DAIRY

LSU AgCenter
Research & Extension

Sustainable Dairy Production

BEST MANAGEMENT PRACTICES (BMPs)

endorsed by

Louisiana Department of Agriculture and Forestry
NRCS
Farm Bureau Louisiana

Table of Contents

Why BMPs Are Important to Louisiana

In Louisiana we are blessed with beautiful and abundant waters to enjoy fishing, hunting, boating or just relaxing on the shore of a lake, river or bayou. Most of the water in Louisiana's rivers and lakes comes from rainfall runoff. As this runoff travels across the soil surface, it carries with it soil particles, organic matter and nutrients, such as nitrogen and phosphorus. Agricultural activities contribute to the amount of these materials entering streams, lakes, estuaries and groundwater. In addition to assuring an abundant, affordable food supply, Louisiana farmers must strive to protect the environment.

Research and educational programs on environmental issues related to the use and management of natural resources have always been an important part of the LSU AgCenter's mission. Working with representatives from agricultural commodity groups, the Natural Resources Conservation Service (NRCS), the Louisiana Department of Environmental Quality (LDEQ), the Louisiana Farm Bureau Federation (LFBF) and the Louisiana Department of Agriculture and Forestry (LDAF), the LSU AgCenter has taken the lead in assembling a group of best management practices (BMPs) for each agricultural commodity in Louisiana.

BMPs are practices used by agricultural producers to control the generation and delivery of pollutants from agricultural activities to water resources of the state and thereby reduce the amount of agricultural pollutants entering surface water and groundwater. Each BMP is a culmination of years of research and demonstrations conducted by agricultural research scientists and soil engineers. A list of BMPs and accompanying standards and specifications are published by the NRCS in its Field Office Technical Guide.

Introduction

The dairy industry is one of the most important animal industries in Louisiana, contributing more than $199 million to the state's economy in 2007. Although dairy farms are located in 16 parishes, the area made up of Tangipahoa, Washington and St. Helena parishes has the largest concentration of dairy farms. Another area of high concentration is DeSoto Parish. Dairying, by its nature, requires specific practices to conserve and protect soil and water resources.

Best management practices (BMPs) have been determined to be an effective and practical means of reducing point- and nonpoint-source water pollutants at levels compatible with environmental quality goals. The primary purpose for implementation of BMPs is to conserve and protect soil, water and air resources. BMPs for dairy farms are a specific set of practices used by farmers to reduce the amount of soil, nutrients, pesticides and microbial contaminants entering surface water and groundwater while maintaining or improving the productivity of agricultural land. This list of BMPs is a guide for the selection and implementation of those practices that will help dairy farmers to conserve soil and protect water and air resources by reducing pollutants from reaching both surface water and groundwater.

dairy BMPs

The Practical Side of BMPs

By implementing or using best management practices (BMPs), Louisiana dairy producers are minimizing pollution of water resources of the state as well as saving money in some cases. Sediment runoff reduction is one of the most important practices a dairy producer can strive for, both from an economical and environmental perspective. Sediment is the largest pollutant by volume of surface water in the nation. Sediment pollution comes from several sources including agricultural operations that leave bare soil exposed to rainfall.

From an economic perspective, allowing nutrient-laden soil to run off the dairy and into rivers and streams is a financial loss to the operation. Soil lost in this manner can never be used by the dairy farmer again to produce forage or grazing pastures to support production. Retaining as much soil as possible can reduce the amount of fertilizers and other soil amendments needed to maintain adequate forage and grazing acreage.

Negative environmental effects that are increasingly noticed and can cause much concern to the public and environmental regulatory agencies include increasing the turbidity of water, reducing light penetration, impairing photosynthesis and altering oxygen relationships (which can reduce the available food supply for certain aquatic organisms). It can adversely affect fish populations in areas where sediment deposits cover spawning beds and also, in some situations and given a long enough period of time, partially fill lakes and reservoirs.

In addition, sediment often is rich in organic matter. Nutrients such as nitrogen and phosphorus and certain pesticides may enter streams with sediment. The potentially harmful effects of these substances accompanying the sediment may include rapid algae growth, oxygen depletion as organic matter and algae decompose, fish kills from oxygen depletion, toxic effects of pesticides on aquatic life and unsafe drinking water caused by nitrate or pesticide content.

Manure runoff reduction is of paramount importance to dairy operators. Dairy producers should practice all cost-effective methods to ensure lagoon, paddock and parlor wastes are handled and treated properly. One of the greatest concerns of the regulatory agencies and the public is the escape of manure runoff and the accompanying bacteria and nutrients that can enter the streams and tributaries of Louisiana's surface waters. Many of the water bodies in Louisiana that are listed as impaired and require attention by the U.S. Environmental Protection Agency and the Louisiana Department of Environmental Quality are polluted with fecal coliform bacteria and do not meet their designated use for swimming, water contact or fishing. Not all of this pollution can be attributed to livestock operations, but in the public's mind livestock is always at least part of the source. Fecal coliform is a term used to describe bacteria found in the intestinal tract of warm-blooded animals. Surface waters are monitored for the presence and concentration of fecal coliforms. Not all coliforms are harmful to human health. In fact, some fecal coliforms are normal and essential for human digestion. Without them, our digestive system would not function properly.

Sediment is the No. 1 pollutant in Louisiana.

If fecal material is present in stream segments in excessive concentrations, the Louisiana Department of Health and Hospitals (DHH) states there is the potential for other harmful pathogens to also be present. Some forms of coliforms such as a few strains of E. coli can be transmitted from cattle to humans or from person to person and may be harmful to human health. When excessive concentrations of fecal coliforms are found in monitored rivers and streams, DHH may issue advisories or closures of affected surface waters. Additionally, manure runoff also contains nitrogen and phosphorus and can result in nutrient overenrichment of water bodies, which can cause algae blooms and oxygen depletion in surface waters and result in killing fish and other aquatic animals.

Nutrient management is another profoundly important aspect of dairy operation, and much attention is given to this aspect of dairy management in this manual. Excessive nutrient runoff can cost the farm significant amounts of money. Often, without a sound, comprehensive nutrient management plan, dairy producers may apply too much of these essential elements. When this occurs, it's just money down the river. Excessive nutrients cost the operation money and ultimately run off the farm and pose environmental problems in nearby surface waters.

Nutrients such as nitrogen and phosphorus can become pollutants. Both are essential for all plant growth and therefore essential for the proper function of ecosystems and necessary for all agricultural operations. Excessive nitrogen and phosphorus concentrations in water, however, can accelerate algae and plant growth in streams and lakes, resulting in oxygen depletion or critically low dissolved oxygen levels. Often referred to as nutrient overenrichment or hypoxia, it is a major concern in many water bodies of Louisiana and the Gulf of Mexico.

Whole farm nutrient planning

Both the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Agriculture (USDA) are encouraging a voluntary approach to handling nonpoint-source pollution issues related to animal agriculture. The implementation of comprehensive nutrient management plans (CNMP) by all dairy producers will ensure that the nutrient value of manure is managed in an environmentally friendly fashion by either (1) properly using manure on the land based on its nutrient value or (2) transferring the manure to an alternative use program.

Manure is an excellent source of organic nutrients that can be incorporated into most farming operations when properly managed. For dairy producers, the proper management of manure is a major consideration in daily operations. Whether the material is used as a nutrient source on land controlled by the producer, provided as a nutrient source on other lands or is offered as a material in an alternative use process, the proper management of the manure is essential. Storage, transportation, application, disease prevention and proper documentation are just a few of the items that need to be included in the manure management plan.

Whole farm nutrient planning is a strategy for making wise use of plant nutrients to enhance farm profits while protecting water resources. Such a plan looks at every part of your farming operation and helps you make the best use of manures, fertilizers and other nutrient sources. Successful nutrient management requires thorough planning and recognizes that every farm is different. The type of farming you do and the specifics of your operation will affect your plan or CNMP. The best plan is one that is matched to the farming operation and the needs of the person implementing the plan.

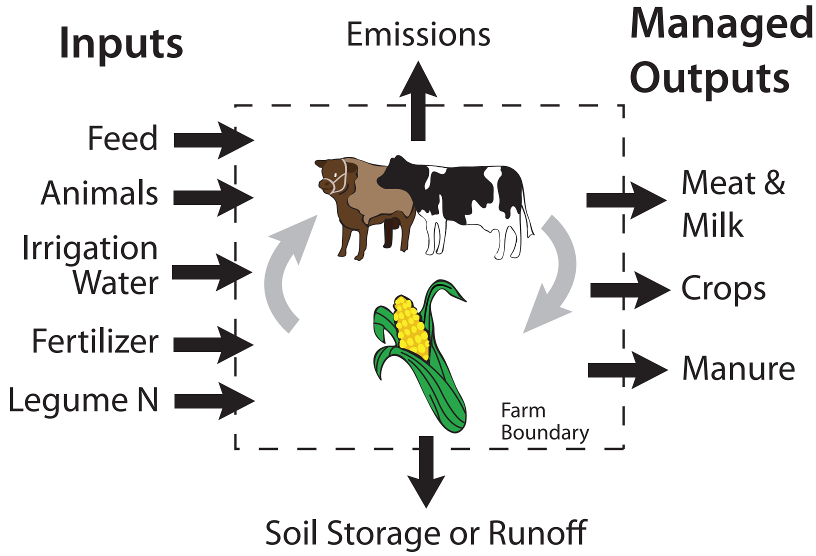


Figure 1. A whole farm nutrient balance considers all nutrient inputs and managed outputs. The difference or imbalance drives the farm's air and water quality risks.

A CNMP takes into account how nutrients are used and managed throughout the farm. It is more than a nutrient management plan that looks only at nutrient supply and needs for a particular field. Nutrients are brought to the farm through feeds, fertilizers, animal manures and other off-farm inputs. These inputs are used, and some are recycled by plants and animals on the farm. Nutrients then leave the farm in harvested crops and animal products. These are nutrient removals. Ideally, the amounts of nutrient inputs and removals should be roughly the same. When nutrient inputs to the farm greatly exceed nutrient removals from the farm, the risk of nutrient losses to groundwater and surface water is increased. When you compare nutrient inputs and nutrient removals, you are creating a mass balance. This nutrient mass balance is an important part of a CNMP and is important to understand for your individual farming operation.

Whole farm nutrient balance

Nutrients are transported along multiple pathways and in a variety of forms on a livestock operation. Our tendency is to focus on a small part of the total picture, such as the nutrients in manure and their loss into the environment. An understanding of the big picture is necessary, however, to identify the underlying cause of nutrient concentration concerns as well as the solutions.

A picture of the flow of nutrients is presented in Figure 1. Nutrients arrive on a livestock operation as purchased products (fertilizer, animal feed and purchased animals), in rain and irrigation water and nitrogen (N) fixed by legume crops. These "inputs" are the origin of all nutrients required for crop and livestock production that accumulate in soils as well as those nutrients that escape into the environment.

Within the boundaries of the farm, there is "recycling" of nutrients between the livestock and crops. Manure nutrients are recycled, at

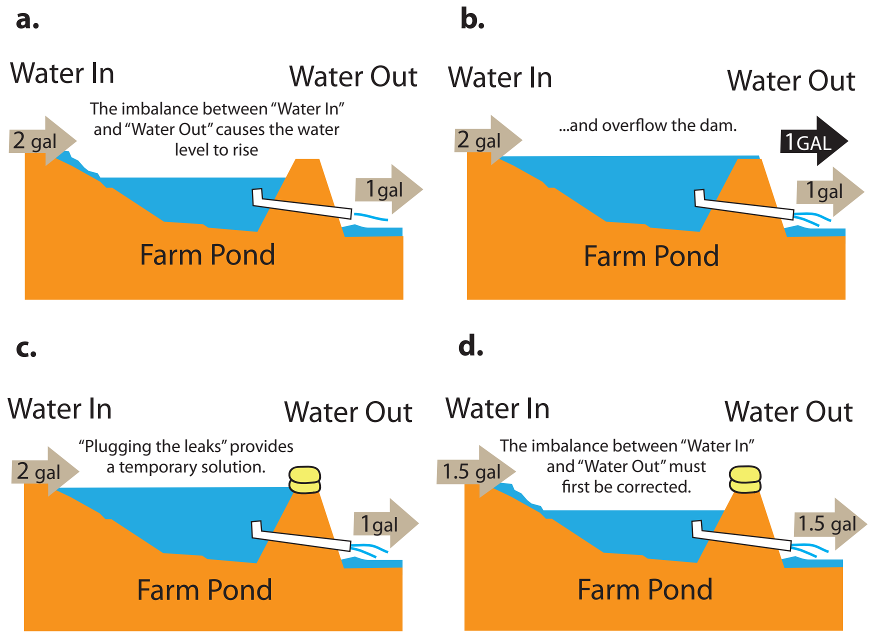


Figure 2. A farm pond as a sustainability tool.

least in part, for crop production. Feed crop nutrients are in turn recycled as animal feed for livestock or poultry production.

Nutrients exit a livestock operation preferably as "managed outputs" including animals and crops sold and possibly other products moved off farm (for example, manure sold or given to a neighboring crop producer). Some nutrients exit the farm as losses to the environment (nitrates in groundwater, ammonia volatilized into the atmosphere, and nitrogen and phosphorus into surface water). Nutrients (especially phosphorus and potassium) 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.

The "imbalance" is the difference between the inputs and the managed outputs. This imbalance accounts for both the direct environmental loss and the accumulation of nutrients in the soil. Livestock operations with a significant imbalance are concentrating nutrients, resulting in increased risk to water quality. In contrast, livestock operations that have achieved a balance represent a potentially sustainable production system. An analogy can be drawn between the whole farm nutrient balance for a livestock operation and water flow in a farm pond (Figure 2). The farm pond is the equivalent of a livestock and cropping operation (whole farm). The "water in" and "water out" (of the pipe) are respectively comparable to nutrient inputs and managed outputs. If the flow of water into the pond exceeds the outflow, the pond level rises. Similarly, if the nutrients entering a livestock operation exceed the nutrients leaving as managed products, the nutrients concentrate within the farm (for example, rising soil phosphorus levels).

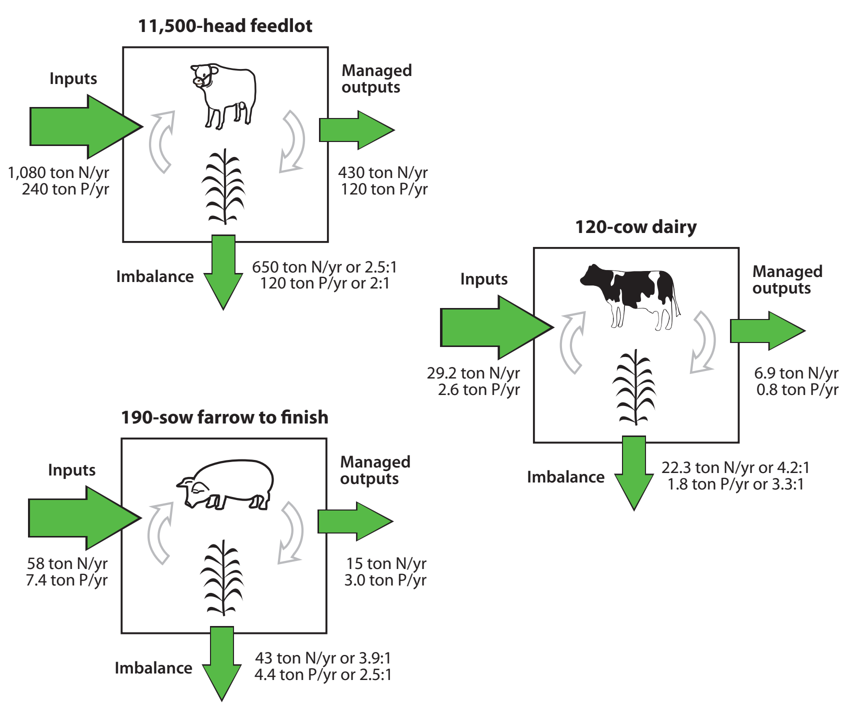


Figure 3. Typical nutrient imbalance observed for several different livestock systems.

If that imbalance is sustained in a pond, water eventually flows over the top of the dam with potentially catastrophic results. Similarly with nutrients, the imbalance eventually is corrected by losses to the environment (for example, nitrates leaching to groundwater or phosphorus exiting with runoff and erosion) of similar magnitude as the imbalance of water. A sustained nutrient imbalance leads to nutrient contamination of water.

Sandbags provide a temporary solution to this problem in a pond. If the water imbalance is not corrected, however, the water level eventually exceeds what the sandbags can hold back. Many current best management practices (BMPs) for manure handling focus on plugging leaks without correcting the origin of the imbalance. BMPs such as grass filter strips, prohibiting applications on frozen soil or soil erosion control do not correct the imbalance and provide only short-term benefits.

Ultimately the imbalance of water flows must be corrected to save the dam and the property downstream. To achieve a balance, the quantity of water entering the pond needs to be reduced and/or the water exiting the outlet pipe must be increased. Similarly, nutrient management planning must ensure a whole farm nutrient balance. The nutrients arriving on farm must roughly balance those exiting the farm in managed products. After a balance is achieved, then BMPs designed to plug the leaks will provide additional long-term benefits.

For the purpose of this discussion, nutrient imbalance will be expressed as a ratio of inputs to managed outputs. A ratio of three to one (3:1) suggests that for every 3 pounds of nutrient entering a farm, 1 pound leaves as a managed product and the remaining 2 pounds are lost to the environment or accumulate in soil.

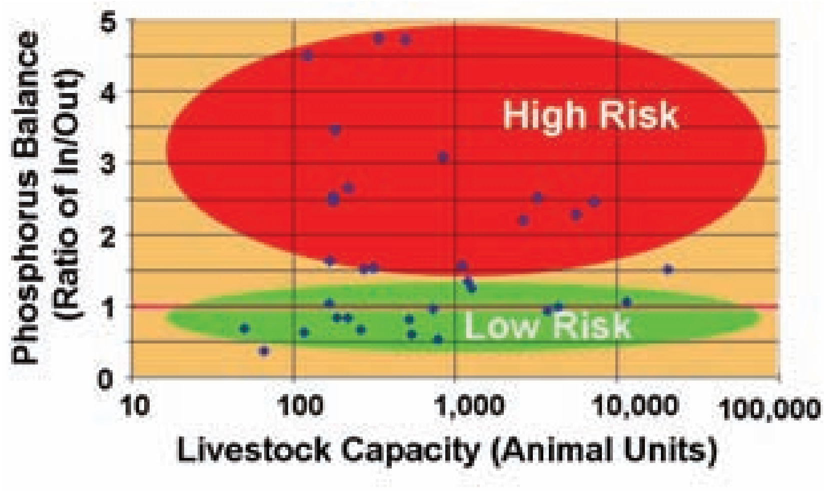


Figure 4. Phosphorus balance versus size for 33 Nebraska livestock operations.

Typical nutrient balances

The nutrient balance is illustrated for a feedlot, dairy and swine operation in Figure 3. For this feedlot, the input-to-output ratio was 2.5:1 for nitrogen (imbalance of 650 tons per year) and 2:1 for phosphorus (imbalance of 120 tons per year). The magnitude of the imbalance is smaller for the dairy and swine operations. However, the ratio of inputs to outputs ranges from 2.5:1 to more than 4:1. Input-to-output ratios of 2:1 up to 4:1 are common for many livestock operations.

Size generally is a poor indicator of the nutrient imbalance in livestock operations. A review of the whole farm nutrient balance for 33 Nebraska swine confinements and beef feedlots did not observe a trend between an increasing imbalance and larger livestock operations as shown in Figure 4. Many of the operations involved in this study experienced a phosphorus balance near the ideal 1:1 ratio while some exceeded ratios of 4:1. Several of the worst imbalances were observed for livestock operations with less than 1,000 animals.

A phosphorus balance provides a preferred indicator of the risk to water quality. An imbalance in nitrogen does not distinguish between the relatively benign losses (for example, denitrification of nitrate to N_2 gas) and the relatively harmful environmental losses (for example, nitrate loss to water or ammonia volatilization). In contrast, phosphorus losses affect only water quality through increased soil phosphorus levels and greater concentration of phosphorus in surface runoff water.

Farms with a phosphorus input-to-output ratio near 1:1 ("low risk" group in Figure 4) have the potential to be environmentally sustainable. Since soil is the primary reservoir for phosphorus, average soil phosphorus should not increase for an input-output ratio near 1:1. If manure is managed appropriately within the available land base, the nutrient-related water quality risk should not increase.

Livestock operations with a large imbalance (1.5:1 and greater) can expect steadily increasing soil phosphorus levels. Runoff and erosion from lands of these operations carry an increasing phosphorus load as soil phosphorus levels increase. Measures to reduce runoff and erosion will partially reduce this risk and provide temporary solutions. But eventually the phosphorus imbalance must be corrected before this growing pollution potential

will stabilize. These “high risk” operations are not environmentally sustainable.

