spreader	fair				
Dump truck	very poor			poor	fair
Liquid Systems: Surface Spread					
Liquid tanker with splash plate	poor	poor	poor		
Liquid tanker with drop hoses	fair	fair	good	poor	fair
Big gun irrigation system	good				
Center pivot irrigation system	excellent	very poor	very poor	excellent	excellent
Liquid Systems: Incorporation					
Tanker with knife injectors					
Tanker with shallow incorporation	good	excellent		poor	fair
Drag hose with shallow incorporation				good	good

*Solid or liquid manure applications may be followed by immediate incorporation to improve ammonia conservation.

Equipment Calibration

A NMP is of little use if the designed application rate cannot be met. Calibration of manure application equipment is essential because it lets you know the amount of manure and wastewater you are applying to an area. More specifically, the calibrated rate and nutrient concentration of manure lets you know the amount of plant-available nutrients you are applying. Then you can adjust your application rate to avoid over fertilization and resulting nutrient losses. Calibration will:

- Verify actual application rates.
- Troubleshoot equipment operation.
- Determine appropriate overlaps.
- Evaluate the uniformity of application.
- Monitor changes in equipment operations (age and "wear and tear").
- Alert you to changes in manure consistency or "thickness."

Detailed procedures for calibrating almost any type of application equipment can be obtained from equipment manuals or the Cooperative Extension Service. Operators should establish written calibration procedures to be used on their operation and schedule calibration activities on a regular basis. Georgia regulations require some type of calibration documentation for custom or professional applicators. At a minimum, annual calibration is recommended for all application equipment on a farm.

Best Management Practices (BMPs)

The term Best Management Practices refers to a combination of practices determined to be effective economical approaches to preventing or reducing pollution generated by nonpoint sources. Even under ideal conditions with properly calculated, well timed, and appropriately placed applications, land application systems will have losses to ground or surface water, so BMPs are necessary to minimize the impacts of these losses. BMPs can be structural like in the construction of terraces, sedimentation basins, vegetated waterways, or fencing or they can be managerial like crop rotation, plant tissue analysis, and conservation tillage. Both types of BMPs require good management to effectively reduce the generation or delivery of pollutants from agricultural activities. In an NMP, it is important to indicate the BMPs that will be used on all land application areas.

Factors Controlling BMP Effectiveness

Best Management Practices use a variety of mechanisms that result in varying degrees of effectiveness. Often, operators will need the assistance of a conservation planner such as your local Natural Resources Conservation Service (NRCS) staff, Soil and Water Conservation District (SWCD) officer, Extension agent, or crop advisor to select and develop a conservation plan for each field. When selecting BMPs, you should use a systematic approach to ensure that the practice you select will solve your problem. The following questions can help you in the selection process:

What pollutants are contributing to the problem?
Sediment, nutrients, bacteria, etc.
Where are the pollutants being transported?
Surface or groundwater
How are the pollutants being delivered?
Availability, transport paths, in the water, or on sediment

The most effective plan will probably consist of several different BMPs that target different mechanisms. Some BMPs may solve a surface water quality problem but create a groundwater quality problem. An expert trained in these systems should design (and review the installation of) the BMPs for your operation. Finally, if a BMP is not economically feasible and well suited for the site, you probably should not use it. When selecting BMPs, consider all the of costs including effects on yield, production and machinery costs, labor and maintenance, and field conditions. Often a very effective BMP will rapidly become a problem if all the costs are not considered before implementation.

Control of soil erosion is probably the best opportunity for preventing pollution from land application areas since sediment is not only a pollutant but can also carry nutrients or pesticides with it. While soil erosion is a natural process, it is accelerated by any activity that disturbs the soil surface. The amount of soil erosion that occurs is a function of the rainfall and runoff generated from the site, the soil erodibility, the slope length and steepness, the cropping and management of the soil, and any support practices that are implemented to prevent erosion. Knowledge of rainfall patterns will allow operators to ensure that the soil is protected during the periods of the year when it receives the largest amounts of rainfall.

Your primary control of soil erosion is through modifications in slope steepness and slope length and in cropping, tillage and residue management, and support practices. Steeper slopes produce more soil erosion, and methods of reducing slope length or steepness such as the construction of levies and terraces can reduce soil erosion. Practices such as strip cropping and vegetated waterway construction can be used to reduce runoff velocities and slope length. Crop canopy and surface cover or residue act as a buffer between the soil surface and the raindrops, absorbing much of the rainfall energy and ultimately reducing soil erosion. Therefore, crops that produce more vegetative cover, have longer growing seasons, or produce a persistent residue will have less soil erosion. Any cropping system with less tillage or greater amounts of vegetative production will result in less sediment leaving the field. Support practices are structural BMPs such as terraces that are proven to reduce soil erosion. These practices are often more expensive than management and cropping changes but may be required on some fields.

While most BMPs reduce soil erosion and transport, some BMPs use other mechanisms to reduce the impact of a pollutant. The three stages of the pollutant delivery process are availability, detachment, and transport. Availability is a measure of how much of a substance in the environment can become a pollutant. For example, an effective BMP for reducing the amount of animal manure entering surface water may be to simply decrease the amount that you are land applying to an area so that less is available. Once a substance is available, it must be detached from the target site to become a pollutant. Pollutants may be detached as individual particles in the water or attached to soil particles. For example, dry manures applied to the surface are more easily detached than the same amount of liquid manure that has soaked into the soil. Incorporation of the dry manure into the soil is therefore a BMP that limits detachment. Transport is the final link in the pollutant delivery chain. To cause a problem, nutrients or other pollutants must travel from the point where they were applied to the surface or groundwater. For instance, using a filter strip to collect sediment before it enters a stream is an example of reducing pollutant transport.

Land Application BMPs

When properly carried out, BMPs improve water quality. Best management practices relating to manure management are those practices that optimize nutrient uptake by plants and minimize nutrient impact on the environment. They will change over time as technology and understanding of the complex environment improves. Likewise, BMPs are very site specific, and a BMP in one place may not be useful for another location. Key BMPs for land application are listed in Table 4 (next page).

Table 4. Common BMPs for land application of manure.

BMP	Mode of Action
Soil, manure or plant analysis	Ensures that proper crop nutrient requirements are met and manure is not over applied: Amount
Nutrient management plan	
Calibration of application equipment	
Manure treatments such as alum	Reduces availability of nutrients to runoff: Availability
Manure injection or incorporation	Places nutrients in the root zone and reduces availability to runoff: Availability
Critical area protection/Vegetated waterways	Removes areas prone to runoff and erosion from production and manure application: Availability
Water diversions	Diverts water from running onto fields: Availability
Terraces or contour planting	Reduces erosion and encourages infiltration: Transport
Riparian buffers or filter strips	Acts as trap to remove pollutants before entering waterways: Transport
Cover crops, "scavenger crops, or crop rotation	Reduces erosion and encourages infiltration, improves soil quality and provides additional uptake: Transport and availability
Conservation or reduced tillage	
Ponds or retention structures	Acts as trap to remove pollutants before entering waterways: Transport
Rotational grazing/Pasture management	Reduces runoff and erosion, increases plant uptake: Transport and availability

A summary of other BMP principles related to land application practices that enhance surface water and groundwater quality are as follows:

1. Application of nutrients at rates corresponding to crop uptake requirements is one of the most important management practice used for reduction of off site transport of nutrients.
2. Maintaining good crop-growing conditions will reduce both surface runoff losses and subsurface losses of plant nutrients. Preventing pest damage to the crop, adjusting soil pH for optimum growth, providing good soil tilth for root development, planting suitable crop varieties, and improving water management practices will increase crop efficiency in nutrient uptake.
3. Timing of nutrient application to coincide with plant growth requirements increases uptake efficiency and reduces exposure of applied nutrients to surface runoff and subsurface leaching. The optimum time of application depends on the type of crop, climate, soil conditions, and chemical formulation of fertilizer or manure. Consult a certified crop advisor or professional agronomist to discuss when manure/nutrients should be applied to maximize crop uptake.
4. Certain soil and water conservation practices will reduce sediment-associated nutrient losses. By reducing sediment transport, contouring, terraces, sod-based rotations, conservation tillage, and no-tillage reduce edge-of-field losses of sediment-bound-N and sediment-bound-P.
5. Proper selection and calibration of equipment will ensure proper placement and rate of nutrient delivery. Improper calibration and equipment maintenance will result in over or under application of nutrients or uneven nutrient distribution. Appropriate handling and loading procedures will prevent localized spills and concentration of manure nutrients.