BMPs also are important to a successful comprehensive nutritient management plan (CNMP) and help us manage the imbalances on dairies. BMPs, such as soil testing and manure analysis, help you select the right nutrient rate and application strategy so that crops use nutrients efficiently. This not only reduces nutrient losses and protects the environment but also increases farm profitability. BMPs may include managing the farm to reduce soil erosion and improve soil tilth through conservation tillage, planting cover crops to use excess nutrients or using filter strips and buffers to protect water quality. Preventive maintenance, record keeping and emergency response plans must be included in a CNMP for dairy operations, too.

Feeding Management

Feeding management involves feed acquisition and allocation in quantity and quality sufficient to supply the herd’s nutrient demands for a given period of time. In other words, feeding management is the mix of feeds (sources of nutrients) acquired or grown within the operation with the intention to maximize production and health, maximize profitability and/or minimize nutrient surplus while maintaining production levels. Feed management is intended for balancing feed demand and supply, thus playing an important role in minimizing the nutrient surplus of livestock production systems. In order to maintain this balance, the dairy producer must comprehend the processes involved with feeding management.

A number of factors influence producers’ choices of feeds and feeding programs. Costs of fossil fuel, fertilizers and feeds are a major limitation to profitability in Louisiana dairy operations. Feed prices alone often account for more than half of dairy producers’ budgets. More recently, public opinion and environmental legislation also are exerting tremendous pressure on livestock producers to apply management practices that minimize environmental and health hazards outside farm boundaries. That is at least in part because unintended exports of excess nutrients from agricultural fields can result in degradation of pristine habitats. Figure 5 shows some of the most important nutrient inputs to and outputs from a dairy operation. Feed choices also represent a large source of nutrients imported into the livestock operation. Minimizing reliance on imported/purchased feeds by closely matching nutrient supply to animals’ demand is one of the simplest practices to optimize nutrient utilization. Proper nutrient use on the farm is a win-win situation because the potential for environmental hazards and operational costs are minimized.

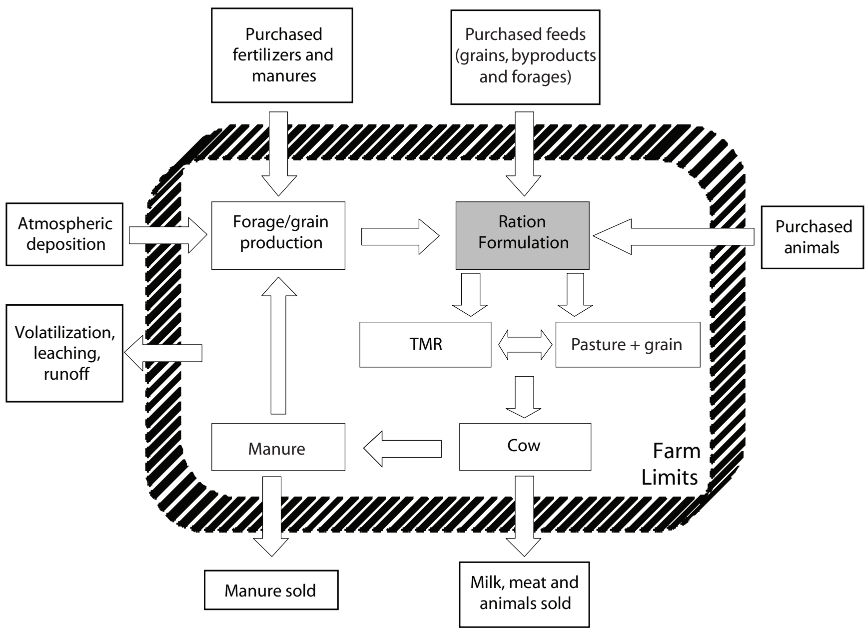


Figure 5. Schematic of important aspects of nutrient management in a dairy operation.

Ration formulation

A precisely formulated ration is a key aspect of feeding and nutrient management for any animal production operation. The important role played by ration formulation in nutrient management is highlighted in Figure 5. Knowledge of animal nutrient requirements (demand) and feed nutrient quantity and quality (supply) are paramount for successful ration formulation.

Animal requirements

Nutrient requirement standards for most economically important species have been reported by the National Research Council (NRC) since the early 20th century (http://www.nap.edu/catalog/nrs/). NRC's most recent edition of the Nutrient Requirements of Dairy Cattle was issued in 2001. Calculations of nutrient requirements and their interactions are integrated by the 2001 Dairy NRC in a computer model (free for download) that allows for accurate estimates of nutrient requirements and dynamic ration evaluation.

Two aspects must be considered to evaluate a ration's adequacy: the nutrients supplied by the diet (nutrients contained in feeds ingested) and the animals' nutrient demand. Nutrient needs for different body functions are dynamic, because nutrient requirements are constantly changing in accordance with body maintenance, body growth, reproductive status, production levels and their interactions with ambient conditions. For instance, lactating cows require different amounts of nutrients from dry or pre-calving cows. Also, pregnant heifers need fewer nutrients per pound of feed than suckling calves. Because of that, rations should be formulated for as many animal categories as practically and economically feasible for every dairy operation. Separately feeding homogeneous groups can improve the opportunity for better nutrient management while maintaining or boosting animal performance and health.

Dry matter intake (DMI)

Accurate knowledge of feed intake is fundamental to the delivery of nutrients in sufficient amounts to obtain optimum animal health and production. Dry matter intake changes with a number of factors including level of milk production, stage of lactation, body weight, breed, diet moisture and fiber contents and climate. Figure 6 exemplifies the effect of milk production and stage of lactation on dry matter intake.

Underfeeding animals can result in low yields and poor health. Overfeeding also can impair health through overconditioning and potential toxicity. Another obvious consequence of overfeeding is the excessive excretion of nutrients. Less obvious but equally problematic is that animals also will excrete excessive amounts of certain nutrients if other nutrients are ingested in insufficient quantity for a given production level. For example, if dietary protein and phosphorus are offered in quantities sufficient to supply the requirements of a heifer to gain 2 pounds per day but energy levels can only supply 1 pound body weight growth per day, protein and phosphorus that would be used for the extra pound of daily growth will be voided in manure, increasing the potential environmental burden of the system. The situation described above easily can be realized in Louisiana when heifers are raised on pastures and are transitioning from cool-season forages to warm-season forages or vice versa but the concentrate mixes are not adjusted for protein and phosphorus content.

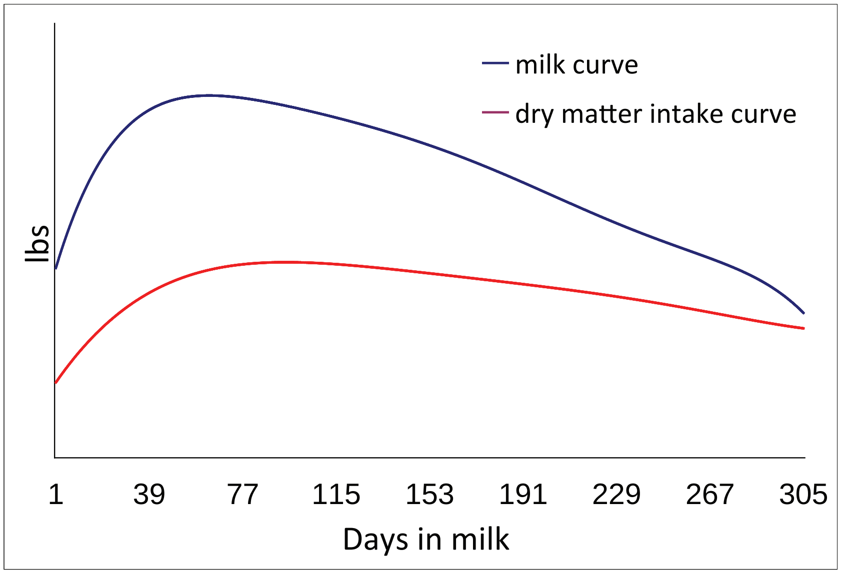


Figure 6. Typical daily milk production and dry matter intake curves throughout the lactation of high-producing dairy cows.

Crude protein (CP)

Protein content in feedstuffs usually is referred to as CP. In the laboratory, feed samples actually are analyzed for nitrogen (N) content, and CP is calculated as:

$$CP = N \times 6.25$$

In the 2001 dairy NRC, feed protein supply is divided into two fractions: rumen-degraded protein (RDP) and rumen-undegraded protein (RUP), where:

$$CP = RDP + RUP$$

Rumen-degraded protein supplies microbial needs. Microbial protein in turn provides high-quality amino acids (protein building blocks) but not in quantity sufficient to fulfill the requirements of a high-producing dairy cow.

Feeding Management

The remainder must be supplied by high-quality protein feed sources in the form of RUP. It is important to point out that RUP and microbial protein must be digested into amino acids before absorption takes place in the cows' intestines. Therefore, amino acid profile of proteins in feeds must be taken into consideration when formulating rations for very-high-producing cows.

The NRC (2001) is a dynamic model that incorporates animal to feed interactions, as well as feed to feed interactions, thus rendering tabulated requirements less important. That means each feed that is included in the ration can affect animal nutrient requirements and availability of other nutrients. In spite of that, it can be generalized that dietary CP contents between 16.5 percent and 17.5 percent of the DM should supply the protein requirements of early lactation dairy cows under most modern dairy farm conditions. Dietary CP should be equal to or below 16.5 percent as cows approach mid- to late lactation.

Phosphorus (P)

Cows are able to convert relatively low-quality feedstuffs into a nutritious food for human consumption. Unfortunately, the efficiency of that conversion is limited. For every 100 parts of phosphorus fed to a cow, we can at best, hope for a third to be turned into milk or stored as the cow's body grows. That proportion can be much lower if ration phosphorus is fed well above a cow's requirement. Cows are particularly efficient at absorbing from intestines and recycling body phosphorus as needed for milk production and other body functions. Therefore, most of the remaining two-thirds of the phosphorus ingested by a cow is excreted in feces, and a very small portion is lost in urine.

The NRC (2001) recommends that lactating dairy cows receive between 0.32 percent and 0.42 percent phosphorus in the diet dry matter (DM) depending on a variety of animal and feed factors such as milk yield, dry matter intake, and feed phosphorus availability. Recommended levels are sufficient to maintain body functions, growth, reproductive performance and high milk yield.

The Forage Quality Laboratory at the LSU AgCenter's Southeast Research Station analyzed 527 samples of TMR for phosphorus over a period of more than nine years (1999 to 2008). The phosphorus content averaged 0.48 percent (± 0.09) of the DM. Only 18.5 percent, or 98 samples, were within the NRC's (2001) recommended phosphorus range. Nearly 78 percent of the TMR samples submitted to the laboratory were above maximum recommended phosphorus levels of 0.42 percent.

Phosphorus is one of the most expensive chemical elements in a cow's diet. Feeding diets with excess phosphorus have high costs, not only directly related to phosphorus supplementation cost but also indirectly to financial, social and environmental costs. It has been estimated that more than $10 to $15 per cow per lactation can be saved simply by avoiding purchase of expensive and unnecessary phosphorus supplement. In the event that phosphorus limits are imposed by legislation, low-phosphorus manure will require less land for manure application or may allow for increased herd size when soil phosphorus is taken into account. Lower manure phosphorus may reduce the need for purchased fertilizer by providing an nitrogen-to-phosphorus ratio closer to crop requirements (~7:1). Along with management practices to reduce soil erosion, lowering manure phosphorus content will substantially lower phosphorus loading into public waters from Louisiana dairy farms.

Potassium (K)

Lactating dairy cows have high demand for potassium. As much as an ounce of potassium will be secreted with every 42 pounds of milk, but even larger quantities are lost with sweat, feces and particularly urine. Those requirements must be supplied on a daily basis because potassium is not stored in the body. NRC (2001) recommends dietary potassium levels ranging from 1.0 percent to 1.2 percent of the dry matter.

Despite recognition that the requirement increases with higher temperatures (sweating), the NRC (2001) potassium model does not take into consideration ambient temperature to calculate potassium requirements. Furthermore, potassium is an important factor in DCAD (Dietary Cation-Anion Difference) calculations, together with sodium (Na) and chlorine (Cl). There has been increased interest in how DCAD affects acid-base balance of dairy cows. Whereas a low DCAD (in general, lower dietary potassium and sodium and high chlorine) has been recommended for periparturient cows to prevent milk fever, higher postpartum DCAD (~+200 meq/kg) is suggested to maximize milk production. This dichotomy raises concerns and complicates potassium balance in a nutrient management plan.

Feed quality

Dairy animals have nutrient requirements that must be supplied daily. Rations deficient in a given nutrient will limit animal performance and may result in economic loss to the producer. Animals limited by a nutrient deficiency will increase loss of other nutrients fed to supply requirements. A major challenge of feeding dairy cows is to ensure consistent daily nutrient delivery in a ration. The variability of nutrient delivery can originate from changes in plant ingredients (species, maturity, growing conditions, soil fertility, harvesting and storage), in byproduct sources (processing methods, chemical treatments and fermentation), and during ration preparation (grinding, chopping, weighing, mixing and contamination). Feeding practices need to be adjusted to account for feed quality variability. Table 1 presents examples of composition variability in feeds analyzed at the LSU AgCenter's Southeast Research Station Forage Quality Laboratory.

Table 1. Composition means and variation (standard deviation) of feeds analyzed at the LSU AgCenter's Southeast Research Station Forage Quality Laboratory (1999-2008).

			Analyses Results[1]						
Feeds	Number of Samples		DM	CP	NDF	ADF	TDN[2]	Ca	P
Alfalfa	347	Means	85.3	21.3	41.1	30.4	66.4	1.39	0.26
		SD[3]	13.1	3.66	10.9	5.4	5.6	0.33	0.05
Bahiagrass	770	Means	85.6	8.1	69.3	42.0	50.1	0.32	0.20
		SD	15.7	2.56	10.7	3.51	3.51	0.14	0.07
Bermuda grass	2,329	Means	86.8	10.3	71.3	38.0	54.0	0.39	0.24
		SD	13.5	3.35	8.38	3.62	3.68	1.48	0.06
Ryegrass	1,671	Means	54.5	14.8	36.0	58.5	62.8	0.29	0.61
		SD	28.2	6.43	7.63	11.4	8.47	0.11	2.59
Corn silage	882	Means	28.8	8.73	49.6	30.0	66.2	0.18	0.20
		SD	6.06	1.46	8.88	4.91	5.35	0.08	0.06
Forage sorghum	80	Means	25.3	9.90	63.6	39.5	50.6	0.24	0.11
		SD	12.5	2.61	12.4	5.73	4.79	0.12	0.07
Corn grain	41	Means	84.3	9.18	NA	9.77	NA	0.26	0.30
		SD	8.58	3.57	NA	14.0	NA	0.38	0.19
Soybean meal	40	Means	90.2	50.45	NA	5.22	NA	2.51	1.26
		SD	0.96	5.53	NA	2.45	NA	1.81	0.65
Brewers' grains	39	Means	27.6	29.9	48.6	23.4	NA	0.23	0.54
		SD	15.0	4.15	NA	3.38	NA	0.11	0.11

[1] Analyses results: DM = dry matter; CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; TDN = total digestible nutrients; Ca = calcium; P = phosphorus.
[2] TDN is estimated by equations based on ADF content.
[3] SD = standard deviation.

Multiple feeds must be offered in adequate amounts to produce rations that can supply the amounts of protein, energy, minerals and vitamins required daily by cows. Forages usually account for the greatest proportion of feeds in a dairy ration, thus supplying a large fraction of those nutrients. The amount of concentrate that needs to be fed to ruminants is a function of forage quality and animal requirement, determined mostly by yield expectation. Maximum production per animal or unit of land, maximum profitability and/or minimum environmental burden (such as lowering phosphorus balance of a property) are some examples of such expectations. Bulky forages (pastures, silages and hays) usually are grown within or near dairy operations mainly because the cost of transportation can be restrictive. Given those constraints, forages often determine what concentrate feeds are needed to complete balanced rations. Thus, lower reliance on imported feeds is driven primarily by the use of high quality forage (see Pasture and Forage Management).

Feeding system

Milk production drives most nutrient requirement in high-producing dairy cows. When choosing a feeding method, the dairy manager has to take into consideration milk yield and dry matter intake patterns and their implications throughout the lactation (Figure 6). Milk production increases rapidly during early lactation, peaking between four and six weeks and decreases slower thereafter. Feed intake follows a similar pattern, but dry matter intake peaks between 10 and 12 weeks. Fresh cows have a nutrient deficit because of the lower intake and higher production. Early lactation cows need to have nutrient storage built up in late lactation and in the early dry period to have body reserves (energy, protein and some minerals) available for mobilization to support nutrients demanded for high levels of milk production until after the peak of lactation.

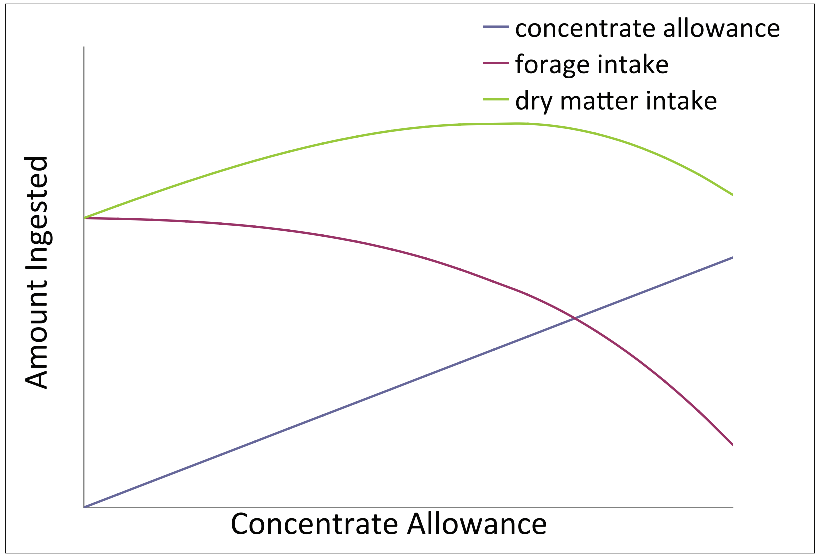


Figure 7. Effect of concentrate allowance on forage and total dry matter intake.

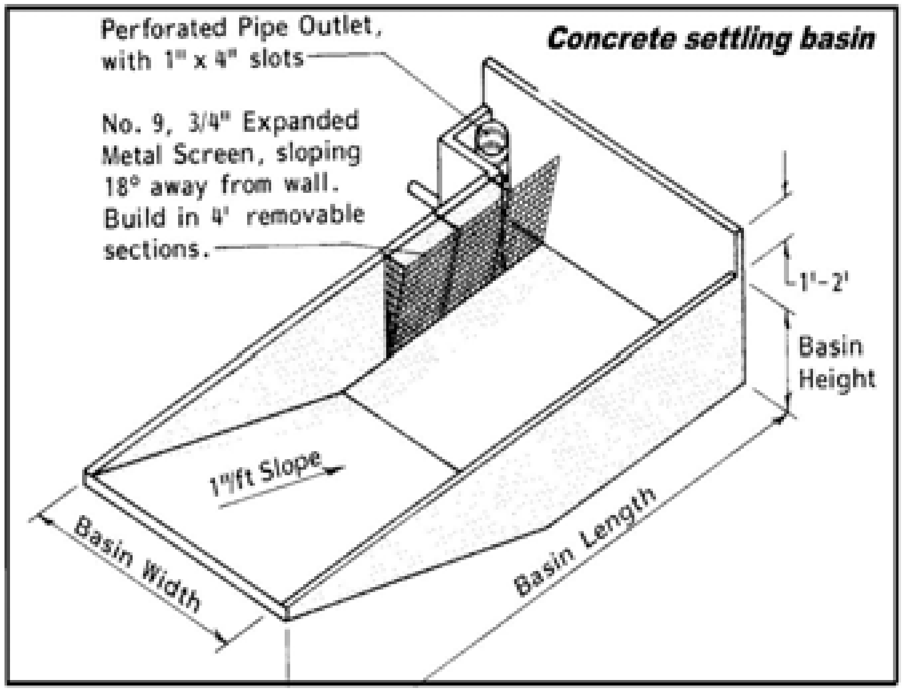
Grazing is the most common feeding system in Louisiana, but feeding practices range from pasture only to a completely TMR-based system, including systems mixing pasture and TMR concurrently or separately in the course of the year. Cows have less chance to sort in TMR (total mixed ration) feeding systems because forage and concentrates are thoroughly mixed. Nutrient allocation is more complex under grazing systems because concentrates and other feed supplements have to be offered separately and need to be adjusted in quantity and quality to cope with pasture availability and maturity. Pasture availability and maturity will change daily. Grazing cows have more opportunity to select plants and parts of plants according to their preferences, which may be different from what was estimated for ration formulation and means they effectively could be ingesting nutrients above or below requirements. Concentrate mixes usually are fed separately from forages in grazing systems and their intake can influence forage intake (Figure 7). Concentrate mixes fed at flat rates across the lactating herd may result in similar milk output to concentrate fed at rates varying according to milk production if feeding rate is set for the top cows or if cows have sufficient body nutrient storages to cope with short-term deficiencies. Nonetheless, flat rates of concentrate feeding will result in greater excretion of nutrients in lower-producing or late-lactation cows, increasing the risk for nutrient imbalances on the farm.

Practical recommendations:

- Choose forages adapted to weather patterns and soil conditions of the operation. Local extension personnel can provide information on varieties and species recently tested by the nearest LSU AgCenter research station. Forage quality is essential to minimize imports of concentrate feeds and to maximize profitability.
- Choose concentrates wisely. For instance, governmental policies are increasing dependency on fuel production from renewable sources. One consequence is the increased availability at competitive prices of byproducts from ethanol plants, such as dry distillers' grains plus solubles (DDGS). High protein content and quality for lactating dairy cows are some of the reasons for their inclusion in dairy diets. The DDGS protein contains large proportions of rumen-undegradable protein but high phosphorus content. DDGS and other products with relatively low protein-to-phosphorus ratios such as whole cottonseed, soybean hulls, rice bran and brewer's grains are commonly fed to dairy cows in Louisiana and often render unnecessary the inclusion of phosphorus in mineral supplements, only rarely accounted for (Table 1).
- Establish a feed (forages and concentrates) inventory/budget sheet for the year. Forage deficiencies occur regularly in Louisiana during periods of transition between summer and winter forages. High quality stored forages should be available to supplement the lactating herd, particularly during mid- to late fall and early winter, when calving season is at its peak. Poor forage quality or insufficient quantity may prevent cows from achieving maximum performance at peak lactation. Every pound of milk lost at peak lactation represents 200 to 250 pounds less milk at the end of a cow's lactation.
- On average, warm-season grasses have lower protein and higher fiber content than cold-season grasses. Concentrate mixes need to be adjusted as frequently as practically possible (monthly, bimonthly, seasonally) to minimize costly excesses or deficiencies. Too frequent (weekly, biweekly) and drastic dietary changes also should be avoided since they can decrease animal performance. Baleage is an excellent roughage supplement for grazing animals, but significant variation in weight and composition may cause problems when fed in a TMR. Each bale is a new silage, with its particular fermentation characteristics.
- Feeds should be analyzed frequently, but the results can only be as good as the sample submitted. A sample needs to be carefully collected as a fraction representative of what is being fed to the herd. Forages are more subject to changes in quality than concentrates. Concentrates should be sampled and analyzed at least upon delivery. Several probes should be taken from each load. Wet grains and forages should be analyzed for dry matter weekly or biweekly. At least 15 bales should be cored or probed from 12 to 18 inches into the bale or stack of hay or baleage. Silage stacked or stored in a horizontal silo (bunker or trench) should be sampled from at least 10 different locations on the open face of the silo. Multiple samples from the same feed should be combined into a single sample and sent for analyses in a reputable laboratory. A pound of dry or wet feed usually is sufficient. A practical recommendation is to completely fill a 1 quart resealable bag.
- Analyses requested of submitted samples should include at least dry matter, crude protein, fibers, fat and minerals. Analyses results should be compared to book values or laboratory means to assist farmers with soil, fertilizer and harvest management strategies. If potassium content of a forage sample is very high, potash application can be limited. In particular, dry matter content of wet forages fed in TMRs need to be determined with more frequency (weekly, biweekly) as significant fluctuations can cause large errors while weighing feed components in the TMR mixer. Some modern mixers can be equipped with real-time NIRS-based dry matter determination equipment.
- Always consult an experienced dairy nutritionist (private or university consultant) for ration formulation.

Manure Management

Manure management systems are composed of structures and devices that collect, transport, recycle (flush), treat, store and land apply the manure and wastewater resulting from the production of animals. Dairy producers need to be knowledgeable of these system components and the proper operation and maintenance. Improper operation of any of these components could lead to a spill or runoff of the wastes.



Solid separation

A gravity settling basin may be less costly while removing 50 percent or more of the solids from liquid manure. Manure solids and sand can be settled and filtered by a shallow basin (2 to 3 feet deep) with concrete floors and walls and a porous dam or perforated pipe outlet. If possible, design basins for a maximum of flow velocity of 0.5 feet per second through the basin. Basins with more surface area (length x width) are more effective than deeper basins. Basins should allow access by a front-end loader to remove solids every one to two months.

The use of solid/liquid separators will improve the waste-handling and treatment efficiencies of many livestock operations. With the removal of manure solids, the storage life of a structure will be increased, and costs can be saved due to the decreased need for sludge removal. The buildup of phosphorus, copper and zinc will be reduced. In some instances where lagoons are undersized or are not effectively treating waste, solids removal may reduce the waste load to a level where proper anaerobic treatment can occur. The buildup of solids in transfer pipes and pumps also will be reduced.

Solids and liquids from mechanical and gravity separators can be used in many different fashions, many of which allow the producer to develop a value-added byproduct. Due to the relatively low moisture content, separated solids may easily be composted or fermented as a feed supplement. Composting of manure solids will create temperatures high enough to kill off bacteria while producing a stabilized soil amendment or bedding source for dairy free-stall barns. The liquid fraction from a separator contains most of the manure fertilizer value. With large fibers and solids removed, this liquid can either be treated in an aerobic or anaerobic lagoon or be pumped efficiently for proper land application. Dried manure solids generally can be stored and handled without offensive odors.

In summary, a solid/liquid separator may accomplish the following:

- reduce the volume of manure storage needed
- improve anaerobic digestion
- reduce concentrations of phosphorus, copper and zinc in sludge and effluents
- reduce pipe clogging problems
- produce value-added byproducts
- allow the use of irrigation or direct soil injection equipment
- reduce pumping horsepower needed and increase pumping distances
- allow a greater hauling distance for the solids versus liquid slurry

Lagoon management and runoff prevention

Anaerobic lagoons generally are used when some treatment of the manure is desired to facilitate better manure handling, reduce the organic strength (BOD) of the wastewater or reduce odors. Lagoons are designed with a permanent "treatment volume" facilitating the growth of bacteria that degrade and stabilize manure organic matter. They are earthen structures but are larger than those designed for slurry storage due to the additional treatment volume. Since bacterial activity is an important factor in lagoon performance, lagoons are designed on the basis of temperature and climatic conditions as well as manure and wastewater volume. Lagoons generally perform better in warmer climates due to increased bacterial activity at higher temperatures.

Since they are earthen structures, investigations for proper soil material, rock or bedrock characteristics and water table elevation must be performed as part of the site evaluation. A seal on the lagoon bottom and sides must be constructed to meet permeability standards required by regulation or good construction practice.

Advantages of lagoon storage of manure may include cost per animal unit, ability to store large amounts of manure and/or runoff, treatment of manure to reduce odors and potential to handle manure with conventional pumping and irrigating equipment. Disadvantages of lagoons may include lack of appropriate soil materials for construction, the need for solids separation or sludge removal equipment if bedding or other nonbiodegradable materials are present, aesthetic appearance and/or public perception, and relatively high nitrogen losses and greenhouse gas emissions primarily through methane production.

Proper liquid management should be a year-round priority for storage ponds and slurry basins as well as for lagoons. It is especially important to manage levels so that you do not have problems during extended rainy and wet periods.

Maximum storage capacity should be available for periods when the receiving crop is dormant (such as winter if Bermuda grass and fescue are the receiving crops and annual ryegrass is not available) or when there are extended rainy spells such as the thunderstorm season in the summer. This means that at the first signs of plant growth in the late winter/early spring, irrigation according to a farm nutrient management plan should be done whenever the land is dry enough to receive animal wastes. This will make storage space available in the structure for future wet periods. In the late summer/early fall lagoons should be pumped down to the low marker (see Figures 8 and 9) to allow for winter storage. Every effort should be made to maintain lagoons close to the minimum liquid level as long as the weather and proper use will allow. Storage ponds and slurry basins should be pumped as low as possible and only need an upper level marker to show maximum permissible liquid level.

Figure 9. Lagoon marker.

Waiting until liquid-manure storage structures have reached their maximum storage capacity before starting to irrigate does not leave room for storing excess water during extended wet periods. Overflow from storage structures for any reason except a 25-year, 24-hour storm is a violation of state law and subject to penalty action.

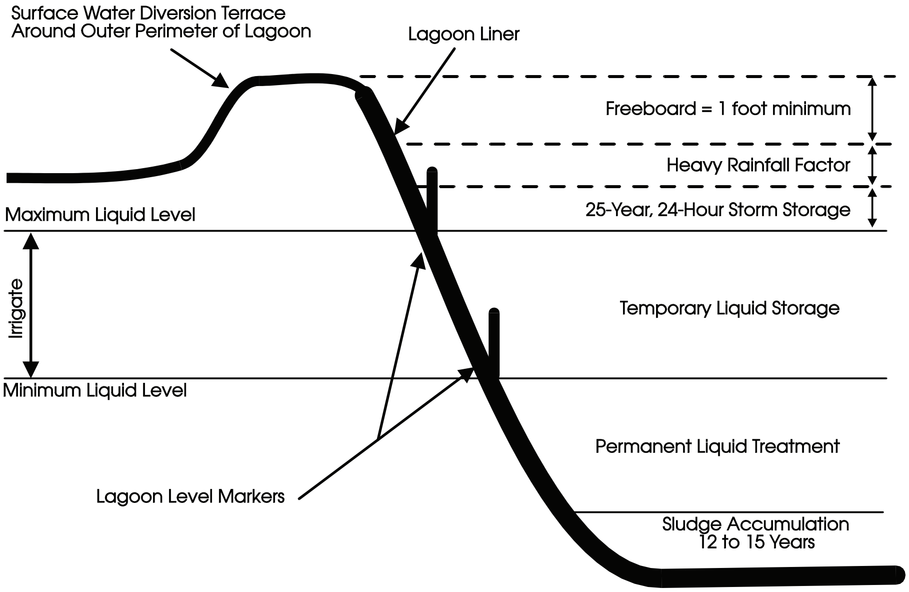


Figure 8. Schematic of an anaerobic waste treatment lagoon (note that this drawing is not to scale).

Lagoon loading

The more frequently and regularly that wastewater is added to a lagoon, the better the lagoon will function. Systems that wash waste into the lagoon several times daily are optimum for treatment.

- Practice water conservation (water reuse) – minimize water use and spills from leaking waterers, broken pipes and wash down through proper maintenance and water conservation. This reduces freshwater consumption and reduces the volume of wastewater that ultimately must be land applied.
- Minimize feed waste and spills. This will reduce the amount of solids entering the lagoon.
- Minimize additions of sand and straw used as bedding materials.

Management

- Maintain lagoon liquid level between the permanent storage level and the full temporary storage level.
- Place highly visible markers or stakes on the lagoon bank to show the minimum liquid level and the maximum liquid level (Figure 9).
- Start irrigating at the earliest possible date in the spring based on nutrient requirements and soil moisture so that temporary storage will be maximized for the summer thunderstorm season. Similarly, irrigate in the late summer/early fall to provide maximum lagoon storage for the winter.
- The lagoon liquid level must never be closer than 1 foot plus the 25 year, 24-hour storm storage to the lowest point of the dam or embankment.
- Do not pump the lagoon liquid level lower than the permanent storage level unless you are removing sludge.
- A dark color, lack of bubbling and excessive odor signal inadequate biological activity. Consultation with a technical specialist is recommended if these conditions occur for prolonged periods, especially during the warm season.
- Do not lower the lagoon liquid level below the seasonal groundwater table (see your system design or contact the local office of the Natural Resources Conservation Service for this level).
- Locate float pump intakes approximately 18 inches underneath the liquid surface and as far away from the drainpipe inlets and embankments as possible.
- Prevent bedding materials, long-stemmed forage or vegetation, molded feed, gloves, rags or other foreign materials from entering the lagoon.
- Frequently remove solids from catch basins.
- Maintain strict vegetation, rodent and varmint control over the entire embankments.
- Do not allow trees or large bushes to grow on lagoon dam or embankments.
- Remove sludge from the lagoon either when the sludge storage capacity is full or before it fills 50 percent of the permanent storage volume.

Year round lagoon management is needed to prevent discharges.

- If animal production is to be terminated, the owner is responsible for obtaining and implementing a closure plan to eliminate the possibility of a pollutant discharge. An alternative to closure is to maintain and comply with the waste management plan for the waste management system, even though there is no addition of animal manure.

Routine maintenance

The routine maintenance of an earthen storage facility is necessary to ensure the structure does not erode, weaken or otherwise allow the wastes to leak or discharge. Routine maintenance involves the following:

- Maintenance of a vegetative cover for the dam. Fescue or common Bermuda grass are the most common vegetative covers. The vegetation should be fertilized each year, if needed, to maintain a vigorous stand. The amount of fertilizer applied should be based on a soil test, but in the event that it is not practical to obtain a soil test each year, the embankment and surrounding areas should be fertilized with 800 pounds per acre of 10-10-10 or equivalent.
- Brush and trees on the embankment must be controlled. This may be done by mowing, spraying, chopping or a combination of these practices. This should be done at least once a year and possibly twice in years that weather conditions are favorable for heavy vegetative growth.

Note: If the vegetation is controlled by spraying, the herbicide must not be allowed to enter the lagoon water. Such chemicals could harm the bacteria in the lagoon that are treating the waste.

Maintenance inspections of the entire facility should be made during the initial filling of the structure and at least monthly. Items to be checked should include, as a minimum, the manure inlet pipes, the lagoon surface and the condition of the earthen embankment. Look for any separation of joints, cracks or breaks, accumulation of salts or minerals on the manure inlet pipes, recycling pipes or overflow pipes. On the lagoon surface look for undesirable vegetative growth and any floating or lodged debris. Along the embankment look for any settlement, cracking, holes, slumps, bulges, wet or damp areas on the back slope of the embankment, erosion due to lack of vegetation or a result of wave action, and any signs of rodent and tree damage.

Removing lagoon sludge

Sludge is a thick, black, viscous substance that is rich in organic material and nutrients. It is comprised of the dead and degraded microbial cells that anaerobically digested the manure influent and of any other materials (excess feed, debris, rocks, etc.) that were placed in the manure collection system and have settled to the bottom of the lagoon.

Over four to five years in the life of a lagoon in Louisiana, the designed volume of sludge will accumulate until it reaches a level at which it should be removed. At this point, it is typically taken from the lagoon and land-applied. Table 2 lists the volume units of sludge that can be expected to accumulate in anaerobic lagoons for various types of cattle. If the amount of sludge becomes too large, the permanent liquid treatment volume (Figure 8) will effectively be reduced. The loss of treatment volume will, in turn, adversely affect the overall treatment ability of the lagoon, causing the nitrogen content of the effluent to increase, more sludge to be produced and more odors to be released from the lagoon's surface.

Table 2. Average dairy sludge generation rates.

Production Unit	Animal Unit	Live Weight *pounds*	Lagoon Sludge *gallons per animal per year*
Calf	Per head	350	395
Heifer	Per head	1,000	1,387
Milk Cow	Per head	1,400	1,935

Rate of lagoon sludge buildup can be reduced by:

- proper lagoon sizing,
- gravity settling of solids
- minimizing feed waste and spills

Lagoon sludge that is removed annually rather than stored long term will:

- have more nutrients,
- have more odor
- require more land to properly use the nutrients.

Lagoon sludge typically is removed by mixing the sludge and lagoon liquid with a chopper-agitator impeller pump and then pumping through a large-bore sprinkler irrigation system onto nearby cropland. This sludge material needs to be analyzed for waste constituents just as you would your lagoon water. The sludge will contain different nutrient and metal values from the liquid. The application of the sludge to fields will be limited by a crop's requirement for these nutrients as well as any previous waste applications to that field. Waste application rates will be discussed under the Pasture and Forage Management section.

When removing sludge, you must also pay attention to the liner to prevent damage. Close attention by the pumper or dragline operator will ensure the lagoon liner remains intact. If you see soil material or the synthetic liner material being disturbed, you should stop the activity immediately, contact a technical specialist and not resume until you are sure that the sludge can be removed without further liner damage. If the liner is damaged, it must be repaired as soon as possible.

Sludge removed from the lagoon has a much higher phosphorus and heavy metal content than liquid. Because of this it should be applied to land with low phosphorus and metal levels, as indicated by a soil test, and incorporated to reduce the chance of erosion. Note that if the sludge is applied to fields with very high soil-test phosphorus, it should be applied only at rates equal to the crop removal of phosphorus.

The application of sludge will increase the amount of odor at the waste application site. Extra precaution should be used to observe the wind direction and other conditions which could increase the concern of neighbors. Injection or incorporation of sludge into the soil should reduce odors from the land application site.

The value of manure

More than half the nutrients in dairy rations are excreted in manure. The key to managing manure is to treat it as a resource by recycling these nutrients to produce forage. For example, one grazing lactating dairy cow's manure can supply enough nitrogen for 1.5 acres of silage corn. But these manure nutrients are not distributed evenly.

More than half the nutrients in feed are excreted in manure (Figure 10). Each year a 1,400-pound lactating cow producing 70 pounds of milk per day excretes 300 pounds of nitrogen, 45 pounds of phosphorus and 165 pounds of potassium nutrients in manure. On Louisiana grass-based dairies where cattle spend the majority of their day on pastures, only 10 percent of the daily manure excretion is typically collected in the lagoon. The uneven distribution of nutrients in feces and urine makes it difficult to match forage requirements (Figure 11). Most of the phosphorus is found in the feces, while most of the potassium is excreted in the urine. Nitrogen is evenly divided between feces and urine, but urinary nitrogen has greater plant availability than fecal nitrogen.

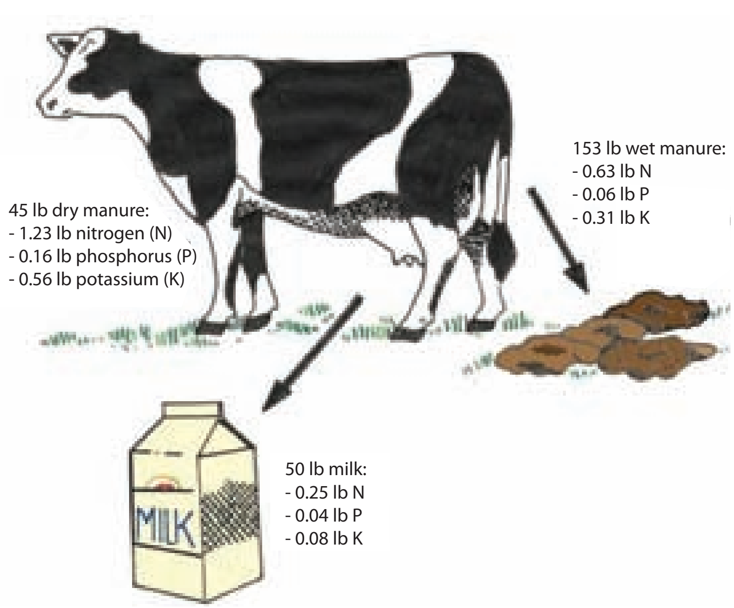


Figure 10. Daily nutrient flow for a lactating cow in Louisiana.

Dairy lagoon nutrient content

Parlor washwater, dumped milk and manure are collected, stored and treated. This wastewater is treated through anaerobic decomposition to reduce its organic strength and thus its odor. During storage, nitrogen from the stored manure will break down, and large amounts of the ammonia will be lost to the atmosphere via volatilization. Manure phosphorus will be metabolized by microorganisms and when they die will settle to the bottom of the lagoon forming sludge.

In the 1990s dairies across Louisiana constructed anaerobic treatment lagoons to process parlor wastewater. Since 2001, 128 dairy waste lagoons have been pumped and manure incorporated into pastures and cropland as part of a BMP assistance program with the Lake Ponchartrain Foundation. A total of 117 dairies/dairy farmers in Washington, Tangipahoa and St. Helena parishes participated in the program. The average amount of manure removed per lagoon was 624,918 gallons. The nutrient content (Table 3) was found to be relatively low compared to dairy parlor lagoons from other states, although the content varied greatly from farm to farm. This high level of variability further enforces the need to test lagoon wastewater to ensure the proper amount of wastewater is applied to receiving crops.

Figure 11. Distribution of nutrients in manure. (We will change P to 1%:99%)

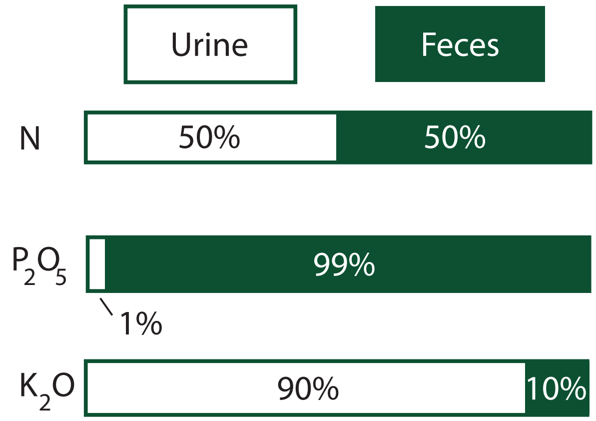


Table 3. Lagoon wastewater nutrient content from 128 lagoons (2001-2007).