6. Crop sequences, cover crops, and surface crop residues are useful tools for reducing runoff and leaching losses of soluble nutrients. Winter cover crops may theoretically capture residual nutrients after harvest of a summer crop. Nutrient credits for "green manures" and cover crops must be taken into account to determine the appropriate rate of additional manure application. On soils with a high potential for leaching, multiple applications of manure at lower rates should be used.
7. Deep-rooted crops, including alfalfa and to a lesser extent, soybeans, will scavenge nitrate leached past the usual soil-rooting zone. Used in crop rotation following shallow-rooted or heavily fertilized row crops, deep-rooted crops will recover excess nitrate from the soil and reduce the amount available for leaching to groundwater.
8. Use commercial fertilizer only when manure does not meet crop requirements.
9. Manure should not be applied more than 30 days prior to planting of the crop or forages breaking dormancy. Incorporate manure to reduce N loss, odors, and nutrient runoff for crops where tillage is normally used.
10. Applications of animal manure should not be made to grassed waterways. If applications are made, they should be conducted at agronomic rates and during periods of low rainfall to minimize runoff from the site.
11. On manure application sites that are grazed, reduce the N rate by 25% or more to account for nutrient cycling through the grazing animals. Use proper stocking rates so that the vegetative cover is not damaged, which could result in increased soil erosion. Controlling animal traffic patterns can help to prevent bare spots that could lead to the formation of gullies.
12. The use of sediment basins or small ponds is a method of preventing off-farm pollution. A sediment basin is a barrier or dam constructed across a waterway to reduce the velocity of the runoff water so that much of the sediment and associated nutrients settle to the basin bottom. Small sediment basins require regular sediment removal while larger basins can almost appear to be a pond and may support fish and wild life. A well-placed pond can collect all of the runoff from an operation and have a positive impact on water quality. It acts as a detention basin by removing sediment and nutrients from the flow and reducing the volumes of flow occurring at peak conditions. It can also filter many nutrients if aquatic vegetation or fish are used. Finally, the pond can act as a buffer between the operation and the external environment.

Note: This module was adapted from the Livestock and Poultry Environmental Stewardship (LPES) curriculum, Lesson 30 authored by Pat Murphy, Kansas State University; Lesson 31 authored by Karl Shaffer, North Carolina State University; Lesson 32 authored by Ron Sheffield, now at the University of Idaho; Lesson 33 authored by Ron Sheffield, now at the University of Idaho, and Pat Murphy, Kansas State University; Lesson 34 authored by Andrew Sharpley, USDA-Agricultural Research Service, and Ron Sheffield, now at the University of Idaho; Lesson 35 authored by Karl Shaffer, North Carolina State University, and Ron Sheffield, now at the University of Idaho; and Lesson 36 authored by Ron Sheffield, now at the University of Idaho, courtesy of MidWest Plan Service, Iowa State University, Ames, Iowa, 50011-3080.

Chapter 6
Maintaining Water Quality in Grazing Systems

L. Mark Risse, Biological & Agricultural Engineering Dept., University of Georgia

Introduction

Although the problems associated with small scale, agricultural livestock production do not receive as much attention as larger operations, small operations can have a substantial impact on rural environmental quality. Even livestock and poultry operations without concentrated animal housing and confinement can still be potential sources of pollutants. Small farms produce many of the same pollutants as their larger counterparts; runoff and soil erosion, animal waste, pesticides, fertilizers, and petroleum products to name a few. Most of these pollutants are classified as non-point source pollutants meaning their origin cannot be traced back to any particular point. While the quantities produced are often much smaller than large operations, usually there are many more small operations within in given area so the total pollutant loads may be equivalent. Therefore, efforts to protect and improve the quality of all of our natural resources need to focus on large and small operations with concentrated confinement and pasture systems.

Best Management Practices (BMPs)

Best Management Practices refers to a combination of practices determined to be effective economical approaches to preventing or reducing pollution generated by nonpoint sources. BMPs can be structural as in the construction of terraces, dams, pesticide mixing facilities, or fencing or they can be managerial like crop rotation, nutrient management, and conservation tillage. Both types of BMPs require good management to be effective in reducing the generation or delivery of pollutants from agricultural activities. Preventive practices such as these are the most practical approaches to reducing nonpoint source pollution. BMP's are refered to in almost every chapter of this manual. The color photo reference guide at the beginning of this manual depicts examples and provides brief explanations. Cooperative Extension, NRCS and local Soil and Water Conservation Councils can provide additional information and technical assistance on installing and implementing these practices.

Voluntary Implementation of Best Management Practices: The Practical Solution

1. Nutrient Management Plans for Pastures
    -Manure or Commercial Fertilizer, mixture is probably ideal
    -Soil Testing and follow recommendations: Over application costs you
    -Spreader calibration and even distribution are important
2. Control Erosion in pastures: Sediment is number one pollutant in Georgia
    -Grassed Waterways, Terraces, and Control of Gullies
3. Use stream side buffers or riparian zones: vegetation and residues trap nutrients and sediment
4. Cows in water are a direct source of pollution, trample vegetation, and increase erosion: keep them out or minimize congregation in streams or buffer zones
5. Pasture Management: Over seeding and no-till planting, proper herbicide use.

Factors controlling Non Point Source (NPS) Pollution

BMPs are used to reduce the effects of all forms of pollutants. They use a variety of mechanisms that result in varying degrees of effectiveness. All activities within a watershed affect NPS pollution but control of soil erosion is probably the best opportunity for preventing pollution since sediment is not only a pollutant itself, but also carries nutrients and pesticides with it. While soil erosion is a natural process, it is accelerated by any activity that disturbs the soil surface. The amount of soil erosion that occurs is related to five factors; the rainfall and runoff, the soil erodibility, the slope length and steepness, the cropping and management of the soil, and any support practices that are implemented to prevent erosion. The rainfall and soil factors are primarily functions of climate and geography that producers have little control over, however, man can manage to reduce the impact of these factors. For example, increasing the amount of rainfall that goes into the soil (infiltration) is an indirect means of reducing erosion as a certain rainfall will produce less runoff and corresponding erosion.

Nutrient Management Planning

The general content of this manual explains Nutrient Management in detail. This concept is just as important in pastures and grazing systems. In many cases these systems will be part of the farm's land application and waste management activities. Managing the amount, source, form, placement, and timing of nutrient applications are activities that will accomplish both crop production and water quality goals. This holds true for all nutrient sources including manure, organic wastes, chemical fertilizers, and crop residues. Whatever the approach, the important concept is that nutrient management, plans examine all nutrients to minimize loss of nutrients to surface runoff and leaching, to maintain soil quality, and to insure adequate soil fertility to meet the intended crop yield goals.

Runoff and Erosion Protection Measures

Essentially, any measure that increases the infiltration rate or water holding capacity of the soil, limits flow velocity, or increases the time that water remains of the soil surface will decrease runoff. Producers should also consider leaving critical areas out of production. Critical areas usually cannot be stabilized by ordinary conservation treatment and if left unmanaged can cause severe erosion problems. Examples of critical areas include dams, dikes, levees, cuts, fills, and denuded or gullied areas where vegetation is difficult to establish. These areas will become reoccurring problem spots if they are put into pasture or cropland. Instead, vegetation should be established and they should be left out of production.

A grassed waterway is a natural or constructed channel, usually broad and shallow, planted with perennial grasses to protect soils from erosion by concentrated flow. These waterways serve as conduits for transporting excess rainfall and diverted runoff from the fields or pastures without excessive soil erosion. Waterways prevent gully erosion in areas of concentrated flow. The vegetation also acts as a filter to remove suspended sediment and some nutrients. Grassed waterways require careful maintenance and periodic reshaping especially after large or intense storms. Performing this maintenance regularly is important as the concentrated flow conditions can lead to rapid gully formation if minor washouts are left unchecked.

The use of farm ponds is one final method of controlling farm runoff. A well-placed pond can collect all of the runoff from a farm and have a positive impact on water quality. It acts as a detention basin by removing sediment and nutrients from the flow and reducing the volumes of flow occurring at peak conditions. It can also filter many nutrients if aquatic vegetation or fish are used. Finally, the pond can act as a buffer between the farm and the external environment. On poorly managed farms, the farm pond can collect and hold any pollutants produced within the farm watershed so that their impact can be reduced. On well managed farms, a healthy pond is indicative of a farmer that uses environmentally sound practices and causes little environmental degradation.

Filter strips and Riparian buffers

All streams, rivers, lakes, ponds, and other water bodies in Georgia are more sensitive to environmental pollutants than the land that surrounds them. By managing the area around these water bodies more intensively, many conditions that may lead to surface or groundwater contamination can be prevented. All potential agricultural pollutants, including pesticides, herbicides, fertilizers, manures, petroleum products, and sediment should be handled with extreme care around any water body. Stream channels and banks should be protected to prevent erosion. Often this can be accomplished using vegetation, however, at times structural measures such as rock riprap may need to be used. Generally, livestock access to water bodies should be controlled and limited to areas with dense vegetation, smooth stable slopes, and firm surfaces.

The area immediately surrounding a stream or lake can also be used to remove sediment or nutrients from runoff or groundwater before it reaches areas where it becomes a pollutant. Filter strips are strips of grass, shrubs, or other close growing vegetation intended to remove sediment or pollutants from runoff. They are normally planted in an area where water will pass over them as sheet flow. The vegetation slows the water, allowing solids to settle out and become trapped in the vegetation. The filtered nutrients and organic matter are biologically decomposed by plants and microorganisms. Filter strips have been found to reduce sediment, nitrogen, phosphorus, and fecal coliform in animal waste runoff and can be effective around feedlots, tilled fields, pastures, and any other pollutant sources.