Nutrient	Concentration (%)	Standard Deviation
Nitrogen (N)	0.10	0.08
Phosphorus (P_2O_5)	0.06	0.07
Potassium (K_2O)	0.04	0.03

To calculate the amount of nutrients applied is simple after an analysis of the wastewater is completed. Lagoon wastewater can be analyzed by the LSU AgCenter/Louisiana Department of Agriculture and Forestry Agricultural Chemistry Laboratory in Baton Rouge. As presented in Table 3, results will be shown as percentages of N, P_2O_5, and K_2O. How to take proper manure samples will be discussed later.

Phosphorus in sludge is much more concentrated than in lagoon liquid.

Step 1.
Multiply the nutrient concentration (percentage) by the number of gallons of water pumped.

Step 2.
Multiply the product by 0.33 to find the plant available nitrogen, accounting for plant availability and volatilization losses during application.

Step 3.
Multiply this number by the 8.34; the density of water (8.34 pounds per gallon).

Example: What was the average amount of nitrogen that was applied from each of the lagoons in the Lake Pontchartrain cost-share program?

Step 1:
Nitrogen: 0.10%
624,918 gallons pumped per lagoon (average)
0.01 x 624,918 = 624.9

Step 2:
624.9 x 0.33 = 206.2

Step 3:
206.2 x 8.34 (pounds per gallon) = 1,719.8

Final:
1,720 pounds of plant available nitrogen per lagoon

How much is manure worth to you?

In the Lake Pontchartrain manure pump-out cost-sharing program, manure and wastewater were applied to approximately 23 acres per farm. The average cost for pump-out per lagoon was $5,000. The producer's cost was $1,250 (25 percent), and the Lake Pontchartrain Basin share was $3,750 (75 percent). In 2008, the manure fertilizer value was approximately $5,480 per farm for commercial N, P, and K costs at that time. So the average producer realized a 438 percent return on the producer's initial $1,500 share of the investment.

Pasture and Forage Management

Grazing systems represent a small fraction of the dairy industry in the United States compared to confinement feeding systems. But in Louisiana and Mississippi, pasture-based dairies represent the majority. Typically, grazing dairies predominate in regions of the world where land cost is relatively low, feed prices are relatively high and/or capital investment is limited. Also, interest in grazing dairy cows is rising as a consequence of niche markets demanding specific health attributes such as high omega-3 fatty acid concentration in milk, because grazing helps preserve a certain preconceived notion of rural landscape or because of a widely disseminated perception that environmental stewardship is an inherent characteristic of pasture-based animal production systems. Grazing systems may be the most economically efficient method for harvesting and converting forages into animal product but they also are the most challenging method. Pastures may be less nutrient-intensive compared to confinement systems, in general, because of lower animal density and less need for manure storage. Poorly managed pasture based dairies, however, may inflict as much environmental degradation as more concentrated production systems. Such degradation can be caused by erosion and direct contamination of rivers and streams or because of limitations in management skills required to match pasture growth and quality to nutrient requirements of the herd throughout the year. Management practices for minimum environmental impact of pasture and forage production systems will be discussed in this section.

Pasture and forage management

Forage production represents an important fraction of the nutrient inventory of a dairy farm. It accounts for the majority of nutrients recycled within the production system. Proper nutrient management and best economic return can be reached concurrently for most animal production systems, because optimum production techniques should contribute to higher product output and lower nutrient input.

The first step that needs to be taken into consideration is to establish achievable goals for the grazing system. Grazing dairy production systems can be based on:

1. Cows with moderate potential for milk production, grazing on intensively managed pastures and fed minimum amounts of concentrate supplement, resulting in high levels of milk production per unit of area but low levels of milk production per cow. This system is prevalent in regions where concentrate costs are high compared to milk prices (near or below the 1:1 ratio). Milk prices in those regions tend to reflect international market, which is often too low to offset grain prices as a result of the need to import grains (New Zealand) or because grain prices in international markets favor their exports over internal consumption (Argentina and Brazil).

2. Cows of high production capacity grazing on moderately managed pastures supplemented with low levels of concentrate, resulting in high levels of milk per cow but low yield per acre (Europe and USA).

3. Cows of high production capacity grazing on moderately to intensively managed pastures supplemented with high levels of concentrate, resulting in high levels of milk production per unit of area and high levels of milk production per cow (Europe and USA).

Figure 12. The greatest challenge of milk production from pasture is to maintain intakes consistently high throughout the year. Cows spend most of the day resting or ruminating instead of grazing. Pasture managers should ensure high-producing cows (frequent and large bites) have access to densely-planted, high-quality pasture (mouthful of nutrients at every bite).

Cost of milk production on pastures is affected by interactions between grazing cows, pastures, conserved forages and concentrate supplements. Grazing methods (Figure 12) appear to have little effect on animal performance, as long as pastures are managed according to the nuances of each method. All pasture management methods require constant adjustments to achieve optimum animal performance. Louisiana dairies most commonly apply continuous grazing with areas fenced off for conserved forage production as their preferred pasture management practices. Other methods of pasture use such as rotational grazing or "greenchop" are less frequent in Louisiana. In principle, grazing methods can be briefly described as:

1. Continuous grazing. A single pasture is used throughout the grazing season. This method allows animals to choose the forages they want to graze. Nutrients tend to be concentrated around the areas where animals tend to congregate for loafing and rumination. Also, much of the pasture stand may be lost to trampling and senescence (dying leaves), and soils may erode because of trails formed (particularly in steep pastures).

2. Rotational grazing. The single pasture is subdivided into multiple paddocks, and the grazing herd is kept in each paddock for a short period of time (up to few days) before moving into the next paddock. There are numerous variations to this grazing method (rotational grazing, strip grazing, leaders-followers). This method increases carrying capacity of the pasture, improves efficiency of pasture harvesting and promotes better distribution of dung (feces) and urine nutrients in the area.

3. Greenchop. Forage is mechanically chopped daily to be offered to cows. This method improves efficiency of pasture utilization but is labor and equipment intensive. With greenchop, forage quality control is complicated as much or more than other grazing methods, and harvesting can be problematic under situations such as rainy days.

Grazing method appears to have little influence on milk output per hectare or animal performance. Rotational grazing should be emphasized for maximum plant and nutrient utilization, while continuous grazing normally results in better individual animal performance. Stocking rate has a significant effect on pasture productivity and quality.

Pasture management is part science and part art. To achieve an efficient milk production from grazed pastures one must balance the amount of forage produced (forage quantity), the efficiency of forage harvesting by the animal (forage quantity versus animal-herd needs), and the efficiency of conversion from forage to milk (forage quantity versus forage quality). Plants' growth and quality and herd nutrient requirements continually change. Dairy producers need to consider the potential forage production and quality in the pastures, assess the herd's nutrient requirements, account for climate and seasonal changes, and then make a decision to adjust the number of animals that a given pasture can support. Stocking rate adjustments according to forage availability on a pasture (grazing pressure) can be achieved by changing the number of animals per acre, changing paddock size or increasing feed supplementation. Altering stocking rate is not an easy task given the number of lactating cows on the farm cannot be changed easily, but using portable fencing can be effective in altering stocking rate by increasing or decreasing paddock size. Pasture supplementation with high proportions of concentrates brought from outside the property is an expensive proposition that results in large nutrient surplus. Effective pasture management is an essential factor to achieving maximum efficiency of nutrient utilization in dairy production systems.

Animal and herd needs

The most effective and economic alternative to feed a dairy herd is to match pasture production and herd requirements. Estimates of dry matter and nutrient intake need to be based on realistic production goals before budgeting forage needs for individual cows throughout the lactation and for the herd throughout a year. The pattern of intake of an individual cow is presented in Figure 13. The intake of a cow increases slowly and peaks after milk yield, gradually decreasing thereafter. Major factors influencing herd forage needs are average milk yield, average stage of lactation, forage quality and climate conditions. Invariably, milking herd requirements for dry matter and nutrient intake will change continually throughout the year. In Louisiana, dairy producers tend to concentrate the calving season between early fall and late spring because of poor cow performance during hot summer months. Depending on the intensity of the calving season, the herd's needs for forage quantity and quality can change dramatically during the year.

Cows tend to rest and ruminate during warmer periods of the day. Cattle graze six to 11 hours per day preferably during cooler times around sunrise and sunset. In spite of their efficient and economic ability to harvest pasture, the intake of grazing cows generally is limited. Poor intake and lower animal density contribute to curtail milk output per area and per animal from grazing systems compared to confinements. Particularly in Louisiana, large-framed U.S. Holsteins have high requirements for body maintenance as a proportion of the animal's total requirements. Smaller-body-frame breeds, such as Jerseys, have been recommended for cross-breeding with Holsteins to lower maintenance requirements, thus requiring less nutrients per pound of milk produced. Jersey-Holstein crosses have lower milk yield than their Holstein parents, but research is still unclear in regard to milk output per pasture area.

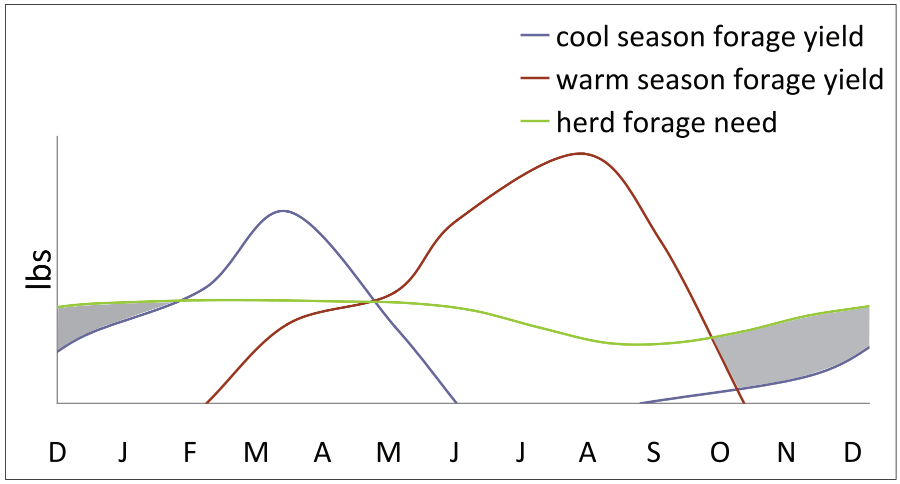


Figure 13. Growth pattern of cool-season and warm-season pastures in southeast Louisiana relative to forage required by the milking herd. Forage needs represent diets containing forage to concentrate ratio of 50:50 in the dry matter. Dashed lines indicate periods of forage production in excess of milking herd needs. That excess needs to be conserved for use later during periods of deficiency (shaded areas). Bermuda grass and ryegrass growth patterns represented warm- and cool-season forages, respectively.

Forage quantity

Forage yields and pasture growth patterns in relation to annual feed demand at the cow and herd levels need to be well understood. Factors influencing pasture and forage quantity and quality include plant species, plant maturity, soil condition, climate and forage/pasture management. Maximum pasture growth can only be achieved if water and nutrient supplies are sufficient, if soil structure is adequate and if improved forage species are persistent.

Growth patterns presented in Figure 13 can be used to describe typical forages used in warm and cool seasons in Louisiana. The example of herd forage needs shown in Figure 13 was estimated based on a calving season in which 70 percent of the milking herd was scheduled to calve between August and November, resulting in similar variation in forage needs (71 percent) during the year. In this example, pasture production was deficient from October through January during which the milking herd would require a supply of forages conserved as hay or silage.

A key aspect to increase milk yield in Louisiana is to conserve enough forage in early spring and summer to supply pasture shortfalls in periods of

transition between warm- and cool-season forages (fall, winter, and mid- to late spring). Louisiana dairy cows tend to calve in the fall and winter, but limited pasture availability during this period can prevent cows from reaching their potential peak of production. It should be pointed out that every pound of milk reduction at peak of lactation results in 200 to 250 pounds of decreased production over the entire lactation.

Forages grown in Louisiana during cooler months include annual ryegrass (Lolium multiflorum), wheat (Triticum spp.), oats (Avena sativa) and rye (Secale cereale), while Bahia grass (Paspalum notatum), Bermuda grass (Cynodon spp.), pearl millet (Pennisetum glaucum), sorghum-sudan (variety of Sorghum bicolor), crab grass (Digitaria sanguinalis), broadleaf signal grass (Brachiaria decumbens) and corn (Zea mays) are forages grown in the warmer months of the year. Typical yield ranges for those forages are presented in Table 4. These ranges generally are large because of variations in rainfall, soil fertility and plant varieties.

Table 4. Typical yield ranges for forages grown in Louisiana.

Forage	Realistic yield expectations *lbs DM/acre*
Warm season forages	
Corn	10,000 - 25,000
Bermuda grass	4,000 - 19,200
Bahia grass	2,000 - 13,500
Sorghum-sudan	11,000 - 14,900
Forage sorghum	10,000 - 20,000
Pearl millet	5,000 - 10,000
Cowpea	1,000 - 3,200
Cool season forages	
Ryegrass	5,000 - 15,000
Triticale	1,000 - 7,500
Rye	4,000 - 10,500
Wheat	2,500 - 6,400
Oat	2,500 - 10,000
White/red clover	1,500 - 4,000
Crimson clover	1,500 - 3,900
Arrowleaf clover	1,000 - 3,500

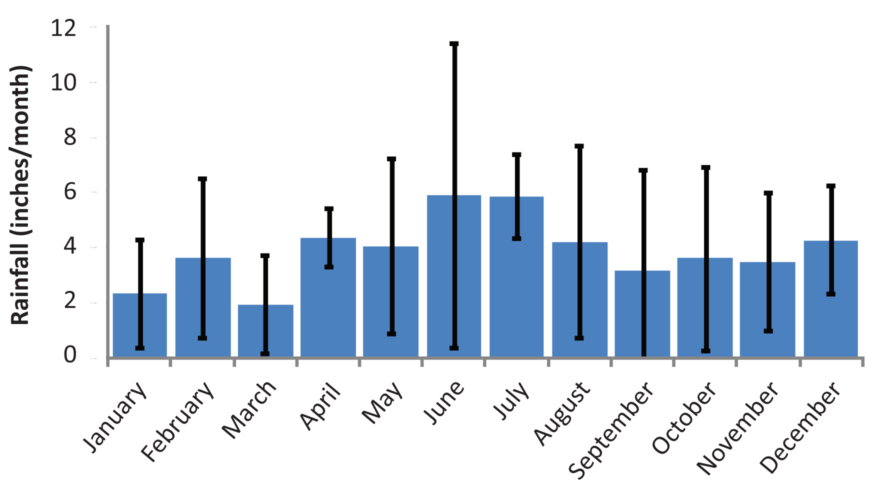


Figure 14. Eight-year average rainfall measured at the LSU AgCenter's Southeast Research Station (Louisiana Agriclimatic Information System data).

Rainfall frequency and intensity are important factors controlling forage growth where irrigation is not available. Drought conditions can limit forage production and alter forage quality at variable degrees. Rain events also can delay harvesting at proper time or prevent wilting before forages are stored in silos or bales. Rainfall on field-wilting forages washes nutrients off haylage/baleage or hay and reduces forage palatability. Under such circumstances, the use of silage inoculants was demonstrated to improve silage fermentation, minimize leachate and increase intake and animal performance. Silage inoculants are additives that contain promoters of silage fermentation such as homolactic bacteria and Lactobacillus buchnerii. It should be noted that seepage from forages ensiled too wet should not be allowed to reach water bodies because it can cause fish mortality. Louisiana, Mississippi and Alabama are among the five U.S. states with the highest annual rainfall totals. Data in Figure 14 shows relatively wetter summers and drier winters in southeast Louisiana, but error bars indicate large year-to-year variability in rainfall for most months. Monthly rainfall distribution is fundamental in planning pasture, feeding and nutrient management in a grazing dairy. Potential forage growth response to fertilization depends on soil moisture and temperature (Table 4).

A feed budget is especially important as feed prices increase. High-quality forages require less concentrate supplementation for a given level of milk production, thus reducing the cost of production, the need to import nutrients and nutrient surplus on the property.

Forage quality

Palatability

Requirements of lactating cows can only be adequately supplied by multiple feeds offered in proportions that allow nutrients to be ingested in amounts sufficient to support high levels of milk production. Given the opportunity, grazing cows will choose to eat certain plants or plant parts over others. Palatability is dictated by taste, smell, and texture, which are characteristics largely influenced by individual preferences. Cows that are restricted to pastures containing only forages of low palatability can still achieve optimum performance if feed intake and quality are not limiting.

Digestibility

After ingestion, cows fragment forage particles into absorbable nutrients through mastication, rumination and digestion. This process is called digestibility. Forage digestibility can range from less than 50 percent for stems and highly lignified or dead leaves to more than 80 percent for succulent leafy forages. Warm-season grasses or overly mature forages have poor digestibility and slow passage through the digestive tract, which will limit intake and ultimately cannot meet the energy requirement for milk production. All living beings need energy to perform their physiological activities, and dry matter digestibility is correlated with energy in forages.

Nutrient content and variability

The most reliable method to determine feed quality is to measure animal performance (in vivo) response. Animal trials usually are carried out by government institutions (USDA-ARS) and universities (e.g., LSU AgCenter research stations) because in vivo studies usually are a costly and time-consuming approach. Chemical composition analyses are less than perfect but are economical and practical indicators of feed quality. Feed chemical analyses for lactating cows may include contents of dry matter, crude protein, fibers (NDF and ADF), energy estimate (TDN or NEL) and minerals (Ca, P, Mg, K, and S). Fiber requirements are not specified in the NRC (2001), but there are recommended ranges. Fibers are important components of dairy cows' diets. Too little neutral detergent fiber (NDF) can increase predisposition to metabolic disorders such as acidosis and displaced abomasum. On the other hand, excess NDF represents bulkiness that fills up the rumen and can limit intake. Digestibility is limited as acid detergent fiber (ADF) content increases in forages. Forage species-specific equations have been developed in many laboratories to estimate energy (TDN and NEL) based on ADF content in forages.

Forage composition and digestibility vary widely with a number of factors, especially species and season (Figure 15). That variation is even more pronounced in areas with wet winters and hot summers. In Louisiana, typical winter-season forages such as annual ryegrass (Lolium multiflorum) and white clover (Trifolium repens) have high crude protein content and digestibility. Forages such as alfalfa and ryegrass usually are rich in rumen-degradable protein. For a given level of milk production, alfalfa- or ryegrass-based diets usually require supplements richer in rumen-undegradable protein or greater amounts of conventional protein supplements, resulting in diets with higher levels of CP than with corn silage-based diets. Also, a combination of low NDF content, high fiber digestibility and intensive concentrate supplementation can increase the risk of acidosis with ryegrass pastures. In contrast, summer grasses often contain less than 15 percent CP while energy averages between 50 percent and 60 percent of estimated TDN.

It is unclear whether average chemical composition of samples submitted to the laboratory are representative of the actual forage inventory at the farm level, but given the wide ranges shown in Figure 15, it is recommended that pastures and conserved forages be sampled and analyzed frequently. Pasture forages should be sampled by grabbing leaf blades imitating a grazing animal from several spots in the pasture. Samples should be composited (mixed) in an amount sufficient to fill a 1-quart resealable bag and sent to a reputable laboratory.

Feed supplementation

A single feed cannot supply all nutrients required by high-producing dairy cows without causing nutrient imbalances or health problems. Nutrient imbalances in pastures need to be corrected with supplementary feeds to closely match animal and herd requirements at any given time, thus improving animal performance, reducing cost per unit of milk produced and minimizing nutrient surplus (See Feeding Management section).

Pasture shortages in nutrient quantity or quality can limit milk production. Certain nutrients stored in the body of lactating cows can be used during relatively short periods of dietary deficiency. For instance, body fat can be easily mobilized by cows with good body condition scores (3.5 to 4.5 on a 5-scale score system) during periods of energy deficiency. Poor condition scores in grazing cows result from a combination of high maintenance requirements (long walks to pastures), low dry matter intake (physical limitation, not enough time for eating, or pasture deficit), low energy density of the diet and poor dietary energy utilization. Similarly, calcium and phosphorus can be mobilized from bones to support milk production in fresh dairy cows. Protein also can be mobilized, but body reserves are quickly depleted. Body storage and mobilization is especially important for high-producing cows in the immediate period following parturition.

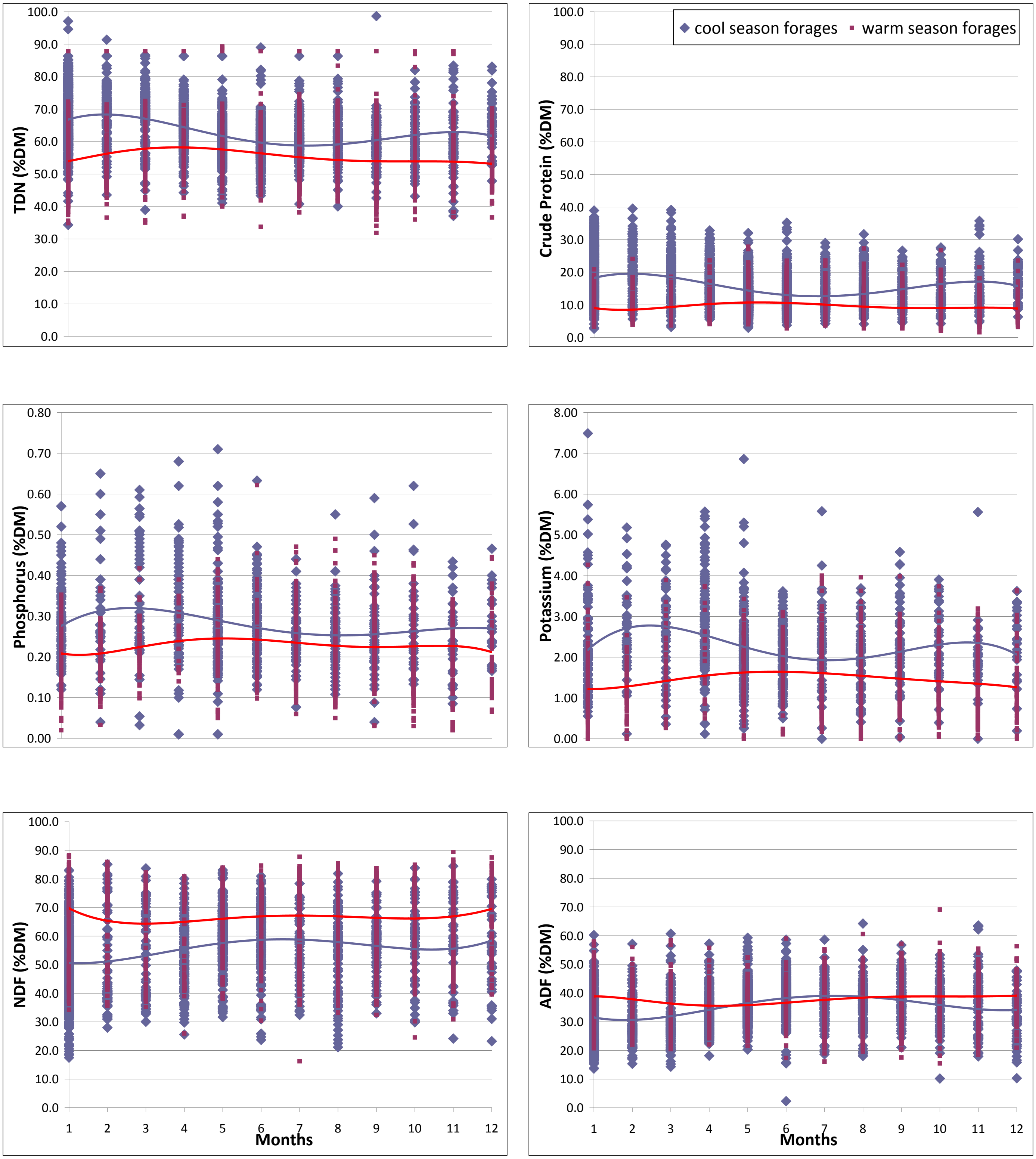


Figure 15. Chemical analyses of cool-season (blue) and warm-season (red) forages by date samples were logged in the LSU AgCenter Southeast Research Station Forage Quality Laboratory database.

Lines indicate average values and markers represent month-by-month sample variability in crude protein, phosphorus, potassium, NDF, ADF and TDN (percentage DM).

All samples submitted for clover, alfalfa, ryegrass, oats, wheat and winter forage mixes were summarized as cool-season forages. Bahia grass, Bermuda grass, crab grass, millet, sorghum-sudan, corn silage, forage sorghum, grain sorghum and summer forage mixes were included as warm-season forages. Bermuda grass and ryegrass represented the vast majority of samples included in the figures.

On the other hand, most vitamins have little or no storage in the body. Also, certain minerals, such as sodium, chloride and potassium are lost in large quantities through sweating so cows can cope with hot weather. Most vitamins and minerals need to be supplied daily for optimum animal performance.

Supplementary feeds are used to spare pasture and/or to increase animal density and/or to increase animal performance through extra intake and production (short-term response), or through improved body condition and fertility (long-term response), or through extended longevity (long-term response). Conserved forages (silages, baleages and hays), byproducts and concentrates (brewers' grains, dry distillers' grains, whole cottonseed, rice bran, soybean meal, corn grain and cottonseed meal) and mineral and vitamin mixes are typical supplements used for lactating dairy cows. Nitrogen fertilization at appropriate times results in extra pasture growth in relatively short periods. That extra forage production also can be considered as supplementary feed.

Supplementation can be uneconomical when pasture growth is slow, when forage or supplement quality are poor and during late lactation. Winter pastures in Louisiana will result in protein ingested in excess of lactating cows' needs when dry matter intake is not limiting (Figure 15). Excess protein intake will invariably be excreted through urine and feces and can lead to air and water pollution. Energy can be deficient in Louisiana throughout most of the year depending on the grazing pressure (stocking rate and forage availability) applied on a pasture. Energy deficit must be corrected with supplements containing high levels of starch and sugars (corn, wheat, barley, molasses) and/or high levels of fat (whole cottonseed, rice bran, tallow).

Periods of pasture deficit and surplus should be well identified to be effectively managed. That can be simplistically described as a combination of Figures 13 and 15. Forage nutrient yields should

be quantified on each operation, however, given the high potential for variability from one farm to another. Careful adjustment of breeding/calving season, supplementary feeding, stocking rates and setting targets for milk production per cow according to patterns of pasture growth should minimize the need for supplementation which, in turn, improves farm economics and minimizes nutrient inputs. It is essential for pasture-based dairy production to maximize the use of homegrown feeds and the rate it is directly consumed by cows or conserved as hay or silage.

Fertilizer and manure application

The use of fertilizers can be strategically used to supplement forage to dairy cows because a pasture can respond relatively quickly, particularly to nitrogen. Forage fertilization can be more economical than concentrate supplementation depending on soil conditions (moisture, pH, nutrient content), animal conditions (nutrient deficiency and potential response to that deficiency) and fertilizer and concentrate prices.

Most Louisiana dairies collect manure from the parlor in single-stage manure storage facilities. Manure stored is often highly diluted by parlor wastewater and rainfall, and the nutrient content is low. Manure management on pasture systems should consider economic feasibility of manure spreading, soil conditions, climatic conditions, crop type and availability of equipment and labor. Manure application (Table 5) should be limited or completely avoided on erodable soils, wet soils or above soil infiltration rate. Depending on fertilizer prices, it can be more economical for the dairy operator to retain and treat manure through solid separation, enhanced biological systems or physical-chemical scrubbers before land applying (See section on Manure Management).

Table 5. Recommended periods for manure and/or fertilizer applications onto crops and forages typically grown in Louisiana.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Corn (grain)				■	■	■	■					
Corn (silage)				■	■	■	■					
Sorghum (grain)				■	■	■	■					
Small grains (grain)		■	■	■								
Small grains (hay, pasture)		■	■	■								
Soybeans							■	■	■			
Cotton						■	■	■				
Bermuda grass (hay, pasture)				■	■	■	■	■	■			
Bahia grass (hay, pasture)				■	■	■	■	■	■			
Tall fescue (hay, pasture)		■	■	■					■	■	■	
Alfalfa (hay)					■	■	■	■				
Annual ryegrass (hay, silage, pasture)		■	■	■					■	■	■	
Millet (hay, silage)					■	■	■	■				

When economically feasible, manure should be recycled to the land as fertilizers to minimize nutrient input and reduce nutrient surplus. Forage crops usually offer more flexibility and frequency for manure application than cereal crops. Both types of crops have the potential for nutrient export from the property as hay, silage or grain sold.

Manure application on pastures should be done after careful consideration. Grazing animals recycle manure nutrients by directly depositing feces and urine on pasture land. Plants can best uptake nutrient when the soil pH is near neutral. Soil acidity should be neutralized with lime before nutrients can be corrected, because plant uptake is less efficient in low-pH soils (Table 6). Manure and fertilizer application rates should be based on agronomic recommendations. Realistic yield expectations or actual yields, soil and manure analyses, soils slopes, proximity to surface waters and climatic conditions should be taken into consideration before deciding on application rates for manure and fertilizers. Note that a representative sample should be sent to a reputable laboratory for analyses. A representative manure sample should be composited from multiple samples taken in different locations in the manure storage facility. Soil samples should be collected throughout the area where manure will be spread and mixed into a single representative sample. Soil samples should be taken in the winter for summer perennial pastures and in the summer before planting winter annuals in the fall. Fertilizer or manure application to the fields should be done within 30 days before establishing pastures and crops – or onto actively growing forages (Table 2). Producers should follow the fertilizer recommendations provided by soil test reports. Soil moisture also needs to be adequate for optimum nutrient uptake by the plants, but manure and fertilizer spreading should be halted before, during and immediately after rain events to prevent runoff or leaching. Intentional or unintentional export of manure from the dairy operation through manmade ditches, surface waters, runoff or drift is not a neighborly activity and is illegal. Rainfall runoff from well managed fields, forests and pastures can be environmentally acceptable, but runoff from surface manure application to land is not tolerable. Buffer strips should be planted around areas onto which manure is regularly applied.

Table 6. Crop response to fertilizers applied onto soils at different pH levels

Soil Acidity	Nitrogen	Phosphorus	Potash	Fertilizer Wasted
Extremely Acid	30%	23%	33%	71.34%
Very Strong Acid	53%	34%	52%	53.67%
Strongly Acid	77%	48%	77%	32.69%
Medium Acid	89%	52%	100%	19.67%
Neutral	100%	100%	100%	0.00%

Biological systems are inherently inefficient. Agricultural production without nutrient inputs is not sustainable. Nutrient-balanced production systems (meaning zero nutrient surpluses) can only sustain competitive yields for a limited period of time until soil nutrients are depleted or if large portions of manure are exported from the property. Manure export usually is limited by cost of transportation of bulky, wet, nutrient-diluted materials. Manure export also presents a public health risk, since some pathogens can survive in manure for long periods. Some nutrient import to the dairy operation is absolutely necessary. The public is increasingly demanding responsible management of water, nutrients and effluents from dairy producers. Management practices that minimize unintended export from agricultural lands to the surrounding environment should be emphasized to prevent water, air and soil contamination. Active prevention is easier and cheaper than reactive correction measures.

Practical recommendations

- Overgrazed pastures can cause erosion that can reduce water-holding capacity, impair fish and wildlife habitats, reduce property value, depreciate recreational and commercial use and limit navigation. Grassy waterways should be constructed and planted with perennial grasses to transport excess rainfall and divert runoff to minimize erosion. Periodic maintenance is necessary.
- A grazing plan needs to be carefully developed including rotational grazing of selected plant species and adjusting stocking rate. Installation of multiple drinking sites and strategic crop and forage harvesting can optimize manure distribution by animals. Areas of heavy use should be minimized. A grazing plan requires constant monitoring to actively detect and fine-tune the production system.
- Preferably cattle should have no access to surface waters that can run outside of the property boundaries. Surface water bodies within pastures should be fenced off. Buffer strips should be planted along riparian zones wide enough to filter out nutrients, bacteria and soil sediment.
- Water and mineral troughs should be placed alternately and away from surface water and erodable areas.

Automated water trough

Soil stabilization is critical around water troughs.

Soil Testing

Soil testing is critical to the success of any nutrient management plan and can save you money. Testing can help dairy producers select the right nutrient rate and application strategy, so forage crops or pasture lands use nutrients efficiently. This not only reduces nutrient loss to runoff but increases dairy profitability.

Soil tests should be conducted at least every two to three years. The county agents in each parish LSU AgCenter Extension Service office can give you advice and assistance on how to take soil samples and where to have them analyzed. They also can help you interpret the results.

Generally, a soil test can be taken successfully by keeping the following in mind:

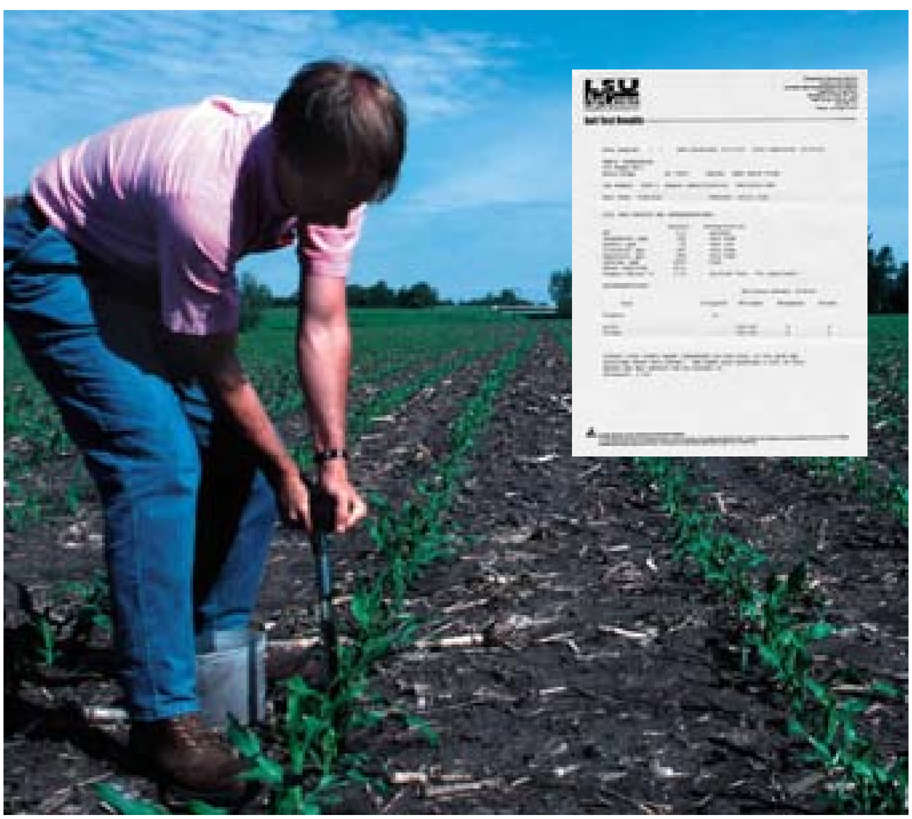
Soils that differ in appearance, crop growth or past treatment should be sampled separately, provided the area is of such size and nature that it can be fertilized separately. For each sample, collect subsamples of soil from 10 or more places in each sampling area in a zigzag fashion so as to make a representative sample.

Mix all random subsamples from one sampling area thoroughly before filling a sampling carton or container to be mailed to the Lab. For each sampling area, the laboratory will need 1 pint of the mixture of all subsamples.

One soil sample should represent 10 acres or less. Avoid sampling directly in the fertilized band.

Proper sampling depth depends on the kind of crop you plan to grow. For pastures, and minimum tillage, take the top 2-3 inches of soil. For cultivated crops, collect the upper 5-6 inches of soil.

If possible. collect and submit samples three to five months before your projected planting date to ensure you have plenty time to plan your liming and fertilization program for the upcoming season.



Manure Sampling

Proper sampling is the key to reliable manure analysis. Although lab procedures are accurate, they have little value if the sample fails to represent the manure produced by your herd.

Manure samples submitted to a lab should represent the average composition of the material that will be spread over a field. Reliable samples typically consist of material collected from a number of locations. Precise sampling methods vary according to the type of manure. The lab, county extension agent or crop consultant should have specific instructions on sampling, including proper containers to use and maximum holding or shipping times. General sampling recommendations follow.

Preparing liquid manure for lab analysis

Liquid manure samples submitted for analysis should meet the following requirements:

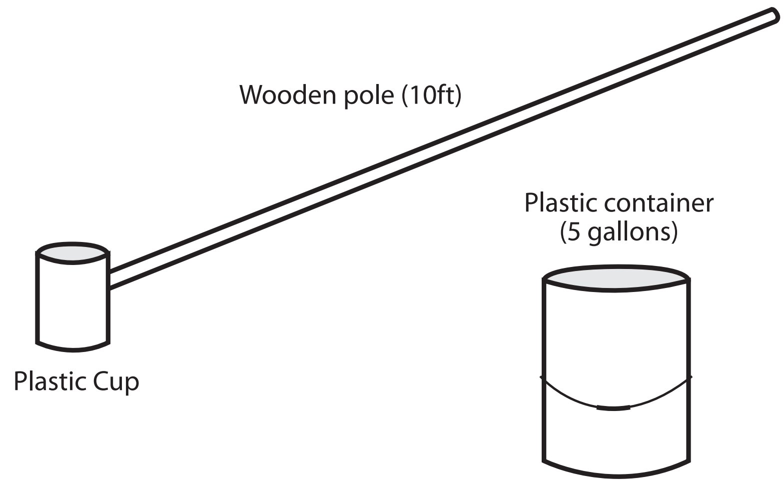
- Place sample in a sealed, clean, plastic container with about a 1-pint volume. Glass is not suitable because it is breakable and may contain contaminants.
- Leave at least 1 inch of air space in the plastic container to allow for expansion caused by the release of gas from the manure material.
- Refrigerate or freeze samples that cannot be shipped on the day they are collected, minimizing chemical reactions and pressure buildup from gases.

Ideally, liquid manure should be sampled after it is thoroughly mixed. Because this is sometimes impractical, samples also can be taken in accordance with the suggestions that follow.

Lagoon liquid. Premixing the surface liquid in the lagoon is not needed, provided it is the only component that is being pumped. Growers with multistage systems should draw samples from the lagoon they intend to pump for crop irrigation.

Samples should be collected using a clean, plastic container similar to the one shown in Figure 16. One pint of material should be taken from at least eight sites around the lagoon and then mixed in the larger, clean, plastic container. Effluent should be collected at least 6 feet from the lagoon's edge at a depth of about a foot. Shallower samples from anaerobic lagoons may be less representative than deep samples, because oxygen transfer near the surface sometimes alters the chemistry of the solution. Floating debris and scum should be avoided. One pint of mixed material should be sent to the lab. Galvanized containers should never be used for collection, mixing or storage due to the risk of contamination from metals like zinc in the container.

Figure 16. Liquid manure sampling device.



A University of Idaho study compared nutrient composition from two sampling locations: direct from storage and during land application. Nitrogen concentration averaged 15 pounds per acre-inch higher in storage samples than from land application samples. Conversely, phosphorus and potassium concentrations were similar between storage and land application samples. Nitrogen application rates may be overestimated if based on nutrient analysis from storage samples.

These recommendations are adequate for average irrigation volumes. If an entire storage structure is to be emptied by such means as furrow irrigation, more frequent sampling with many more sampling points is recommended.

Liquid samples should be sent to the lab in plastic bottles, not in plastic bags as shown.

What does my manure analysis report tell me?

Lab results may be presented in a number of ways. The easiest to use is a wet, "as-is" basis in pounds of available nutrient (nitrogen, phosphorus, potassium) per ton, per 1,000 gallons of manure or wastewater or per acre-inch of manure or wastewater.

If a lab reports results on a dry basis, you must have the moisture content of the manure to convert the results back to a wet basis. A lab also may give results as a concentration (parts per million [ppm] or milligram per liter [mg/l]), which likewise requires conversion factors to get the results into a usable form based on how you apply the manure. Finally, if a lab reports phosphorus and potassium (P and K) as elemental phosphorus and potassium, you must convert them to the fertilizer bases of P_2O_5 or K_2O. This can be done with the following conversions:

$$\mathbf{P \times 2.29 = P_2O_5}$$

$$\mathbf{K \times 1.20 = K_2O}$$

Select a lab that reports an analysis on an "as-is" basis in the units of measure most useful to your operation.

Buffers and Field Borders

Field borders (NRCS Code 386) and filter strips (NRCS Code 393) are strips of grasses or other close-growing vegetation planted around fields and along drainageways, streams and other bodies of water. They are designed to reduce sediment, organic material, nutrients and chemicals carried in runoff.

In a properly designed filter strip, water flows evenly through the strip, slowing the runoff velocity and allowing contaminants to settle from the water. In addition, where filter strips are seeded, fertilizers and herbicides no longer need to be applied right next to susceptible water sources. Filter strips also increase wildlife habitat.