Stream side forest buffers or riparian zones are areas of trees, woody shrubs and other vegetation, located adjacent to and up gradient from streams or other water bodies. They usually consist of natural vegetation that provides a filter for sediment and organic material that carries many pollutants. They also provide an area where nutrients may be utilized by vegetation and where chemical decomposition can take place. Riparian zones are not intended to serve as the only water quality practice or to replace erosion control but they do provide a final opportunity to improve water quality before it enters a stream. Research has indicated that riparian zones and filter strips are so effective that many State governments are now developing programs to purchase land around critical water bodies to establish riparian zones for water quality protection. While these BMP's require little maintenance once they are established, if the sediment loads entering the filter strip are heavy, you may have to periodically remove them and reestablish the vegetation.

Livestock Exclusion/ Alternate Watering Facilities

Animal access to surface waters and adjacent areas also represents possible sources of water contamination. Not only does the manure deposited directly in or adjacent to streams pollute the water, but the livestock also reduce stream-side vegetation by foraging or trampling and disturb sediment on the stream bank and bed. This increases erosion and decreases the buffering capacity of the stream-side vegetation. Stream and waterways protection can be accomplished by limiting livestock access and stabilizing stream banks. Livestock exclusion is the use of fencing or other barriers to prevent cattle from having access to streams, rivers, and lakes. The primary mechanisms that this BMP are the elimination of manure and sediment deposited directly in the stream from animals and less transport through surface flow as a "buffer" zone is established. Vegetation or rip-rap established along the edges of the stream buffer the banks from channel erosion as well as the erosion caused by animal traffic. The main drawbacks of livestock exclusion are the costs associated with establishing and maintaining fences.

An alternative to building fences for total exclusion of livestock is the development of alternate watering facilities. Several research projects have recently documented improvements in water quality through simply supplying a watering tank or trough at selected locations away from the stream or water body that needs protection. When given a choice, cattle will usually drink from the closest source of water. Therefore, alternate water sources reduce the total amount of time cattle spend in the water and traveling to and from the water. One study showed that stream bank erosion was reduced by 77% and concentrations of total suspended solids, total nitrogen, ammonium, total phosphorus, and fecal coliform were reduced by 90%, 54%, 70%, 81%, and 51%, respectively, due to the installation of an off stream watering source. In other words, the results clearly indicated that off stream watering sources were an effective BMP.

General Pasture Management

There are several keys to maintaining adequate and sustainable pastures. Plant selection is critical as the plant must be adapted to both the soil and climate to insure adequate cover throughout the year. Determining proper stocking rates that will not damage the vegetative cover and result in increased soil erosion is also essential. Controlling animal traffic can help to prevent bare spots that could lead to the formation of rills and gullies. Weeds may be a problem in some pastures, however, proper grazing management and fertilization should reduce weed problems. When herbicides are necessary, use only labeled products at recommended rates. When pasture renovation becomes necessary, no-till or other conservation tillage practices that minimize erosion should be used.

Common sources of pollution from pastures include the "loafing" areas, outside areas near the barn or catchpen where the livestock gather or any other area of heavy animal traffic. Water runoff from these muddy areas is easily polluted from contact with waste and soil and contaminated with nutrients and suspended solids. Groundwater contamination is caused by nitrate leaching from the excessive manure deposited in the loafing areas. Diversion of upslope rain runoff, channeling of contaminated runoff into an impoundment or natural buffer strip, and locating loafing areas away from wells can reduce surface water and groundwater contamination. Use of geotextiles for erosion control, drainage, and stabilization in loafing areas also restricts ground water contamination, as well as stabilizes the soil and can reduce mastitis in dairy cows. Feed bins and watering sources can also be moved to different locations allowing the heavily trafficed areas to reestablish vegetation.

Georgia Farm*A*Syst Program

The Farmstead Assessment System (Farm*A*Syst) is a unique self-assessment tool that provides farmers and rural residents with the ability to identify and reduce drinking water and groundwater contamination from agricultural non-point and point sources of pollution on their properties. While the program does create an awareness and concern about pollution risks, its ultimate goal is to aid individuals to voluntarily take actions to prevent pollution. Worksheets provide a systematic framework for evaluating relative pollution risks at a specific site and provide information on specific action plans and sources of technical, financial, and educational assistance. An index of Georgia Farm*A*Syst materials currently available online at: http://www.agp2.org.

Table 1 Best Management Practice Summary Guide.

BMP	Surface Water			Ground Water	
	Sediment	Soluble Pollutants	Adsorbed Pollutants	N Loss	Pesticide Loss
Soil testing/Plant analysis	0	++	+	++	+
Equipment Maintenance & Calibration	0	+	+	+	+
Application methods and timing	0	++	++	+	+
Nutrient Management Plans	+	++	++	++	0
Conservation Tillage	++	0	++	0	0
Critical Area Planting	++	+	+	0	0
Pasture Management	+	0	+	0	0
Irrigation Management	+	++	+	++	+
Contours and Terraces	++	+	++	-	-
Filter Strips	++	+	++	0	0
Grassed Waterways	+	0	+	0	0
Subsurface drainage	+	-	0	++	++
Water Control Structures	++	+	++	-	-
Waterbody Protection	++	+	++	0	0
Stream Buffers	++	+	++	+	0
Livestock Exclusion/Watering	++	++	++	0	0

KEY: ++ Medium to high effectiveness   0 Almost no effect
+ Low to Medium effectiveness   - Could have detrimental effect

Note: BMPs are site specific in nature. These generalizations are not necessarily true under all conditions. Soluble pollutants dissolve in water like N. Phosphorus is a example of an absorbed pollutant that moves attached to sediment.

Chapter 7
Pesticide and Chemical Management for Water Quality

Thomas M. Bass, Biological & Agricultural Engineering Dept., University of Georgia.

Introduction

Properly managing petroleum, pesticides and other agricultural chemicals is important for protecting water quality as well as farm family, employee and livestock health. Even low-level contamination of ground water used for drinking supplies can result in chronic health effects.

A small gasoline leak of one drop per second can often go unnoticed, but it could result in the release of about 400 gallons of gasoline in one year. Not only does this cause economic loss, but it also causes environmental and health problems. The improper introduction of these chemicals and fuels to your animal waste storage area can taint the manure resource, rendering it unusable on crops and requiring a farmer to clean it up as a hazardous waste.

Every site has unique geologic and hydrologic conditions that can affect ground water movement. How quickly a chemical such as fuel reaches ground water also depends upon local soils. The more porous the soil is (sands and gravels, for example), the faster the rate of downward movement to ground water. The further the distance to your water source, the more assurance you have that contaminated water will not reach it. The direction of groundwater flow frequently follows the surface topography. In other words, ground water usually flows downhill. If possible, the tank should also be located downhill from the well.

Some simple measures can help keep pesticides, petroleum products and other chemicals out of water resources and manure storages. A lagoon or manure storage is an engineered structure designed for treatment or temporary containment of a valuable resource; it is not a catch-all dumping site. Under no circumstances should it be used for disposal of agricultural chemicals or petroleum products. Antifreeze jugs, oil cans and other trash floating in a lagoon or pond are examples of very poor stewardship and sure fire ways to attract attention from regulatory agencies.

Storage

Pesticides: Store in a secure and lockable dry place with protection from activities that may tear break containers. Some sort of secondary containment should be used in storage areas; this can be a constructed structure like an impermeable floor with 4 inch curbing or a plastic tub, bin or child's pool that can contain a spilled material. Secondary containment should be able to hold 125% of the stored material. Pallets should be used to elevate containers off the floor. Storage buildings should be 100 feet away from drinking water wells.

The chemical storage area must be posted with signs around the area and entrance stating "DANGER: PESTICIDES," "KEEP OUT," "NO SMOKING AREA" or similar notices. Access to this facility must be limited to only one, two or three individuals. Never store pesticides where food, feed, seed, fertilizers or other products can become contaminated. Store dry pesticides on top shelves and liquids on lower shelves. Always store chemicals in their original and properly labeled containers. Make sure they're tightly sealed.

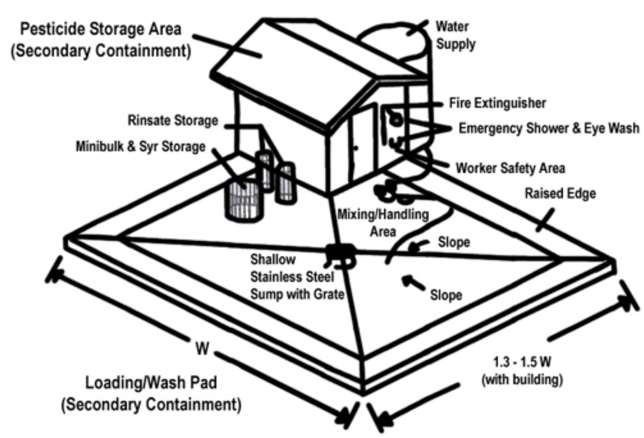
Nearly three-fourths of all pesticide accidents occur to non-users of the materials. Each year there are several cases of children, livestock and pet poisonings from accidental contacts with improperly stored pesticides. These accidents cause human suffering and economic losses; improper storage is illegal. The pesticide label describes the proper storage environment for each product. Read the label: It is the law.