Soil particles (sediment) settle from runoff water when flow is slowed by passing through a filter strip. The largest particles (sand and silt) settle within the shortest distance. Finer particles (clay) are carried the farthest before settling from runoff water, and they may remain suspended when runoff velocity is high. Farming practices upslope from filter strips affect the ability of strips to filter sediment. Fields with steep slopes or little crop residue will deliver more sediment to filter strips than more gently sloping fields and those with good residue cover. Large amounts of sediment entering a filter strip may overload the filtering capacity of the vegetation, and some may pass on through.

Filter strip effectiveness depends on five factors:

1. **The amount of sediment reaching the filter strip.** This is influenced by:

   • Type and frequency of tillage in cropland above the filter strip. The more aggressive and frequent tillage is above filter strips the more likely soil is to erode.

   • Time between tillage and a rain. The sooner it rains after a tillage operation, the more likely soil is to erode.

   • Rain intensity and duration. The longer it rains, and thus the more sediment deposited, the less effective filter strips become as they fill with soil.

   • Steepness and length above the filter strip. Water flows faster down steeper slopes. Filter strips below steep slopes need to be wider to slow water and sediment movement adequately.

In general, a wider, uniformly shaped strip is more effective at stopping or slowing pollutants than a narrow strip. As a field's slope or watershed size increases, wider strips are required for effective filtering. Table 7 gives the suggested filter strip width based on slope. For a more accurate determination of the size of filter strip you will need for your individual fields, consult your local NRCS or Soil and Water Conservation District office.

Table 7. Suggested vegetated filter strip widths* based on land slope (%).

Land Slope, %	Strip Width, Feet
0-5	20
5-6	30
6-9	40
9-13	50
13-18	60

*Widths are for grass and legume species only and are not intended for shrub and tree species.
Adapted from the NRCS Field Office Technical Guide, 1990.

2. **The amount of time that water is retained in the filter strip.** This is influenced by:

   • Width of the filter area. Filter strips will vary in width, depending on the percentage of slope, length of slope and total drainage area above the strip.

   • Type of vegetation and quality of stand. Tall, erect grass can trap more sediment than can short, flexible grass. The best species for filter strips are tall, perennial grasses. Filter strips may include more than one type of plant and may include parallel strips of trees and shrubs, as well as perennial grasses. In addition to potential for improving water quality, these strips increase diversity of wildlife habitat.

3. Infiltration rate of the soil

Soils with higher infiltration rates will absorb water and the accompanying dissolved nutrients and pesticides faster than soils with low infiltration rates. Parish soil survey reports include a table listing the infiltration rate group for the soils identified in each parish.

4. Uniformity of water flow through the filter strip

Shallow depressions or rills need to be graded to allow uniform flow of water into the filter strip along its length. Water concentrated in low points or rills will flow at high volume, so little filtering will take place.

5. Maintenance of the filter strip

When heavy sediment loads are deposited, soil tends to build up across the strip, forming a miniature terrace. If this becomes large enough to impound water, water will eventually break over the top and flow will become concentrated in that area. Strips should be inspected regularly for damage. Maintenance may include minor grading or re-seeding to keep filter strips effective.

Grassed waterways (NRCS Code 412) are natural or constructed channels that are shaped or graded to required dimensions and planted in suitable vegetation to carry water runoff. They are designed to carry this runoff without causing erosion or flooding and to improve water quality by filtering out some of the suspended sediment.

Riparian forest buffers (NRCS Code 391) are areas of trees, shrubs and other vegetation located adjacent to and uphill from water bodies. This practice may be applied in a conservation management system to supplement one or more of the following:

- To create shade to lower water temperature, which would improve habitat for aquatic organisms.
- To remove, reduce or buffer the effects of nutrients, sediment, organic material and other pollutants before entry into surface water and groundwater recharge systems.

This practice applies on crop, hay, range, forest and pasture areas adjacent to permanent or intermittent streams, lakes, rivers, ponds, wetlands and areas with groundwater recharge where water quality is impaired or where there is a high potential of water quality impairment.

In summary:

- Vegetative filter strips can reduce sediment effectively if water flow is even and shallow.
- Filter strips must be properly designed and constructed to be effective.
- Filter strips become less effective as sediment accumulates. With slow accumulation, grass regrowth between rains often restores the filtering capacity.
- Filter strips remove larger sediment particles of sand and silt first. Smaller clay-size particles settle most slowly and may be only partially removed, depending on the strip width and water flow rate.
- Because soil-bound nutrients and pesticides are largely bound to clay particles, filter strips may be only partially effective in removing them.
- Fewer dissolved nutrients and pesticides will be removed than those bound to soil particles.
- Filter strips are a complementary conservation practice that should be used with in-field conservation practices such as conservation tillage, contour buffer strips, strip cropping and waterways.

Manure Application

Selecting the appropriate land application method

The land application of livestock manure is facing growing scrutiny because of potential surface water and groundwater contamination as well as odor nuisances. As a result, when selecting and operating manure application equipment, producers must consider environmental issues along with material-handling and economic factors (Table 8).

Table 8. Environmental rating of various manure application systems.

Type of System	Uniformity of Application	Nitrogen Conservation	Odor Nuisances	Soil Compaction	Timeliness of Manure Application
Solid System					
Box spreader; tractor pulled	poor	very poor	fair	fair	poor
Box spreader; truck mounted	poor	very poor	fair	fair	fair
Flail spreader	fair	very poor	fair	fair	poor
Side-discharge spreader	fair	very poor	fair	fair	poor
Dump truck	very poor	very poor	fair	very poor	fair
Liquid Systems: Surface Spread					
Liquid tanker with splash plate	poor	poor	poor	poor	fair
Liquid tanker with drop hoses	poor	fair	good	poor	fair
Small impact sprinkler system	good	very poor	poor	excellent	good
Big gun irrigation system	good	very poor	very poor	excellent	excellent
Center pivot irrigation system	excellent	very poor	very poor	excellent	excellent
Liquid Systems: Incorporation					
Tanker with knife injectors	good	excellent	excellent	poor	fair
Tanker with shallow incorporation	good	excellent	excellent	poor	fair
Drag hose with shallow incorporation	good	excellent	excellent	good	good

Environmental considerations

Manure spreader as a fertilizer applicator. The fundamental principle underlying both best management practices and future regulatory requirements for manure application will be efficient crop use of applied nutrients. Manure spreaders will need to be managed like any other fertilizer or chemical applicator. Spreaders and irrigation equipment will need to apply manure uniformly, provide a consistent application rate between loads and offer a simple means of calibration. Appropriate equipment selection and careful operator management will contribute to the efficient use of manure nutrients.

Nitrogen conservation. The availability of the nitrogen and phosphorus in applied manure is usually out of balance with crop needs. Typically, high soil phosphorus levels result from long-term applications of manure. The ammonium fraction, originally representing roughly half of the potentially available nitrogen, is lost by the long-term open lot storage of manure, anaerobic lagoons and the surface spreading of manure. Systems that conserve ammonium nitrogen and provide nutrients more in balance with crop needs increase the manure's economic value.

Odor nuisances. Odor nuisances are the primary driving factor behind more restrictive local zoning laws for agriculture. Better management of manure nutrients through increased reliance on manure storage and land application of manure in narrow windows of time may add to or reduce odor complaints due to weather conditions or the location and your relationship with neighbors. Manure application systems that minimize odor deserve consideration and preference when neighbors live near application sites.

Soil compaction. Manure spreaders are heavy. In a 3,000-gallon liquid manure tank, the manure alone weighs more than 12 tons. In addition, manure often is applied at the time of year – late fall and early spring – when high soil moisture levels and the potential for compaction are common. The impact of manure application on potential soil compaction requires consideration.

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

Irrigation systems

A properly designed irrigation system provides the operator the opportunity to uniformly apply wastewater at agronomic rates without direct runoff from the site. A "good design" does not guarantee proper land application, however. The performance of a well-designed system can be ruined by poor management; likewise, a poorly designed system can sometimes provide good performance with proper, intensive management. You should be familiar with your system components, range of operating conditions, and maintenance procedures and schedules to keep your system in proper operating condition.

Stationary sprinkler systems

Stationary systems for land application of lagoon liquid usually are permanent installations (lateral lines are PVC pipes permanently installed below ground). One of the main advantages of stationary sprinkler systems is that these systems are well suited to irregularly shaped fields. Thus, it is difficult to give a standard layout, but there are some common features between systems. To provide proper overlap, sprinkler spacings normally are 50 to 65 percent of the sprinkler wetted diameter. Sprinkler spacing is based on nozzle flow rate and desired application rate. Sprinkler spacings typically are in the range of 80 feet by 80 feet using single-nozzle sprinklers. Other spacings can be used, and some systems are designed to use gun sprinklers (higher volume) on wider spacings. A typical layout for a permanent irrigation system is shown in Figure 17. Most permanent systems use Class 160 PVC plastic pipe for mains, submains and laterals and either 1-inch galvanized steel or Schedule 40 or 80 PVC risers near the ground surface where an aluminum quick coupling riser valve is installed. In grazing conditions, all risers must be protected (stabilized) if left in the field with animals.

The minimum recommended nozzle size for wastewater is ¼ inch. Typical operating pressure at the sprinkler is 50 to 60 PSI. Sprinklers can operate full or partial circle. The system should be zoned (any sprinklers operated at one time constitutes one zone) so that all sprinklers are operating on about the same amount of rotation to achieve uniform application. Gun sprinklers typically have higher application rates; therefore, adjacent guns should not be operated at the same time (referred to as "head to head").

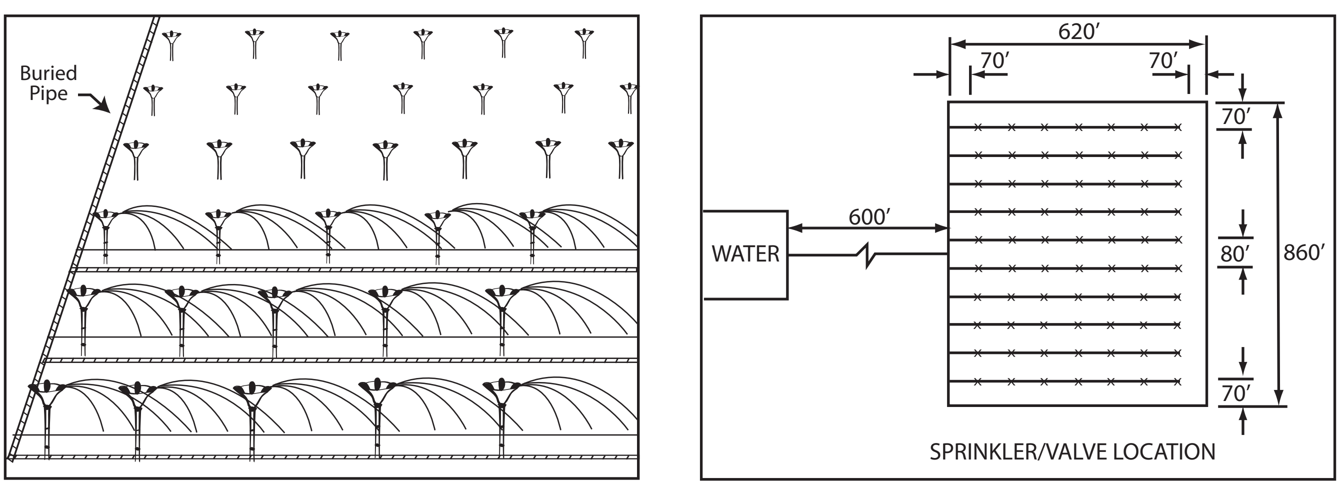


Figure 17. Schematic layout of a permanent irrigation system used to apply animal waste.

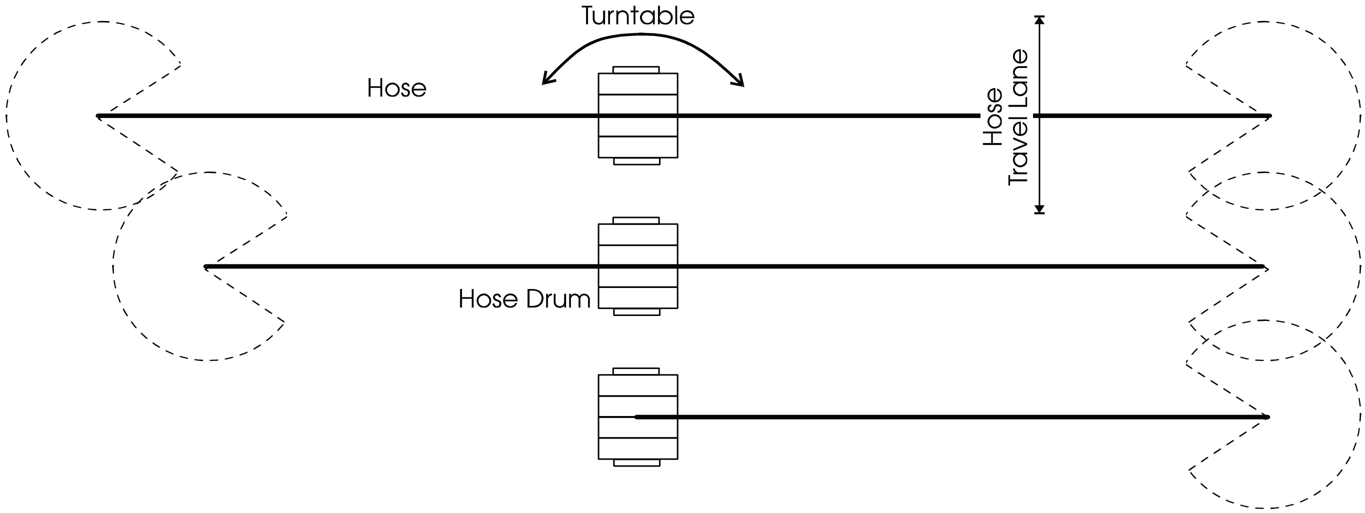


Figure 18. Schematic layout of a hose-drag traveler. Travel lanes are 100 to 300 feet apart, depending on sprinkler capacity and diameter coverage.

Traveling sprinklers

Traveling sprinkler systems are either cable-tow traveler, hard-hose traveler, center pivot or linear-move systems.

The cable-tow traveler consists of a single-gun sprinkler mounted on a trailer with water being supplied through a flexible, synthetic fabric, rubber- or PVC-coated hose. Pressure rating on the hose normally is 160 PSI. A steel cable is used to guide the gun cart.

The hose-drag traveler consists of a hose drum, a medium-density polyethylene (PE) hose and a gun-type sprinkler. The hose drum is mounted on a multiwheel trailer or wagon. The gun sprinkler is mounted on a wheeled or sled-type cart referred to as the gun cart. Normally, only one gun is mounted on the gun cart. The hose supplies wastewater to the gun sprinkler and also pulls the gun cart toward the drum. The distance between adjacent pulls is referred to as the lane spacing. To provide proper overlap, the lane spacing is normally 70 to 80 percent of the gun wetted diameter. A typical layout for a hard-hose traveler irrigation system is shown in Figure 18.

The hose drum is rotated by a water turbine, water piston, water bellows, or internal combustion engine. Regardless of the drive mechanism, the system should be equipped with speed compensation so the sprinkler cart travels at a uniform speed from the beginning of the pull until the hose is fully wound onto the hose reel. If the solids content of the wastewater exceeds 1 percent, an engine drive should be used.

Nozzle sizes on gun-type travelers are ½ inch to 2 inches in diameter and require operating pressures of 75 to 100 PSI at the gun for uniform distribution. The gun sprinkler has either a taper bore nozzle or a ring nozzle. The ring nozzle provides better breakup of the wastewater stream which results in smaller droplets with less impact energy (less soil compaction) and also provides better application uniformity throughout the wetted radius. But, for the same operating pressure and flow rate, the taper bore nozzle throws water about 5 percent further than the ring nozzle. That means the wetted diameter of a taper bore nozzle is about 5 percent wider than the wetted diameter of a ring nozzle. This results in about a 10 percent larger wetted area with the taper bore nozzle, since the precipitation rate of a taper bore nozzle is approximately 10 percent less than that of a ring nozzle.

A gun sprinkler with a taper bore nozzle is normally sold with only one size nozzle, but a ring nozzle is often provided with a set of rings ranging in size from ½ inch to 2 inches in diameter. This allows the operator flexibility to adjust flow rate and diameter of throw without sacrificing application uniformity. There is confusion, however, that leads people to believe using a smaller ring with a lower flow rate will reduce the precipitation rate. This is not normally the case. Rather, the precipitation rate remains about the same, because while a smaller nozzle results in a lower flow, it also results in a smaller wetted radius or diameter. The net effect is little or no change in the precipitation rate. Furthermore, on water-driven systems, the speed compensation mechanism is affected by flow rate. There is a minimum threshold flow required for proper operation of the speed compensation mechanism. If the flow drops below the threshold, the travel speed becomes disproportionately slower, resulting in excessive application even though a smaller nozzle is being used. System operators should be knowledgeable about the relationships between ring nozzle size, flow rate, wetted diameter and travel speed before interchanging different nozzle sizes. As a general rule, operators should consult with a technical specialist before changing nozzle size to a size different from what was specified in the certified waste management plan.

Table 9. Advantages and disadvantages for stationary and traveling irrigation systems:

	Advantages	Disadvantages
Stationary Systems	good for small or irregular fields	higher initial costs
	do not have to move equipment	must protect from animals in fields
		small-bore sprinklers more likely to get plugged or broken
		no flexibility to move to other (new) fields
Traveling Systems	system is transportable	more difficult to calibrate
	application rate can be adjusted (speed and nozzle settings)	does not maximize the use of area for irregularly shaped fields
	easily used for new fields	impractical for small areas

Solid manure application systems

Manure of 20 percent solids or more typically is handled by box, side-discharge or spinner spreaders.

Box-type spreaders range in size from under 3 tons (100 cubic feet) to 20 tons (725 cubic feet). Box spreaders provide either a feed apron or a moving gate for delivering manure to the rear of the spreader. A spreader mechanism at the rear of the spreader (paddles, flails or augers) distributes the manure. Both truck-mounted and tractor-towed spreaders are common.

Flail-type spreaders provide an alternative for handling drier manure. They have a partially open top tank with chain flails for throwing manure out the spreader's side. Flail units have the capability of handling a wider range of manure moisture levels ranging from dry to thick slurries.

Side-discharge spreaders are open-top spreaders that use augers within the hopper to move wet manure toward a discharge gate. Manure is then discharged from the spreader by either a rotating paddle or set of spinning hammers. Side-discharge spreaders provide a uniform application of manure for many types of manure – with the exception of dry poultry litter.

Spinner-type spreaders, used to apply dry poultry litter, are similar to the hopper-style spreaders used to apply dry commercial fertilizer or lime. Manure placed in the storage hopper is moved toward an adjustable gate via a chain drive. Manure then falls out of the spreader onto two spinning discs that propel the litter away from the spreader. Uniform application can be achieved easily with spinner spreaders by either varying the spinner speed or angle.

Application rates can be adjusted by changing the travel speed and opening or closing the opening on the spreader gate. With the growing concern about manure contamination of water and air resources, spreaders must be capable of performing as fertilizer spreaders. Typically, such equipment has been designed as disposal equipment with limited ability to calibrate application rates or maintain uniform, consistent application rates. Several considerations specific to solids application equipment follow:

- The operator must control the application rate. Feed aprons or moving push gates, hydraulically driven or power takeoff (PTO) powered, impact the application rate. Does the equipment allow the operator to adjust the application rate and return to the same setting with succeeding loads?
- Uniformity of manure application is critical for fertilizer applicators. Variations in application rate are common both perpendicular and parallel to the direction of travel. Uniformity can be checked by laying out several equal-size plastic sheets and then weighing the manure that falls on each sheet during application. The variation in net manure weights represents a similar variation in crop-available nutrients.
- Transport speed and box or tank capacity affect timely delivery of manure. Often 50 percent or more of the time spent hauling manure is for transit between the feedlot or animal housing and field. Truck-mounted spreaders

can provide substantial time savings over tractor-pulled units for medium- and long-distance hauls. Trucks used for manure application must be designed to travel in agriculture fields, however. Available four-wheel drive and dual- or flotation-type tires should be considered for trucks that will apply manure. Increased box or tank capacities speed delivery. Spreaders must be selected to move and apply manure quickly.

- Substantial ammonia is lost from solid manure that is not incorporated. Most of the ammonia nitrogen, representing between 20 percent and 65 percent of the total available nitrogen in manure, will be lost if not incorporated within a few hours. Practices that encourage the incorporation of manure into the soil on the same day that it is applied will reduce ammonia losses but may increase soil erosion.

Table 10. Nitrogen losses during land application. Percent of total nitrogen lost within 4 days of application.

Application Method	Type of Manure	Nitrogen Lost, %
Broadcast	Solid	15-30
	Liquid	10-25
Broadcast with immediate incorporation	Solid	1-5
	Liquid	1-5
Knifing	Liquid	0-1
Sprinkler irrigation	Liquid	15-50

Source: Livestock Waste Facilities Handbook, MWPS-18.

Table 11. Odor emission rates during land spreading of pig slurry from manure storage.