Petroleum: Above ground storage tanks should be protected from traffic by posts or fencing. Tanks should be at least 6 inches off the ground and clear of brush and debris to reduce the chance of fire and to more easily detect leaks. Generally, you should try to locate your storage tanks at least 500 feet from any well to provide adequate assurance that subsurface flow or seepage of contaminated water will not reach your water. "DANGER: FLAMMABLE," "NO SMOKING AREA" and signs identifying the specific type of fuel or product being stored should be utilized around tanks and drum storage areas. Local petroleum dealers can advise on what signs should be displayed for their farm and bulk customers.

Mixing and Loading

Pesticides: Field loading of chemicals moves the handling site farther from the farmstead and potentially from the well. Use a nurse tank to supply water to fill the sprayer and add chemicals at the field location. Field loading of chemicals will be exempt from secondary containment if you vary the location of the mixing/ loading site. The law requires you to report and clean up spills. The liability associated with and the cost of clean-up falls to the person or firm responsible for the spill.

When finishing a field, mix only the amount required to finish spraying the field. Clean the tank by adding water, at least 10 percent of tank volume, to remove chemical residue. This creates a 2 to 3 percent labeled solution. Then you can spray this material back over the field. Wash the exterior at the same time, but avoid repeated washing in the same location; stay clear of wells, surface water bodies and field drains. This will allow for the residue to be left in the field of pesticide destination. Moving the site each time the sprayer is filled will prevent chronic spills from saturating the site.



A mixing/loading facility will be required if chemicals are mixed and loaded at one location. Mixing/ loading pads consist of a pad containing a sump and a set of tanks to hold water containing pesticide solution. The secondary containment volume needed in the pad area will depend on the size of rinsate tanks or sprayer tank size. It should be able to hold 110 to 125 percent of the volume of the largest tank within the containment area. This could either be a sprayer tank or a rinsate tank. This allows for a margin of safety.

Mixing/loading pad sizes and shapes depend on the functions performed, and the orientation and boom width of the equipment. As a general rule, pads should extend at least 5 feet on each side of the edges of the spray equipment's extended boom to catch any splashed water or boom sprays. You may need extra space for workers to easily move around or in between pieces of equipment. A simple concrete pad that drains to a single sump in the center of the pad may meet the containment needs. Pads can incorporate a small pesticide storage building on or adjacent to them. When connected as an extension to the pad with its own containment, these buildings provide needed storage without increasing the pad size.

Fueling and Lubricating

Petroleum: Fueling equipment should be well maintained and free of leaks. When changing oil or other lubricants, use catch basins or tubs of sufficient size to contain the material being changed. Use funnels or a proper pump when transferring petroleum products from different drums or containers. Floor drains in the garage or workshop should be covered and sealed while working with petroleum products (floor drains in workshops and garages are generally a bad idea and a major water quality threat). It is also a good idea to have absorbent granules and chemical/petroleum spill clean-up kits on hand.

Container Disposal

Pesticides: Used pesticide containers should be triple rinsed with small volumes of water; the rinsate should be used to mix the next load of the same chemical. After containers have been properly rinsed and puncture they can be taken to a collection site for recycling or taken to a licensed landfill.

Petroleum: Empty containers should be properly disposed of in a licensed landfill. Recycling opportunities may exist and are preferable where available. Large drums may be returned to the distributor or used for other purposes after they have been cleaned with any residue being disposed off in a licensed facility.

Recycling, Re-use and Waste Products

Pesticides: When at all possible, pesticides should be used for their intended purpose. Even rinse water can go back into mixing that chemical the next time. If surplus or expired material is unavoidable, watch for a chemical collection amnesty day. If there are no such collections organized in your community, call the local landfills to see where you may take unused pesticides for disposal. Once again, never dump such products into the manure storage areas for disposal.

Petroleum: For spent and surplus engine fluids, use a reputable recycling service or collection program to collect used oil. Spent engine fluids may also be burned in a waste oil heater (heat work shop or greenhouse). Follow all of the manufacturer’s recommendations regarding suitable fuels and operation. Prevent oil and other petroleum products from being contaminated (and thus becoming hazardous waste) through contact with other wastes.

Purchasing and Inventory Control

Keeping a large inventory of chemicals and potential hazardous materials on farm is a liability. While purchasing in bulk is preferable from an economic and environmental standpoint, one should carefully consider how much of a product can be used before it expires. Maintain a current inventory of all materials in storage, along with a label of all materials, in a secure area away from the storage area. Date and identify all pesticides when they are placed into storage, and store no more than will be needed for one season. Establish a policy of first-in, first-used, so that pesticides do not become outdated.

References: excerpts taken from GA Farm*A*Syst publications "Pesticide Storage and Handling" and "Petroleum Storage and Handling". See Chapter 12, Resources for more information.

Chapter 8
Mortality Management

Thomas M. Bass, Biological & Agricultural Engineering Dept., University of Georgia.

Introduction

In Georgia, very simple and straightforward rules on mortality disposal and management apply to all livestock and poultry operations, regardless of the size or permit status. These laws also extend to include most hobby farms, horse operations, exotic animal breeders and even kennels. Proper management of mortalities on the farm has implications in nutrient management, flock and herd health, and farm family and public health. For this reason it is imperative to be familiar with the law and best management practices for dealing with dead animals

Incineration

This is a very safe method of compost management from a bio-security standpoint. This practice is limited to small carcasses, primarily poultry. Incineration must be done in an approved device with air quality and emissions controls. This method is energy intense and the cost of fuel often makes it not economically feasible.

Burial

This is probably the most common method dead animal disposal currently employed in Georgia today. If done correctly, this method can be safe; however mortalities can persist for years in an anaerobic environment. Poultry burial pits have been discovered with whole birds during construction projects on old farms. In many parts of our state high water tables and sandy soils do not allow proper cover or depth of burial without threatening ground water. All burial sites must be approved by the Georgia Department of Agriculture (GDA).

Rendering

Rendering is a low maintenance method of mortality management for the farmer and it leaves no lasting legacy on the farm. Most farmers in the state do not have good access to rendering facilities. There can often be fees and charges associated with a rendering service. However, if a farmer has access to a rendering service and it is affordable, then it is a highly recommended practice. The cost should also be weighed against the time of management or input cost to other available methods.

Composting

For many species composting is an environmentally preferable method to deal with mortalities. When managed correctly, completely composted mortality may be incorporated into existing land application of manures. Much information is available on poultry composting and it is not an uncommon practice. It is also possible to compost larger carcasses. The UGA Swine Research Farm successfully composts larger stock including sows. Policy regarding composting of cattle is in transition, although this looks to become a viable option for the future. Most composting requires storm water protection and covering. Compost can be beneficially used on forest and crop land; however certain guidelines should be followed. Contact your local Extension Office or USDA Service Center for information on composting facilities and best management practices.

Alternative Methods

These are not specifically defined. They may include homogenization, digestion or chemical processes and technologies to recover products from mortalities. These must be approved on a case by case basis by GDA.

No matter how one plans to deal with mortalities, the Georgia Department of Agriculture must be contacted for approval. Likewise the state veterinarian (part of GDA) should be the first person contacted regarding any suspected disease related death or a catastrophic loss of livestock or poultry. The current rules on mortality management are summarized below. Contact information for GDA Livestock and Poultry Field Forces are listed at the end of the regulation summary.

State Authorities

- Georgia Dead Animal Disposal Act (O.C.G.A. 4-5) passed 1969, Amended 2002.
- Georgia Department Of Agriculture Rules (Chapter 40-13-5) adopted April 1970, amended May 1984, October 1985, and February 2003.

Purpose

"….. To prevent the spread of infectious, contagious and communicable diseases from dead animals….."

Definitions

Dead Animals: carcasses, parts of carcasses, fetuses, embryos, effluent, or blood of cattle, swine, sheep, goats, poultry, ratites, equine, and alternative livestock; animals associated with animal shelters, pet dealers, kennels, stables, and bird dealers licensed by the Georgia Department of Agriculture; animals processed by commercial facilities which process animals for human consumption and animals associated with wildlife exhibitions.

Violations

- To abandon dead animals on personal, private or public land.
- To dispose of dead animals on another person's property WITHOUT PERMISSION.
- To dispose of dead animals in a city or county landfill without making arrangements with the city or county officials for proper disposal.
- To abandon dead animals in wells or open pits on personal, private or public land

Time Requirements

All dead animals must be disposed of within 24 hours of death or discovery!

Methods of Disposal

- **Incineration**
  - Within 24 hours of death or discovery.
  - Entire carcass reduced to ashes.
  - Under conditions approved by U. S. Environmental Protection Agency and Georgia Environmental Protection Division.

- **Burial or Pits**
  - Within 24 hours of death or discovery.
  - At least 3 feet below ground level.
  - No more than 8 feet deep.
  - Covered with at least 3 feet of earth on top.
  - 100 feet from wells, streams, sink holes or wetlands and 15 feet from an embankment slope of moderate grade.
  - Soils must be of slow to moderate permeability.
  - Poultry pits must have site approved prior to construction.
- **Rendering**
  - Within 24 hours of death or discovery.
  - Longer than 24 hours if refrigerated or frozen.
- **Composting**
  - Approved by State Veterinarian;
  - According to U. S. Natural Resources Conservation Service standards or equivalent.
- **Other Methods**
  - Approved by State Veterinarian on a case by case basis.
  - Risk assessment for disease spread conducted by Georgia Department of Agriculture personnel.
- **Transportation**
  - Must be in covered, leak-proof vehicles.
  - May be required to transport directly to rendering or destroyed on site if death due to infectious, contagious, or communicable disease.

Penalty for Violations

- Administrative Hearing
- Fine up to $1000 per violation
- Consent Order by the Commissioner
- Guilty of a misdemeanor

Summary

The purpose for mortality disposal is "to prevent the spread of infectious, contagious and communicable diseases." Disposal or management must take place within 24 hours of death or discovery. Approved methods (still requires individual registration) include: burial or pits, incineration, rendering, composting, or any method approved by the State Veterinarian.

For more information on the rules and regulations contact:

Georgia Department of Agriculture
Livestock and Poultry Field Forces
19 MLK, Jr. Drive, Room 112
Atlanta, GA 30334
Tele: (404) 656-3665
Fax: (404) 656-9383

Chapter 9
Record Keeping

L. Mark Risse and Thomas Bass, Biological & Agricultural Engineering Dept., University of Georgia.

Introduction

Regular monitoring of structures, equipment, and other critical control points and thorough record keeping is essential on all animal feeding operations. It is your best insurance against accidental discharges, and in the event of a compliance inspection, it documents that you are doing things correctly. Keeping accurate records, along with implementing proper BMPs on your operation, is the primary way you prove to state water quality agencies and to the general public that farm is not causing an environmental impact. Assistance with record keeping can be obtained from Certified Crop Advisors and other technical specialists, the Cooperative Extension Service, the NRCS, and the local SWCD (see chapter 12, Resources).

Record keeping is a major component of site inspections. Often a complaint leading to an inspection can easily be resolved if proper records are available. Larger operations with permits are required to keep records, but all operations should consider keeping them for their own benefit (Table 1).

Nutrient Management Plan (NMP)

Most records will be part of a NMP, and you should store them with your plan. These records should be maintained for at least five years or as long as they are useful. For items such as soil and manure testing, be sure to include the procedures used for sampling and analysis of each test. It is important to remember that a NMP is just a plan of what you intend to do. Without records that indicate what you actually did, the NMP is of little use in documenting compliance on the farm.

Weather

Weather records should include daily rainfall records. These can be obtained through simple rain gauges or more complex weather stations. Rainfall data is very useful in both managing crops and irrigation scheduling and in monitoring your manure storage. Where odor is an issue, some producers have also found it useful to keep wind speed and direction data.

Manure Storage

For all lagoons or manure storages, you should record weekly lagoon level (freeboard) records as well as inspection records. Often routine inspections get overlooked unless they are regularly scheduled and recorded. These records not only prevent emergencies but can also aid in a better understanding of your storage structures.

Equipment

Equipment maintenance records seem trivial, especially when maintenance is only performed when equipment breaks down, but well-maintained equipment is more reliable and efficient. Good maintenance programs can save you money in the long run. Many people regularly change the oil in their cars, and as a result, get improved gas mileage and longer engine life. Do we do the same thing with our irrigation pumps? What will happen when the lagoon is 2 inches into the freeboard and it finally decides to breakdown?

Assessments and Testing

Water quality monitoring or environmental assessments are proactive measures that producers should use to track their environmental performance. Usually, this type of monitoring is not required but could be very helpful; these records are very useful in alerting you to problems early as well as documenting that the operation is not the source of a problem. Testing all wells at least bi-annually for drinking water contaminants is also recommended. For surface water flowing through your operation, semi-annual upstream and downstream testing for nitrate would be the cheapest and most effective strategy. Third parties such as consultants, the NRCS, or your local SWCD can conduct environmental assessments or you can use one of the many readily available self-assessment tools such as Georgia Farm*A*Syst. More information about these types of assessment tools is available in the reference section or from your local Extension office.

Table 1. List of Record-Keeping Requirements for Land Application and Other Activities at Large CAFOs, these are also recommended for small un-permitted farms.

Parameter	Units	Frequency
Nutrient Management Plan		
CAFO operators must maintain on-site a current, site-specific NMP that reflects the existing operational characteristics. Operators must also maintain on-site all necessary records to document that the NMP is being properly implemented with respect to manure and wastewater generation, storage and handling, and land application.	N/A	N/A
Soil and Manure/Wastewater Nutrient Analysis		
Analysis of manure to determine N and P content	ppm lbs/ton	Conduct initial sampling, then at least annually.
Analysis of soil in all fields where land application activities are conducted to determine P content.	lbs/acre	Conduct initial sampling, then at least once every 5 yrs.
Operation and Maintenance		
Visual inspection of all water lines	N/A	Daily
Document depth of manure and process wastewater in all liquid impoundments	Ft	Weekly
Document all corrective actions taken	N/A	As necessary
Document animal mortality practices	N/A	As needed
Design documentation for all manure, litter, and wastewater storage structures including the following information: • Volume for solids accumulation • Design treatment volume • Total design volume • Days of storage capacity	Cubic yd/gal Cubic yd/gal Cubic yd/gal Days	Once/permit term unless revised weekly

Table 1 continued…		
Parameter	**Units**	**Frequency**
Operation and Maintenance continued…		
Document all overflows from all manure and wastewater storage structures including their: • Date and time • Estimated volume	 Mo/day/yr hr gal	 Per event Per event
Document manure application equipment inspection and calibration.	N/A	Seasonally
Land Application		
For each application event where manure, litter or wastewater is applied, document the following by field: • Date of application • Method of application • Weather conditions at the time of application • Total amount of N and P applied	 Mo/day/yr N/A N/A Lbs/ac	 Daily Daily Daily Daily
Document the crop and expected yield for each field.	Bushel/ac	Seasonally
Test methods and sampling protocols used to sample and analyze manure, litter, wastewater, and soil.	N/A	Once/permit term unless revised
Documentation showing the total N and P to be applied to each field including nutrients from the application of manure, litter, and wastewater and other sources as well as how these rates were determined	Lbs/ac	Once/permit term unless revised
Manure Transfer		
For all manure transfer off the farm, operators must maintain the following records: • Date of transfer • Name and address of recipient • Approximate amount of manure, litter, or wastewater transferred	 N/A N/A Tons/gallons	 As necessary As necessary As necessary
Water Quality and Environmental Assessment *Not required unless specified in permit		
Documentation on any surface or groundwater testing and analysis conducted on the farm. Common test parameters may include nitrate, ammonia, total N, P, and fecal coliform bacteria. May also voluntarily include results from regular environmental assessments.	ppm or cfu/100ml	As necessary

Land Application

Operators should maintain records on all nutrient applications including manure, commercial fertilizer, or waste materials, such as municipal biosolids or industrial residuals. These records should include the analytical results, application rates, and soil tests for each application site. A certain amount of record keeping is needed to manage the manure application system and calibrate the equipment. The record-keeping forms provided here will help you document site-specific data that is currently limited on many animal operations. These forms will allow you to easily track your applications and provide you with an easy resource to ensure that you do not exceed recommended application targets on any fields. When combined with such site-specific data as your waste analysis, plant analysis, soils analysis, crop yields, and other plan items, these forms will provide evidence that you are managing your manure application properly and not exceeding agronomic rates.

The forms included here are as follows:

IRR-1: Irrigation Field Record is used to record each irrigation event. The IRR–1 or 2 forms can be used with all types of irrigation systems including solid-set sprinklers, solid-set volume guns, hard hose travelers, center pivots, and liner move irrigation systems.
IRR-2: Cumulative Irrigation Field Record is used to record the total annual manure application to one field per crop cycle. It enables operators to calculate the total N and P application to the field and compare it to recommended loading rates.
SLUR-1: Liquid Manure Slurry Field Record is used to record manure application from liquid tanks. These forms would be used to record the broadcast or injection of any liquid manure, effluent, and sludge.
SLUR-2: Cumulative Liquid Manure Slurry Field Record is used to record the total annual manure application to one field per crop cycle with a slurry or pump and haul system. It enables operators to calculate the total N and P application to the field and compare it to the recommended loading rates.
SLD-1: "Solid" or Semisolid Manure Field Record is used to record each application event from a manure box, flail, or side-discharge spreader. These forms would be used to record the broadcast of any solid manure, separated manure solids, bedding, litter, or compost.
SLD-2: Cumulative Solid Field Record is used to record the total annual manure application to one field per crop cycle. It enables operators to calculate the total N and P application to the field and compare it to the recommended loading rates.