Application Method	Total Odor Emissions [1]
Irrigation	6,250
Tanker with splash plate	1,322
Deep injection	689
Shallow incorporation	503
Low-trajectory spreader with 15 trailing hoses	130

[1]Odor units per 1,000 gallons of slurry applied as measured by olfactometer.

Source: Phillips et al. 1991, Odor and Ammonia Emissions from Livestock Farms.

Surface broadcast of liquid manure. Surface application of liquid slurries provides a low-cost means of handling the manure stream from many modern confinement systems. Tank wagons equipped with splash plates are commonly used to spread manure. Surface application suffers from several disadvantages, however, including ammonia loss, odor and poor uniformity.

- **Ammonia losses.** Surface application of slurries results in losses of 10 percent to 25 percent of the available nitrogen due to ammonia volatilization (Table 9).
- **Odor.** Aerosol sprays produced by mixing manure and air carry odors considerable distances (Table 10).
- **Uniformity.** Splash plates and nozzles provide poor distribution of manure nutrients. Wind can add to this challenge.

A few recent developments attempt to address these concerns. For the first time, boom-style application units for attachment to tank wagons or towed irrigation systems are appearing commercially. These systems use nozzles or drop hoses to distribute slurry. They tend to reduce odor concerns and improve uniformity of distribution. Other systems are under development.

Direct incorporation of liquid manure. The options for direct incorporation of liquid manure are increasing (Figure 19). Injector knives have been the traditional option. Knives, often placed on 20- to 25-inch centers, cut 6- to 8-inch deep grooves in the soil into which the manure is placed. High power requirements and limited mixing of soil and manure are commonly reported concerns.

Injector knives with sweeps that run 4 to 6 inches below the soil surface facilitate manure placement in a wider band at a shallower depth. Manure is placed immediately beneath a sweep (up to 18 inches wide), which improves the mixing of soil and manure. Locating the manure higher in the soil profile minimizes potential leaching, decreases the number of hot spots that affect plant growth and reduces power requirements. Sweeps can be used to apply a higher rate of manure than a conventional injector knife.

Other shallow incorporation tillage implements (s-tine cultivators and concave disks) are increasingly available options on many liquid manure tank wagons. These systems are most commonly used for pre-plant application of manure. Manure is applied near the tillage tool, which immediately mixes the manure into the soil. Speed of application, low power requirements and uniform mixing of soil and manure have contributed to the growing popularity of this approach. In addition, such systems are being used to side-dress manure on row crops without foliage damage. Side-dressing expands the season during which manure can be applied and increases the use of manure nutrients. All soil incorporation systems also offer the advantage of ammonia conservation and minimal odors.

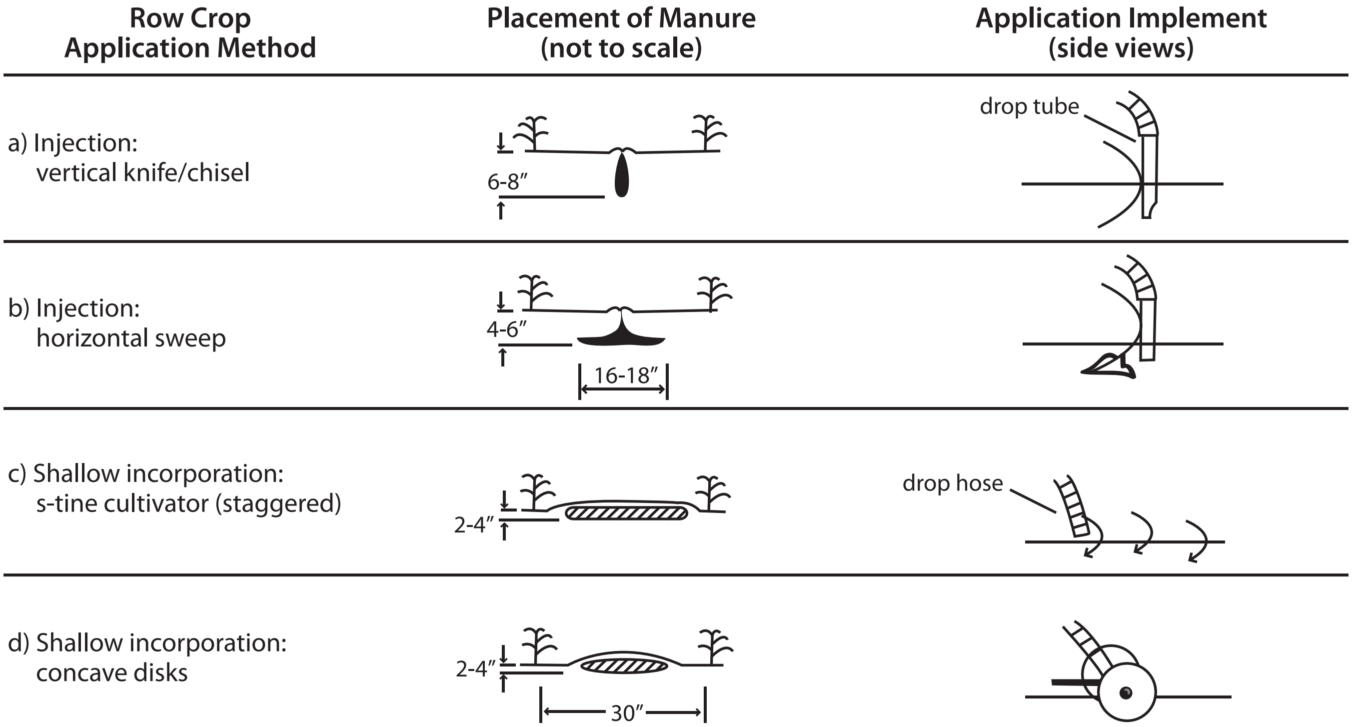


Figure 19. Options for manure incorporation into the soil. Adapted from Jokela and Cote 1994.

Flexible hose systems. Flexible hose delivery systems tied to a tractor-pulled field implement or injector unit move liquid manure quickly (Figure 20). A common approach begins with a high-volume, medium-pressure pump located at the liquid manure reservoir. Manure is delivered to the edge of the field (at the field's midpoint) by standard 6- or 8-inch irrigation line. At this point, a connection is made to a 660-foot-long, 4-inch-diameter, soft, irrigation hose. Often two lengths of hose are used. Manure is delivered to a tractor with toolbar-mounted injectors or splash plates immediately in front of a tillage implement. Flexible hose systems distribute manure at rates up to 1,000 gallons per minute (gpm). Thus, a million-gallon storage can be emptied in a 24-hour pumping period. Comparatively, using 3,000-gallon or greater tankers increases soil compaction. But the high cost of capital equipment makes the larger-scale approach affordable only to larger livestock operations and custom applicators.

Pumping liquid manure from the manure storage to the field is becoming increasingly common. Manure of up to 8 percent solids is being pumped several miles to remote storage or to field application equipment. Pipe friction is the primary limiting factor. Manure with a solids content below 4 percent can be treated as water in estimating friction losses. An additional allowance for friction loss is required, however, to pump manure with solids content above 4 percent.

Manure-handling systems that involve the addition of significant dilution water or liquid-solids separation equipment provide a slurry that is most appropriate for this application. To pump manure (with greather than 4 percent solids) longer distances requires heavy-duty equipment. Aggressive chopper units often are installed just before the pump when solids separation equipment is not used. Industrial slurry pumps are selected to overcome the pipe friction losses and avoid potential wear problems. Buried PVC piping with a high-pressure rating (e.g., 160 PSI) generally is selected. Because manure leaks are far more hazardous than water leaks, joints must be carefully assembled and tested. Special care also must be given to piping crossing streams and public roads. If public roads will be crossed, appropriate local governments maintaining these roads should be contacted early in the planning process.

Equipment calibration

You can avoid the potentially adverse effects of overfertilization on ground and surface water by applying only the amount of manure, effluent or wastewater necessary to maintain soil fertility for crop production. The calibration – or combination of settings and travel speed needed to uniformly apply manure, bedding or wastewater at a desired rate – of manure-spreading equipment is important because it tells you the amount of manure and wastewater that you are applying to an area. Knowledge of the application rate and nutrient concentration of manure nutrients lets you apply manure at agronomic rates.

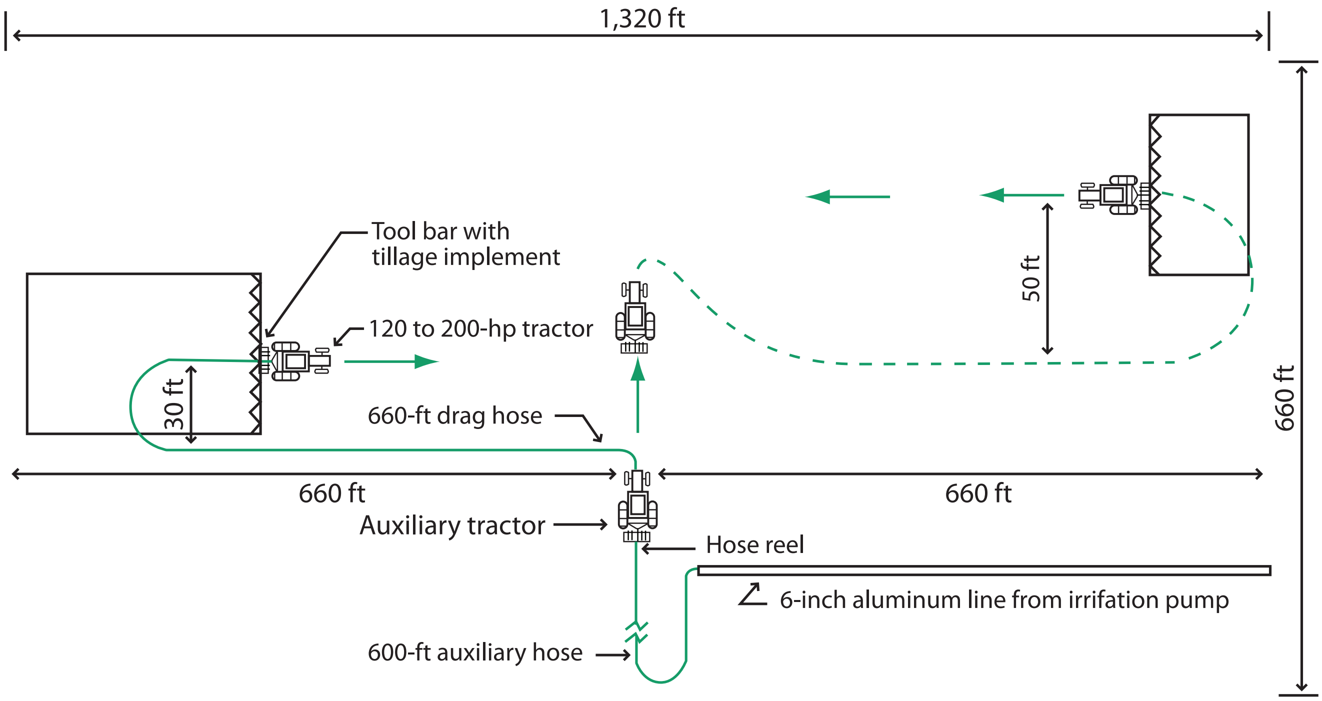


Figure 20. Drag-hose setup for 20-acre field. Towed-hose systems move manure from storage to field via a pump, pipeline and soft hose that are pulled behind the tractor and application equipment. Source: NRAES-89.

Why calibrate?

- Verify actual application rates
- Troubleshoot equipment operation
- Determine appropriate overlaps
- Evaluate application uniformity
- Identify "hot spots" or areas of deficient application
- Monitor changes in equipment operations, such as usage and "wear and tear"
- Determine changes in manure consistency or "thickness"

Simply put, calibration enables producers to know how much manure they are applying. Knowing the actual application rate allows them to apply manure and nutrients at specific rates that meet the needs of growing crops. If required, calibration also ensures rates do not exceed state or local regulatory limits or the conditions expressed in a livestock facility's operating permit.

Direct injection is the best way to prevent odor and increase the value of your manure.

Farmstead Management

Heavy-use area protection (NRCS code 561)

Open, unpaved, bare areas are common on Louisiana dairies. Examples are feeding or watering areas, pathways to the barns, pre-milking staging areas, shaded animal areas and transition areas from pavement to dirt. These areas may be considered to need runoff controls in most cases, and improvements to these areas will minimize the effects of runoff into streams.

Unpaved areas of high cattle density, such as around open feed areas or transition areas from pavement to dirt, may be underlaid with suitable surface materials to reduce muddy conditions. One option might be geotextile fabric or filter cloth. If used, the surface on which the nonwoven geotextile is placed should be graded smooth and free of loose rocks, depressions, projections and standing or flowing water. The geotextile is unrolled and placed loosely on the graded soil surface, overlapping at the seams by 18 inches. Approximately 4 to 6 inches of crusher-run gravel is placed on top of the geotextile. This installation allows surface liquids to drain through and provides a firm footing for the animals, thereby preventing miring of their hooves.

When possible, dirt lots should be located at least 100 feet away from perennial streams and 25 feet away from intermittent streams and drainage ways and should have a permanently vegetated buffer. These lots should not have an unfenced stream or wet area within their boundaries. All surface water from above these lots should be diverted around them. Sloping lots should have cross terraces to reduce erosion and collect eroded sediment and manure solids. At the lowest point of the lot edge, earthen or concrete settling basins help trap solids that may otherwise leave in rainfall runoff. Where possible, these lots should be rotated and the surface manure pack scraped from the unused lot before reseeding with grass. Waterers located within these areas should be kept in good repair to minimize leakage and spillage.

Trough or tank (NRCS code 614)

Dairy animals typically are managed on pastures in partial confinement. While animals are on pasture, their waste should not be a resource concern if stocking rates are not excessive, grazing is evenly distributed and grazing is not allowed during rainy periods when the soil is saturated.

It is best for pasture feeding areas to be located on the higher points of the pasture and away from streams. Portable feed bunks should be moved periodically. Permanent cattle waterers should be located away from streams and have an improved apron around them of concrete, gravel or gravel and geotextile fabric.

If using rotational grazing, where pastures are divided into paddocks separated by electric fencing, paddock subdivisions that allow a one- to three-day rotation of the cattle have been found to be successful. When subdividing long slopes, make the paddocks cross the slope so animals are not forced to graze up and down steep, narrow hillsides, if applicable. Lanes that provide access to shade and water should be as centrally positioned as possible for efficient cattle movement. Lane surfaces likely will need to be improved with gravel, geotextile fabric or both.

Drinking water, when provided in every pasture or paddock, increases the amount of time the cattle graze and reduces the amount of manure in the vicinity of the primary waterer. Shallow tubs beneath fence lines can serve two or more paddocks. Water can be piped in through underground lines. Quick couplers can be installed in water mains to allow one to two tubs to be moved with the cattle from paddock to paddock.

Stream and stream bank protection (NRCS code 580)

Cattle movement from pasture to pasture or paddock to paddock is best done by improved cow lanes and stock trails. These lanes should be planned efficiently for animal movement, should follow the contour of the land whenever possible and should be as far away from streams as possible. Lane surfaces, in many cases, will need to be improved with gravel, geotextile fabric or both to reduce muddy conditions and erosion. Trails for dairy cows, which are used intensively each day, must direct the cows from the pastures to the milking center.

Improved crossings in pasture or dry-lot areas where cattle must cross a stream can help to maintain bank integrity and reduce erosion. These crossings may be in conjunction with fenced stock trails or they may be in open pastures. In open pastures, an approach segment of the stream above and below the crossing may need to be fenced to train the cattle to use the crossing.

One method to improve a stream crossing is to uniformly grade a 10- to 15-foot wide section of the bank on each side, as well as the stream bottom. If it is not solid, use geotextile fabric and gravel on the surface of the graded section. Concrete slabs also have been used to hard-surface crossings.

Another crossing method is to install a culvert covered with compacted soil in the stream. Care must be taken to size the culvert with enough capacity to handle storm events. A third method is to construct a bridge for cattle to cross larger or wider streams. Professional advice should be sought to ensure that bridges and culverts will be structurally sound.

Stream fencing (NRCS code 382)

Fencing cattle out of streams is needed only when the water quality or stream banks have been or will be significantly degraded because of the presence of cattle congregating or lounging in the stream. Stream segments through feedlots, near heavy-use areas or where stream banks have been severely eroded probably will need to be fenced to restrict cattle access. Wetlands or spring-fed water courses also may need to be fenced. Streams in pasture or wooded areas where stream bank integrity is maintained and stream edges that have permanent wooded or vegetated buffers may not need to be fenced.

Sediment basin (NRCS code 350)

This is a basin constructed to collect and store manure and sediment. Its purpose is to maintain the capacity of lagoons, to prevent deposition on bottom lands and to trap sediment, agricultural waste and debris. Another application of the sediment trap can be used to help prevent field boarders or filter strips from becoming inundated with solids. A sediment basin placed before the vegetative filter to separate manure solids from the wastewater is a good management practice, when practical, to prevent the upper side of the vegetative filter from clogging with solids and reducing soil infiltration. The most common type of settling basin is a shallow, reinforced-concrete structure with a sloping entrance ramp to permit equipment access for solids cleanout. The basin should have a drain in one sidewall so liquids can be removed. Solids should be removed from the basin monthly or after each heavy rainfall, when practical.

Vegetated areas receiving settling basin liquid overflow consist of either an overland flow plot or a shallow grassed channel or waterway. These areas should be bermed or terraced so that all surface water outside the infiltration area is diverted.

Care should be taken during construction of a vegetative filter. Since infiltration is most important, every effort should be made to maintain soil integrity and permeability. Mulching, fertilizing, liming and even watering should be used to establish a healthy sod as soon after seedbed preparation as possible to prevent soil erosion.

Vegetative filter areas should be prepared and seeded at least one growing season before use. A combination of seasonal forage species that can tolerate wet conditions is suggested. Foliage should be clipped periodically and removed from the filter area. Do not remove late-fall foliage; this foliage growth will help filter winter and spring runoff. Vegetative filters can provide low-cost, low-management control of barnyard runoff and milking center wastewater for many small- and medium-size dairies. Studies indicate vegetative filters can remove more than 95 percent of the nutrients, solids and oxygen-demanding material from wastewater. They are not effective, however, on farms where large areas of paved feedlot drain into the filter or where large amounts of water are used in the milking center. See sections titled Field Boarders (NRCS Code 386) and Filter Strips (NRCS Code 393) for additional details.

Roof runoff management (NRCS code 558)

This practice can be used if rainfall runoff from barns or other structures is flowing across animal waste areas or bare ground areas where significant erosion is occurring. Management of this runoff ensures manure waste and sediment are not transported into drainage branches or small creeks that ultimately can carry pollutants into surface water off the dairy. The practice also can sometimes have the added benefit of protecting the foundation of the building from water inundation and weakening. In some cases, if desired, roof runoff can be collected, stored and used for other purposes such as lot wash-down water.

Gutters and down spouts commonly are used with care taken to ensure water from downspouts is directed away from the building foundation and areas of concern. Water velocity from downspouts is emptied onto the ground surface with velocity dissipation systems such as rock pads, rock filled trenches, or concrete to prevent erosion and to ensure ground infiltration.

Critical area planting (NRCS code 342):

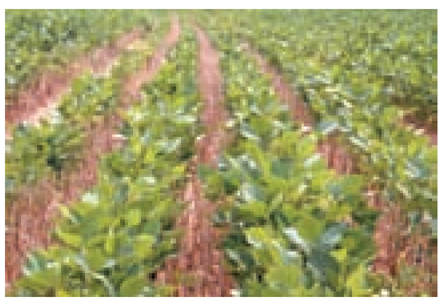
Examples of applicable areas are levees, cuts, fills and denuded or gullied areas where vegetation is difficult to establish by usual planting methods. The easiest and most effective way to protect these areas is to maintain perennial plants in these locations. These plants provide soil stabilization, help control erosion, provide water quality protection and supply wildlife habitat.

The roots of native grasses, low shrubs and aquatic plants bind to the soil and provide the necessary benefits. Proper treatment of a critical area involves the planting of vegetation, such as trees, shrubs, vines, grasses or legumes, on highly erodible or critically eroding areas. This practice does not include planting trees for wood products.

Although any rooted plants growing in these areas are helpful, some plants give better protection than others. Low grasses and shrubs that provide deep, strong, fibrous root systems are the best and grow faster than trees. One group of native tree that grows relatively fast and provides the necessary root system are the willows (Salix). Unlike trees, these are woody shrubs that love water and develop deep, strong root systems in wet soil. Plants that are suitable for planting in theses areas can be found in most nurseries or can be transplanted from existing stands. For advice on the proper plants for your situation, contact the local NRCS office or Cooperative Extension agent.

Survival of these plants depends on proper planting and care until the plants are firmly established. Bank shaping, weeding, fertilization, mulching and fencing from livestock may also be necessary, depending on individual circumstances.