The record forms IRR-2, SLUR-2, and SLD-2 require operators to calculate the amount of N that has been applied to a given crop. The necessary formulas to complete the forms are provided in the first row of the form. For recording purposes, field size is that portion of the field that receives manure applications. When using irrigation, this is often referred to as the "wetted" or "irrigated" area. Wetted area is equal to or less than field size due to the irrigation system layout, the area required for required or recommended buffers, and the shape of the field. Application areas within fields may also be reduced because their slope, seasonal wetness, or soil type makes them inaccessible to spreader equipment.

It is important that operators obtain permission to land apply manure on land that is rented from or owned by another person. A legal manure application agreement could be your only protection in the event of a spill or environmental investigation. It also may be required as part of an NMP on operations that are land limited. Several example agreements are included in this module to assist you in developing these forms. They are only examples and may not be legally binding.

Records should also be kept on all manure transported off the operation. When transporting manure off-site or selling manure, the records should include the amount sold or given away, the recipient, the manure nutrient content and the intended use. It is also advisable to give the recipient a copy of the manure analysis and to provide information about appropriate utilization. Manure should be treated in the same manner as commercial fertilizer; most people would not purchase fertilizer of unknown nutrient content that did not have proper directions for utilization.

UGA Extension Engineers have translated these forms into simple to use Excel spreadsheet files for computer based record keeping including some automatic calculations. Visit http://www.agp2.org/aware, click on search, type "record" in the blank and hit enter.

Form IRR-1

Irrigation Field Record
For Recording Irrigation Events on Different Fields

Farm Owner ____________________

Irrigation Operator ____________________

Facility Number __________ - __________

Tract #	Field #	Date (mm/dd/yr)	Crop Type	Field Size, ac	Irrigation Time			Number of Sprinklers Operating
					Start Time	End Time	Total Minutes	

Form IRR-2

Irrigation Field Record
One Form for Each Field per Crop Cycle

Tract # ______ Field # ______ Facility Number ______ - ___

Field Size, ac = **(A)** ______

Farm Owner ______ Irrigation Operator ___

From Manure Utilization Plan

Crop Type ______ Recommended PAN Loading, lb/acre = **(N)** ______ Crop P needs, lbs/acre =P

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	Irrigation									
Date (mm/dd/yr)	Start Time (hr:min)	End Time (hr:min)	Total Minutes (3) - (2)	# of Sprinklers Operating	Flow Rate, gal/min	Total Volume, gal (4) × (5) × (6)	Volume Per Acre, gal/ac (7) ÷ (A)	Waste Analysis[1] PAN, lb/1,000 gal	PAN Applied, lb/ac [(8) × (9)] ÷ 1,000	N Balance [2], lb/ac (**N**) - (10)
								Add column for P		Add column for P
					Crop Cycle Totals					

Owner's Signature

Operator's Signature

[1] See your manure management plan for sampling frequency. A recent manure analysis is your best method of properly utilizing your manure nutrients.
[2] Enter the value received by subtracting column (10) from **(B)**. Continue subtracting column (10) from column (11) following each application event.

Form SLUR-1

Slurry and Sludge Application Field Record
For Recording Slurry Application Events on Different Fields

Farm Owner		Facility Number		-
Spreader Operator				

Tract #	Field #	Date (mm/dd/yr)	Crop Type	Field Size, ac	Application Method[3]	# of Loads Per Field	Volume of Loads[4], gal

[3] SI = soil incorporated (disked); BR = broadcast (surface applied)
[4] Can be found in operator's manual for the spreader. Contact a local dealer if you do not have your owner's manual.

Form SLUR-2

Slurry and Sludge Application Field Record
One Form for Each Field per Crop Cycle

Tract # ______ Field # ______

Field Size, ac = **(A)** ______

Farm Owner ______

Facility Number ______ - ______

Spreader Operator ______

From Manure Utilization Plan

Crop Type ______

Recommended PAN Loading,lb/ac = **(B)** P entry

(1) Date (mm/dd/yr)	(2) # of Loads Per Field	(3) Volume of Loads[5]	(4) Total Volume, gal (2) × (3)	(5) Volume Per Acre, gal/ac (4) ÷ (A)	(6) Waste Analysis[6] PAN, lb/1,000 gal	(7) PAN Applied, lb/ac [(5) × (6)] ÷ 1,000	(8) N Balance[7], lb/ac (**B**) - (7)
					Panalysis		P balance
			Crop Cycle Totals				

Owner's Signature

Operator's Signature

5 Can be found in operator's manual for the spreader. Contact a local dealer if you do not have your owner's manual.

6 See your manure management plan for sampling frequency. A recent manure analysis is your best method of properly utilizing your manure nutrients.

7 Enter the value received by subtracting column (7) from **(B)**. Continue subtracting column (7) from column (8) following each application event.

Form SLD-1

Solid Manure Application Field Record
For Recording Solid Manure Application Events on Different Fields

Farm Owner		Facility Number		-
Spreader Operator				

Tract #	Field #	Date (mm/dd/yr)	Crop Type	Field Size, ac	Application Method [8]	# of Loads Per Field	Volume of Loads9, tons

[8] SI = soil incorporated (disked); BR = broadcast (surface applied)
[9] Can be found in operator's manual for the spreader. Contact a local dealer if you do not have your owner's manual.

Form SLD-2

Solid Manure Application Field Record
One Form for Each Field per Crop Cycle

Tract # ______ Field # ______

Field Size, ac = **(A)** ______

Farm Owner ______

Facility Number ______ - ______

Spreader Operator ______

From Manure Utilization Plan

Crop Type ______

Recommended PAN Loading, lb/ac = **(B)** Pneeds

(1) Date (mm/dd/yr)	(2) # of Loads Per Field	(3) Weight of Loads[10], tons	(4) Total Weight, tons (2) × (3)	(5) Weight Per Acre, tons/ac (4) ÷ (**A**)	(6) Waste Analysis[11] PAN, lb/ton	(7) PAN Applied, lb/ac (6) × (5)	(8) N Balance[12], lb/ac (**B**) - (7)
					P analysis		P balance
			Crop Cycle Totals				

Owner's Signature

Operator's Signature

[10] Can be found in operator's manual for the spreader. Contact a local dealer if you do not have your owner's manual.
[11] See your manure management plan for sampling frequency. A recent manure analysis is your best method of properly utilizing your manure nutrients.
[12] Enter the value received by subtracting column (7) from **(B)**. Continue subtracting column (7) from column (8) following each application event.

Example of Manure Agreement Wording

Manure Utilization Agreement for Leased Land

I, _______________________________, hereby give _____________________ permission to apply waste from his poultry production facility on ________ acres of my land for the duration of the time shown below.

I understand that this manure contains nitrogen, phosphorus, potassium, and trace elements, and when properly applied should not harm my land or crops. I also understand that the use of animal manure will reduce my need for commercial fertilizer.

Adjacent Landowner: __________________________________ Date: _________

Manure Producer: _____________________________________ Date: _________

Technical Representatives: _____________________________ Date: _________

Term of Agreement: ________________, 20___ to ________________, 20___.

Example of Third Party Form:

Manure Utilization–Third Party Applicator Agreement

I, _______________________________ hereby acknowledge that I have received a copy, have read, and understand the Nutrient Management Plan dated ________________ that was developed for/by ____________________________________ for their facility located at ____ ____ in ___________________ County.

I hereby agree to manage and land apply the manure that I received from this facility in a manner consistent with all federal, sState, and local laws.

Third Party Receiver: __________________________________ Date: 20___

Manure Producer: _____________________________________ Date: 20___

Technical Representatives:

Term of Agreement: ___________________, 20___ to _________________, 20__

Note: This chapter was adapted from the Livestock and Poultry Environmental Stewardship (LPES) curriculum, Lesson 30 authored by Pat Murphy, Kansas State University; Lesson 31 authored by Karl Shaffer, North Carolina State University; Lesson 32 authored by Ron Sheffield, now at the University of Idaho; Lesson 33 authored by Ron Sheffield, now at the University of Idaho, and Pat Murphy, Kansas State University; Lesson 34 authored by Andrew Sharpley, USDA-Agricultural Research Service, and Ron Sheffield, now at the University of Idaho; Lesson 35 authored by Karl Shaffer, North Carolina State University, and Ron Sheffield, now at the University of Idaho; and Lesson 36 authored by Ron Sheffield, now at the University of Idaho, courtesy of MidWest Plan Service, Iowa State University, Ames, Iowa, 50011-3080.

Chapter 10
Coexisting with Neighbors

Casey W. Ritz, Ph.D. Poultry Science Department, University of Georgia (original text from Bulletin 1263, Coexisting with Neighbors: A Poultry Farmers Guide); adapted by Thomas Bass, Biological & Agricultural Engineering Dept., University of Georgia.

The farming environment in which we live is continually changing. Several factors stand out as influences of that change in this day and age: the geographic consolidation of agricultural industries is creating a concentration of agricultural wastes, national public awareness of the environment and pollution has heightened, urban growth is spilling over into our nation's farmland, and few people understand typical farming practices. All too often people feel that lawsuits are the only way to settle these conflicts. Each of these conditions has an influence on the relationship between old farmers, new farmers and their non-farm neighbors alike.

All livestock operations have to deal with neighbor-related issues on a regular basis. As the urban community continues to expand into the rural landscape, conflicts between farm and non-farm neighbors will increase. Many urbanites that move to the country to get away from urban pressures are not accustomed to, nor even understanding of, farming practices and "country living" conditions. They have a disconnect as to where their food comes from and what it takes to get it to their plates. This lack of knowledge has caused the general public to expect pristine environments and aseptic conditions even within production agriculture systems. The presence of dust, odors and insect pests that are normal occurrences with farming operations are not on the radar screen of many urbanites who move to a more rural setting seeking "pastoral" living conditions.

Problems between neighbors can and do arise as the boundaries between rural and urban life blur. A number of issues can cause contention between neighbors, often the result of differing viewpoints. From the farmer's point of view, increases in road traffic and trash, trespass from pets and people, and constraints about normal farming practices may become an issue. For non-farm neighbors, dust and odors, insect pests, noise and obstructed views may become sources of irritation. Some common complaints of non-farm neighbors include:

- Odors that make them physically ill, forcing them to stay inside with closed windows.
- Not being able to invite friends over because of odors and insect pests.

While these problems typically surface where human population is more concentrated, they can arise even in the most rural of counties. Neighbors with a farm background or living on a farm themselves can have the same perception of nuisance toward other farms as those who are new to rural living. They are familiar with agricultural conditions on their own farm or surrounding area, may recognize more readily the source of a particular nuisance, and be less tolerant of situations they believe could be improved.

At times neighbor relations become strained as disagreement over issues heats up. Litigation is too often seen as the means for relief from these conflicts. Litigation, however, rarely results in a true winner because the outcome is often financial cost, physical stress and broken relationships. Whatever the issue may be, preventing problems before they cause a contentious situation is the most effective way to minimize neighbor conflicts. The old adage "an ounce of prevention is worth a pound of cure" certainly applies to the arena of neighbor relations.

Conflict prevention measures can be both tangible and intangible in nature. Communication skills and disseminating information may be as important as minimizing odors or pests through improved management practices. The following are practices and suggestions that can help farmers maintain or improve neighbor relations. Proper manure handling practices are foremost points to consider in avoiding potential nuisance complaints or court action.

- **Get to know your neighbors.** This is perhaps the most important and simplest action you can take. People are more open to discussion with individuals they know. Be neighborly and a good listener. As a result, your neighbors will be more likely to come to you with a complaint instead of reporting you to an authority or enforcement agency. A lack of good will between neighbors is a contributing factor in most nuisance complaints.
- **Operate your farm as if you were the next-door neighbor.** Try understanding their viewpoint as non-farm neighbors living in a farming community. Recognize that neighbors have the right to enjoy their property without the nuisance of flies, odor and dust. Properly maintained and operated livestock and poultry farms do not need to be, and should not be, a nuisance to neighbors.
- **Small things matter in maintaining good relationships, such as a wave and a smile.** Be particularly mindful of sensitive neighbors. Little gestures of friendliness go a long way toward fortifying goodwill. Reward tolerant neighbors with a token of your appreciation — perhaps free poultry litter for their gardens, a neighborhood barbeque, a holiday turkey or something similar.
- **Invite neighbors over the fence.** "Show and tell" your farming operation, explaining the need for some practices that perhaps are unappealing or objectionable. The general public has no idea of what it takes to put food on their tables.
- **Screen some things from public view.** Since people often "smell" with their eyes, screen from public view production, manure storage and composting facilities with the use of tree lines or shelterbelts. Minimizing visibility helps reduce the suggestion that the farm might be a source of odor, flies or other nuisances.
- **Cover manure that is transported on public roadways to prevent spillage and blow out.** Not only is it a sensible practice toward maintaining good neighbor relations, but most states by law require that any material that can blow out during transport, such as poultry litter, must be covered and contained.
- **Cover stored manure** in accordance with best management practices for nutrient retention and water quality protection. A stack house structure common for storing poultry litter, however covering stacked manure with a tarp, keeping it away from roadways, waterways and property lines is advisable and sufficient. Uncovered stacked manure can be a potential water quality problem.
- **Be considerate when land applying manure.** Consider the prevailing winds and weather conditions when spreading manure near neighbors. Allow a little flexibility

in your spreading schedule to accommodate unfavorable spreading conditions. Windy or wet conditions can displace nutrients from where they were intended, causing poor fertilization uniformity and potential contamination problems on adjacent properties. Incorporate manure into the soil wherever and whenever possible to maximize the fertilization benefits from the available nutrients and to minimize odor dispersion and potential nutrient runoff due to storm water.

- **Land apply manure in the morning hours to allow for greater odor dissipation and manure drying throughout the day.** Applying manure in the late afternoon and evening hours allows the still night air to trap and spread odors close to the ground, a common complaint of livestock and poultry farm neighbors.
- **Inform neighbors when you intend to spread manure.** Be willing to be flexible with your spreading schedule to avoid disrupting special occasions such as a backyard wedding, family reunion, etc. Maintain no-spread buffer zones at the property line and avoid spreading on weekends or holidays when neighbors are more likely to be out-of-doors.
- **Keep manure, feed and other organic material around facilities as dry as possible.** Wet materials generate more odors and flies than do those that are kept dry. Clean up spilled feed and manure around the facilities and roadways to prevent an increase of flies, rodents, and odors.
- **Make your farm appealing.** The appearance of the farm plays an important part in what others in the community think of you and your farming operation. Eyesores create less goodwill and public sympathy if problems arise. Farm appearance can easily be construed as a reflection of a farmer’s professionalism, competence and concern for neighborhood conditions.
- **Maintain property line fences.** Sage advice continues to hold true that "good fences make for good neighbors."
- **Develop manure and odor control management plans.** Make sure all employees understand the importance of appropriate manure handling and odor control. Use manure management practices that reduce the release of offensive odors such as composting or transfer of excess manure off the farm. Maintain records of manure application rates and timing as evidence of adhering to appropriate Best Management Practices for manure use.
- **Communicate plans for new construction or expansion with neighbors.** Show how you have taken their concerns about manure management and odor control into consideration. At times this may go further than just being neighborly; it may actually be a requirement where county ordinances stipulate the need for a public hearing or comment period prior to construction or expansion.
- **Give prompt and genuine responses to complaints or problems when they arise.** Be sympathetic and understanding of neighbors’ concerns and avoid being uncaring or arrogant. Sometimes it is better to bite your tongue to do what is best for your farm over the long term. Ignoring issues, whether you feel they are relevant or not, can quickly drive a neighbor to seek legal action. Maintaining open lines of communication will always help resolve issues when they arise. Inform your poultry company of any potential nuisance situations with a neighbor and seek their advice on the issue. Solving the problem may be as simple as making a management change.

- **Consider new alternatives and technologies for manure handling and odor control.** A small investment now may prevent large legal expenses later on.
- **Comply with applicable federal, state and local environmental regulations.** Don't give neighbors legal reason to investigate or sue over environmental infractions.
- **Conduct an environmental self assessment** similar to the University of Georgia Farm*A*Syst program, or have a third party help you identify environmental concerns before they become a nuisance or legal problem.
- **Be active in the community.** Better educate the public by supporting agricultural education activities and outreach programs. Be active with the local government, promoting pro-agriculture public opinion, legislation and regulation. Get to know your local representatives and community decision makers and keep them informed about your business.

While applying these steps may not prevent someone from taking legal action against your farming operation, they can encourage taking reasonable precautions, help control how the farm operates, and assist with neighbor relationships and fostering of good report within the community. Then, should problems arise, your reputation as a conscientious neighbor will enhance the resolution of conflicts.

Developing and improving neighbor relations can be one of the most important activities that help farming operations survive in our changing rural environment. By helping neighbors understand the activities associated with agriculture, farmers may help shape how they feel about agricultural practices and avert needless conflicts and animosity. Treating neighbors with concern and respect will help ensure continuation of appropriate, responsible farming practices in the future.

References:

Bokhari, S. 1989. Ten ways to minimize nuisance complaints. California Poultry Letter. University of California at Davis, Cooperative Extension Service.

Hamilton, N.D. 1992. *A livestock producer's legal guide to: nuisance, land use control, and environmental law.* Drake University Agricultural Law Center Press.

**Hilchey, D., and N. Leonard. 1996. Cultivating farm, neighbor, and community relations.
Farming Alternatives Program, Community Agriculture Development Series, Cornell University.**

Kelsey, T.W., and C.W. Abdalla. 1996. *Good neighbor relations: advice and tips from farmers.* The Pennsylvania State University, Publications Distribution Center.

Chapter 11
Emergency Action Plans

Thomas M. Bass, Biological & Agricultural Engineering Dept., University of Georgia.

Introduction

There are a variety of dangerous situations and accidents that can occur on a farm. The National Safety Council rates the three most dangerous occupations in the U.S. as mining, farming and construction. Not being prepared for emergencies could result in personal injury, property damage and environmental damage on the farm and in the larger community. Accidents you may want to plan for include: fire and explosions, medical emergencies, severe weather, and last but not least, threats to water resources and the environment. While it is a good idea to plan for a variety of accidents, the focus of this chapter is on environmental emergencies.

The largest causes of regulatory fines levied against animal agriculture are manure spills and discharges. Preventing and properly responding to accidental discharges on a farm is everyone's concern. Communication between the farm owner, supervisors, and employees generates ideas and awareness that leads to accident prevention and quick response if a spill does occur. Good, current response plans, and regular inspections of your manure management and application system are essential links in maintaining a safe, accident-free operation.

A properly written, complete plan will…

- Provide essential information to workers and others in the event of an accident
- Demonstrate responsible preparation.
- Protect you and others against environmental damage.
- Meet state or other regulatory requirements.

What is an Emergency Action Plan

An emergency action plan is a basic, yet thorough, common sense plan that will help you, your family, and your employees make the right decisions during an emergency. Such a plan should include three sections:

Part 1 of EAP – Site Plan

The site plan should include a detailed description of the animal production facility site, and land application areas. Your farm map should be a part of this plan and any additional detailed maps or diagrams of buildings and waste storage structures. Consider including the following details on your emergency plan maps and diagrams:

- Entrances and exits from each building
- First aid kit and fire extinguisher location(s)
- Manure storage facility details (access, valves, pumps, switches, etc.)

- Wells, water lines, and water valves
- Electrical service boxes for each building
- Gas lines and all fuel storage
- Tile lines in and near the farmstead, and especially surface inlets
- The location of all emergency equipment
- All land application areas normally used
- Property boundaries
- Emergency land application areas (should be nearby and usable all year)
- Nearby water resources to protect such as creeks, streams, rivers, wetlands, and lakes
- Tile lines, surface inlets, and outlet locations
- Drainage ways and potential locations of emergency berms or storage

Part 2 of EAP – Emergency contact information

A phone tree or contact sheet should be made with the names and phone numbers of anyone who might be able to help in the event of an emergency. Suggested contacts for an emergency contact sheet include:

- Farm Owner
- Manager
- Assistant Manager
- Emergency Response Agencies and Law Enforcement
- Earth Moving and Pump Equipment
- Technical Assistance Providers (Extension, NRCS, Consultants)
- Neighbors
- Local Health Department
- Environmental Agency
- Department of Agriculture

This sheet should be posted next to every telephone so that even part-time employees or a stranger could make emergency calls if necessary. A copy should also be maintained in your Emergency Action Plan file.

The following information should be provided during an emergency call. Make sure someone is always on-farm who can speak English.

- Facility address
- Physical directions to the facility, (i.e. 3 miles west of "town" on County D3, and ½ mile North)
- Human injuries (known or suspected)
- Type of emergency or spill
- Direction spill is headed (water impacted)
- How long has spill been going on/when did it occur
- Steps already taken address the situation

Part 3 of EAP - Plan of Action for Manure Spills

Do not wait until manure or wastewater reaches a stream or leaves your property to acknowledge that you have a problem; make every effort to ensure that this situation does not happen. Your Emergency Action Plan should be available to all employees, and they should be trained in its use because accidents, leaks, and breaks can happen at any time. To be most effective, your Emergency Action Plan should follow these steps:

- Eliminate the source
- Contain the spill, if possible
- Assess the extent of the spill and note any obvious damage
- Notify the appropriate agencies
- Clean up the spill and make repairs
- Prepare and submit a summary report

Considering these generic steps, you should write specific responses to emergencies that could cause the most damage and are possible considering the type of storage and application systems you have.

Post-spill assessment and reporting

If a spill occurs on your farm, the Georgia Environmental Protection Division requires that you report the spill within 48 hours and will normally require a written report to be submitted following the accident. Environmental emergencies in Georgia can be reported at 800-241-4113. Assessments or "follow-up" reports give you and the regulatory agency an opportunity to reflect and learn from the events that led up to the spill and those actions that were taken following the spill. The following suggestions provide the information that should be included in a post-spill assessment report. This record will help you should any legal action result, and will help you prevent similar occurrences in the future.

- Assess the extent of the spill and note any obvious damages
    - Did the waste reach any surface waters, wetlands, tile drains, or wells?
    - Approximately how much manure was released and for what duration?
    - Did you note any damage, such as employee injury, fish kills, or property damage?
- Response to spill
    - When and where was the spill contained?
    - What measures were taken to avoid additional contamination and threat to the environment or human health?
    - Did anyone or any local group assist in the cleanup?
    - Was a technical specialist (NRCS, Conservation District, or engineer) consulted? What corrective actions are necessary to repair any damage to your storage structure, manure transfer, or application equipment?
- Cause of the spill
    - Can you determine the cause of the spill or discharge?
    - If appropriate, were signs present of the condition before the accident occurred?

- Contact the appropriate agencies
    - When were local and state agencies contacted (record the day, hour, and minute), notifying them of the spill?
    - Did a representative of the state water quality agency or health department respond to the notification? List names, titles, and agencies.
    - Did state or local representatives give you any "special" instructions?

Creating a Community Response Plan

When an emergency arises, you may need the assistance of neighboring farmers, fire departments, or other county services. Consider who in the community (producers, farmers, or community services) owns equipment that may be locally available for use in the event of a manure spill. Large equipment or custom services that may be necessary to respond to and clean up a manure spill include: earth moving equipment, generators, pumps, tanker wagons, irrigation equipment and dump trucks. Also in a an emergency you may want permission to access neighboring property if there is a chance to stop a spill from reaching surface waters.

Note: Excerpts taken from Livestock and Poultry Environmental Stewardship Curriculum, Lesson 50 "Emergency Action Plans" and ISU Extension pub Pm-1859, "Emergency Action Plans".

Chapter 12
Resources for Small Animal Feeding Operations

AGENCIES & PEOPLE

UGA Cooperative Extension County Agents: look for Extension in the local government section of your phone book, or visit: http://www.caes.uga.edu/extension

Georgia Soil and Water Conservation Commission (GASWCC): call (706) 542-3065 to locate your nearest office and Conservation District, or visit: http://www.gaswcc.org

Natural Resource Conservation Service (USDA-NRCS): call (706) 546-2272 to locate your nearest USDA Service Center, or visit: http://www.ga.nrcs.usda.gov

Georgia Department of Agriculture – Livestock and Poultry Field Forces: call (404) 656-3665, or visit: http://www.agr.state.ga.us

Georgia DNR, Environmental Protection Division: call (404) 657-5947 or (888) 373-5947 (toll free outside metro Atlanta), or visit: http://crd.dnr.state.ga.us

Georgia DNR, Coastal Resources Division: call (912) 264-7218, or visit: http://crd.dnr.state.ga.us

INTERNET

Agricultural Pollution Prevention Program Homepage (AgP^2): this is a one stop source for conservation and pollution prevention information in Georgia, visit: http://www.agp2.org

USDA-CSREES Water Quality Program: cooperative program between USDA and state land-grant universities, also known as National Extension Water Quality Program: http://www.usawaterquality.org

> **Southern Region Water Quality Program**: direct link to southern region of the USDA-CSREES WQ Program: http://srwqis.tamu.edu

EPA Agricultural Compliance Center: USEPA program and regulatory information is available at: http://www.epa.gov/agriculture

PRINT

Animal Waste System Operator Certification Manual: this is the manual used in the required certification program for medium sized and larger feeding operations. Hard copies are available for a fee and an online version exists at: http://www.agp2.org/aware

Best Management Practices for Georgia Agriculture – Conservation Practices to Protect Surface Water Quality: published by the GASWCC, this manual provides more technical descriptions for implementing practices. Contact the Commission as referenced above.

Georgia Poultry Environmental Management System Guidebook: this resource was designed with poultry growers in mind, but the process and exercises contained can help any producer manage environmental issues and continually improve the operation. Hard copies are available for a fee and an online version exists at: http://www.agp2.org/aware

Georgia Farm*A*Syst Environmental Self Assessments: The Georgia Farm*A*Syst program provides farmers and rural residents with risk assessments - a tool to identify environmental and health risks and to supply information on corrective actions. Twenty-one modules exist. Hard copies are available and an online version exists at: http://www.agp2.org/aware

Learning for Life

Bulletin 1293 **Reviewed May, 2009**

The University of Georgia and Ft. Valley State University, the U.S. Department of Agriculture and counties of the state cooperating. Cooperative Extension, the University of Georgia College of Agricultural and Environmental Sciences, offers educational programs, assistance and materials to all people without regard to race, color, national origin, age, gender or disability.

An Equal Opportunity Employer/Affirmative Action Organization

Committed to a Diverse Work Force