Conservation tillage practices (NRCS code 329):



This system is designed to manage the amount, orientation and distribution of crop and other plant residues on the soil surface year-round. In conservation tillage, crops are grown with minimal cultivation of the soil. When the amount of tillage is reduced, the stubble or plant residues are not completely incorporated, and most or all remain on top of the soil rather than being plowed or disked into the soil. The new crop is planted into this stubble or small strips of tilled soil. Weeds are controlled with cover crops or herbicides rather than by cultivation. Fertilizer and lime are either incorporated earlier in the production cycle or placed on top of the soil at planting.

A sequence of changing tillage practices in several watersheds in Oklahoma enabled comparison of surface-water and groundwater effects associated with native grasses, conventionally tilled wheat and no-till wheat. Conversion of native grasses to conventionally tilled wheat increased soil loss dramatically. In areas where no-till cultivation was practiced, however, dramatic reductions in soil loss were minimized. This obvious conclusion was made further relevant by the fact that nutrient runoff was substantially reduced as a consequence of soil retention and soil moisture increased as an added benefit.

Reduced tillage practices in agronomic crops from forages such as corn, wheat and other forage species were introduced more than 50 years ago to conserve soil and water. Fifty years have proven crops grown without tillage use water more efficiently. In addition, the water-holding capacity of the soil increases, and water losses from runoff and evaporation are reduced. For crops grown without irrigation in drought-prone soils, this more-efficient water use can translate into higher yields. In addition, soil organic matter and populations of beneficial insects are maintained, soil and nutrients are less likely to be lost from the field and less time and labor is required to prepare the field for planting. In general, the greatest advantages of reduced tillage are realized on soils prone to erosion and drought.

There also are disadvantages of conservation tillage. Potential problems are compaction, flooding or poor drainage, delays in planting because fields are too wet or too cold and carryover of diseases or pests in crop residue. Another consideration is that as no-till is generally practiced in agronomic crops, the field is prepared for planting by killing the previous crop with herbicidal desiccants such as glyphosate (e.g., Roundup) or gramoxylin (e.g., Paraquat). The no-till seeders available for agronomic crops were designed to plant into these dried residues. Recently, agronomists have been developing no-till systems where cover crops are planted for weed control and then killed with flail or other types of mechanical cutters instead of herbicides. No-till seeders must be modified to work on these tougher residues.

This practice may be applied as part of a conservation management system to supplement one or more of the following:

- Reduce sheet and rill erosion.
- Maintain or improve soil organic matter content and tilth.
- Conserve soil moisture
- Provide food and cover for wildlife.

Irrigation water quality

Irrigation water (surface and/or well) should be tested in the spring to determine the salinity (salt) level before irrigating a field or pasture. Take samples to an approved laboratory for analysis.

Fuel storage tanks

Above-ground fuel storage tanks in Louisiana are regulated by the State Fire Marshal and by the EPA if surface water is at risk. Above-ground tanks containing 660 gallons or more require secondary containment. The State Fire Marshal recommends some sort of secondary containment be used with all fuel storage tanks. This could include the use of double-walled tanks, diking around the tank for impoundment or remote impoundment facilities.

Fuel storage requirements:

- Any existing above-ground fuel storage tank of 660 gallons or more (1,320 gallons if more than one) must have a containment wall surrounding the tank capable of holding 100 percent of the tank's capacity (or the largest tank's capacity if more than one) in case of spillage.
- The tank and storage area should be located at least 40 feet from any building. Fuel storage tanks should be placed 150 feet and down slope from surface water and water wells.
- It is recommended that the storage tank be on a concrete slab to prevent any spillage from entering surface water and groundwater.
- The storage area should be kept free of weeds and other combustible materials.
- The tank should be conspicuously marked with the name of the product it contains and "FLAMMABLE – KEEP FIRE AND FLAME AWAY."
- The bottom of the tank should be supported by concrete blocks approximately 6 inches above the ground surface to protect the bottom of the tank from corrosion.
- If a pumping device is used, it should be tightly and permanently attached and meet NFPA approval. Gravity discharge tanks are acceptable, but they must be equipped with a valve that will automatically close in the event of a fire.
- Plans for the installation of all storage tanks that will contain more than 60 gallons of liquid must be submitted to the State Fire Marshal for approval.
- All tanks that catch on fire must be reported to the State Fire Marshal within 72 hours of the fire.
- Underground storage tanks are defined as containing more than 10 percent of their total volume beneath the soil surface. Underground tanks represent more of a problem than above-ground tanks, because leaks often can go for long periods without being detected. This poses a serious threat to groundwater sources in the vicinity of the tank. If you have an underground fuel storage tank, you need to contact the State Fire Marshal's Office for regulations affecting these storage tanks.

Odor Prevention

Odors on dairies arise from many different sources. There are more than 160 odorous compounds that have been identified coming from manure. Some of these gases are said to contribute to global warming and the production of acid rain. There are four primary sources of odor from animal facilities: livestock operations with buildings or open lots, manure treatment/storage facilities, manure transport systems and areas of land application.

There are many variables that can cause odor and are almost impossible to eliminate. A combination of manure solids, dander, hair, bedding and feed are the cause of the majority of the dust problems in animal feeding operations. Some larger factors are animal activity, temperature, relative humidity, stocking density and feeding methods. Dust also harbors gases and odors. So dust reduction can significantly reduce problem odors.

Lagoons

An anaerobic lagoon is a basin, frequently earthen, used to treat and store manure from animal production facilities. A lagoon looks similar to an earthen liquid manure storage structure; but it serves the added function of dilution and treatment. Lagoons and storage structures differ in the length of storage, the amount of dilution needed and the fact that a lagoon is never completely emptied.

Treatment of animal waste in lagoons is performed by bacteria that decompose organic matter in an anaerobic environment. Anaerobic means the waste is treated without aeration or mixing devices in an oxygen-limiting environment. Anaerobic lagoons are used because of their efficiency and cost advantages. A properly sized and operated lagoon reduces organic material (which is the source of the majority of the odor), reduces the nitrogen concentration of the waste, allows treated liquid to be used for flushing of production facilities and allows solids to settle out. Most of the phosphorus will accumulate in the sludge in the bottom of the lagoon. As part of the best management practices (BMP) on dairy farms, waste lagoons were designed to hold solids for four years – although dairy lagoon cleaning requires expensive agitators, pumps and piping that most dairy producers do not possess.

An undersized lagoon increases the need for both more intensive management and pumping frequency. It also increases odor potential and nutrient (nitrogen and phosphorus) levels of water that leaves the lagoon, either as flush water or as irrigation water to a field. An undersized lagoon also increases the rate of sludge (solids) buildup in the lagoon and requires more frequent sludge removal.

Solid manure management

Odors from solid waste storage usually are considered to be less offensive than those from liquid storage. The liquid is removed from the solid waste and can be stored using two different methods. The two types of systems are stacking and composting. Stacking is for storage only, while composting is treatment and storage. For the solid manure to break down, it should have the appropriate ratio of carbon, nitrogen, porosity and the appropriate moisture level. By frequent mixing, noncomposted material is mixed with composted material – increasing the treatment efficiency and reducing the time in which the material is stabilized. Solid manure can be stored indoors to prevent exposure to wind, blown soil and rain.

Land application

Typically, more than 50 percent of all odor complaints filed nationwide are a result of applying manure. When the manure is applied to land, the exposed surface area is enlarged and that allows a large odor plume to form. One way to solve this dilemma is to rapidly incorporate or inject the manure into the soil. Odors also can be caused if concentrated liquid manure is pumped through an irrigation system at high pressures or without dilution.

Other emission sources

Dead animals have potential to be a source of odor. Proper disposal of dead animals is a must. Animals should never be disposed of in manure basins or storage pits. Truck and tractor activity also can cause large amounts of dust. Heavily traveled roads should be graveled or watered regularly to keep the dust down.

What are your options?

So what can you do if you have an odor problem? The following suggestions should not be used as a list of required practices for any or all dairies. Any odor-control strategies should be made keeping the farm's production goals, regulatory requirements and nutrient management plan in mind.

Clean up your farm. Clean up those random piles of manure. Easy places to find them are at the end of free-stall barns where they're getting scraped, underneath the corral fence lines and stockpiled on remote areas of the farm. Any feed that spills should be cleaned up right away, as well. This not only helps reduce odors but also cuts down on flies and dust.

Plant a windbreak. A cost-effective way to reduce odors from free-stall barns is to plant a windbreak. Planting a row of evergreens and fast-growing, hardwood trees near the barnyard will break wind flow and dilute smells. Plant trees far enough away from barns so natural ventilation can still occur. They also make the farmstead more attractive.

Improve protein utilization. Managing odors really starts with the ration the cows are eating. Make sure you aren't overfeeding protein and ending up with large amounts of nitrogen in the manure. Have a dairy nutritionist review your rations to look into feed additives that may improve feed efficiency and nitrogen utilization.

Separate solids. Removing the solids up front makes the liquid less intense when it's applied to land. Separated manure solids have little odor and can be hauled and land applied easily. Separating solids is not recommended just to move nutrients off the farm. Research is showing that you're only removing at most about 15 percent of the nutrients at best.

Empty out settling basins. Settling basins concentrate all of the biologically available solids in one spot. This results in plenty of biological activity and subsequent odors. Basins should be cleaned out at least every two weeks to prevent odor generation.

Use freshwater dilution. If water is available, this is an easy way to cut back on odors and can be a way of compensating for not separating solids. Blend fresh water with manure at a minimum of a 2 to 1 ratio.

Inject or incorporate manure. Incorporate broadcasted or irrigated manure within 24 hours after spreading to prevent odors. Injecting manure is even better. This prevents gasses in manure from reacting with and escaping into the atmosphere.

Keep irrigated manure out of the air. Odor concentrations during pivot or Big Gun applications can be reduced by eliminating the travel of wastewater through the air. Pivot irrigators should consider using drag tubes and spray nozzles that spread wastewater very low to the ground lower odor emissions. Pivot end guns should also not be used if there is a concern of odor emission. Wastewater should also not be irrigated when winds are more than 10 miles per hour.

A word of caution

It is important to evaluate your own farm before making any changes in how you handle manure to cut down on odors. Critically evaluate your options. A practice that works on one farm won't necessarily be successful on another farm because of the differences in how you manage your manure and your land-application system.

If you unfortunately have a problem, seek the help of technical experts with engineering and dairy management backgrounds who have seen the good and the bad of many manure systems. Work with them and take time to figure out what is going to work the best on your farm. Then design a plan, implement a strategy and monitor its success.

Responding to Complaints

It only takes a drive through any parish back road to see that more and more families are moving into rural areas of Louisiana. These families typically come from a nonfarmer background and do not understand contemporary agricultural practices. For a variety of reasons, they also are increasingly sensitive to issues related to agriculture, environmental quality, food safety and quality. Concerns about agricultural odors, dust and chemicals are exacerbated by both limited knowledge of agriculture and the desire of these rural immigrants to have a home in the country. Balancing the expectations of rural landowners and the needs of dairy producers to provide a safe and economical supply of milk will become more challenging in the years to come. There are some things that can be done, however, to make the situation better.

Being friendly and courteous to people who are neighbors to your farm can go a long way to help improve the image of the operation. The appearance of the farming operation also helps. A clean atmosphere is much more pleasing to look at than a dirty and unclean one. The way a manager handles complaints and concerns also is a vital part in keeping good relations with neighbors.

Be caring to neighbors. Give advance notice when you are planning to spread manure that may cause offensive odors. Talk with your neighbors to avoid spreading manure around outdoor weddings, barbecues, picnics and other social events that potentially could be ruined. Let your neighbors know you are willing to talk about odor problems and that you care. Ask your neighbors if they would like some compost or separated solids for their gardens.

A system of communication also may need to be set up. This will help solve any problems before they get out of hand. Some people feel more comfortable talking to someone other than the person with the problem. Give concerned members of the community a contact person to talk to. This third-party can be separated from the issue, be less emotionally involved and can likely identify simple and mutual solutions. Finally, dairy producers need to work with community leaders and regulatory agencies before complaints get out of hand. Today, in most parts of the country, community leaders set and enforce the regulations on farming operations. A dairy farmer working with community leaders may reduce the demands for regulations against odor. If dairy farmers do not work with neighbors and community leaders, it could mean losing profits or even your farm.

Emergency Action Plan

Potential hazards associated with manure

Accidents and injuries are a result of lack of preparedness for dangerous situations. Safety precautions need to be taken proactively. The preparation of an emergency plan, including safety manuals, safety training and safety meetings, should help prevent unsafe conditions and rationalize actions.

Manure can be hazardous to humans in numerous ways. Unfortunately, deaths by drowning or asphyxiation in manure storage facilities are not uncommon. Repetitive routines involved with manure transportation to and spreading on fields create conditions conducive to accidents. Manure also carries a variety of pathogens (disease-causing organisms) that can pose a threat to human health.

Manure pits, silos, tank spreaders, below-ground manure storage, grain bins and dryers constitute confined spaces under OSHA (Occupational Safety and Health Act) regulations. Only permitted personnel should have access to those areas. There are five main gases that can be toxic to humans in animal operations:

• Ammonia (NH_3) has a pungent odor. It causes irritation of eyes and nose at low concentrations and asphyxiation at high concentrations.

• Carbon Dioxide (CO_2) is an odorless gas. It causes drowsiness, headache and asphyxiation.

• Carbon Monoxide (CO) is an odorless gas. It can cause headache, chest pain and asphyxiation.

• Hydrogen Sulfide (HS_2) smells like rotten eggs. It poses the greatest risk among manure-emitted gases. Causes headache, dizziness, nausea, unconsciousness and death.

• Methane (CH_4) is an odorless gas. Causes headache and asphyxia and poses risk of explosion.

Manure agitation can increase release of those gases into the atmosphere, particularly early in the process. If there is a victim of intoxication or asphyxiation caused by manure gases, others should not attempt to rescue that person unless adequate breathing protection is available. Immediately request emergency assistance from trained personnel for the victim. If the person affected is in an open area, away from the risk area, and rescue is possible, check for breathing and pulse. If the person is not breathing, give four quick mouth-to-mouth breaths and check for pulse. If the person has pulse, maintain mouth-to-mouth breathing every 5 seconds. If there is no pulse, start CPR (cardio-pulmonary resuscitation).

To minimize the risk of accidental drowning, a fence should be built around the perimeter of the manure storage facility with signs posted indicating danger of drowning, intoxication and contamination. Gates should be closed at all times to minimize transit in the area. Unauthorized, untrained personnel should only be allowed near the storage area under supervision.

Employees should be properly trained to operate manure-handling equipment. First-aid-trained personnel should be available at all times in the operation. First-aid supplies should be readily available, and emergency telephone numbers should be easily accessible.

Considerations for an emergency action plan

The emergency plan is an essential part of a manure management plan. An emergency plan should consider the following aspects:

- A plan to prevent or minimize manure discharge by eliminating the source and containing the spill.
- A map with important sites, including buildings, fields, surface waters and emergency equipment.
- A cleanup and repair plan.
- Damage assessment and report.
- A list of contacts.
- Reiteration of the emergency action plan.

Discharge elimination plan

It is illegal to discharge directly into public waters, and such events can result in severe penalties. All efforts should be made to prevent a spill. A detailed plan for emergency spreading or transfer of manure stored on the property should be prepared to control leakage, overflow and/or runoff during or after hurricanes and tropical storms, heavy rains, catastrophic structural failure, flooding and catastrophic animal loss. Dairy producers should evaluate alternatives for an emergency spreading when soil or crop conditions are not conducive to spread manure adequately. Manure handling structures, piping, pumps and reels should be inspected on a regular basis to prevent breakdown, leaks and spills. Maintenance checklists should be kept on-site. In spite of the severity of the situation, an emergency plan should always be in compliance with current federal and state manure management regulations.

The first action in the event of an imminent discharge is to stop the flow of manure. Discharges usually occur as a result of manure storage overtopping or leaking, leakage of manure handling equipment or manure runoff during spreading. Possible solutions to stop manure overtopping storage facilities include prevention of any input to the storage, raising the berm level with soil and pumping manure onto available fields at an adequate rate. Storage freeboard should be monitored regularly, and minimum requirements should be respected to prevent manure spills.

A small well or a ditch should be dug to contain seepage associated with leakage from storage facilities. Manure storage should be concurrently pumped out to stop the spill. Sometimes clay soil may be used to seal a leaking hole temporarily.

Livestock producers should consider electronic monitoring devices when manure storage facilities are located in high-risk areas, such as near subdivisions, neighbors or upstream from public surface waters, particularly those preferred for recreation (fishing, swimming, boating, etc.).

Leakage control from handling equipment requires halting manure pumping, closing valves to prevent more discharge, verifying a siphoning condition was not created in the pipes and repairing the equipment before restarting the pump. Runoff from fields spread with manure should be avoided by stopping manure distribution and then diverting, containing and incorporating running manure into the soil to avoid unintended discharges. Manure equipment should be supervised at all times while manure is spread.

Site maps

The emergency action plan should include provisions for emergency manure spreading such as fields best suited, application rates, distribution method and minimum setbacks to avoid runoff into surface waters. The plan should include a map describing fields for emergency spreading along with buildings, fences and surface water locations.

Damage assessment

After taking corrective measures to avoid further discharge, the extent of the spill should be assessed. Records should be kept, including duration and amount of manure reaching surface waters; damages caused to personnel, to property and to the environment; actions taken in response to the situation; causes of the emergency; and a potential route to correct the issue in the future.

Proper training and equipment are needed before entering confined spaces.

Notification to the authorities

All spills should be reported to the proper authorities regardless of the extent of the spill. The appropriate agencies should be contacted depending on the type and extent of damages. Those agencies may be:

- For injuries, call the Department of Health and Hospitals, local emergency medical services or call 911.
- For environmental emergencies, call the Louisiana Department of Environmental Quality.
- For technical advice, call the local LSU AgCenter Extension Office, Louisiana Department of Agriculture and Forestry or NRCS.

All procedures should be implemented according to technical assistance provided to remediate damages and correct the system. The manure management plan should be reassessed to avoid future manure discharges.

All personnel involved with the dairy operation should have access to and understand the emergency plan. A copy of the emergency action plan should be kept in a remote location. Owners, managers and employees should learn to recognize threats to the environment and to employees' safety.

Reiteration of the emergency action plan

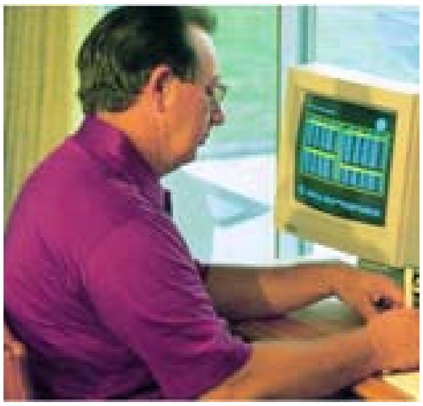
The emergency action plan should be re-evaluated after any event that triggers its deployment to verify adequacy and for readjustments that will improve future response actions to emergency situations.

Remember, preventive actions always are better than reactive corrections!

Record Keeping

Whether or not the operation has a comprehensive nutrient management plant (CNMP), keeping good, detailed records that help you monitor your progress are essential to determine if your economic and environmental goals have been accomplished. You should always keep records of:

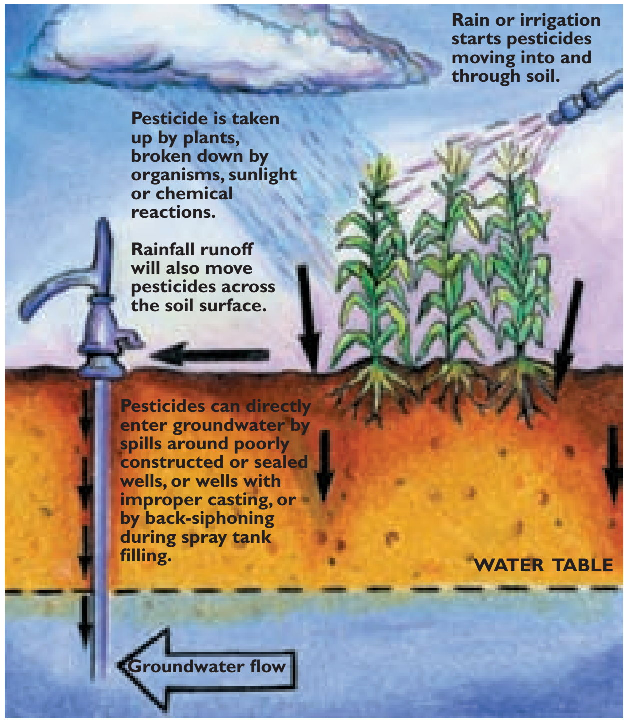
- Nutrient management plan documents.
- Soil, plant and manure tests. Observe the response to management practices over time.
- Purchased feeds and fertilizers.
- Animal trades.
- Crop yields. Update your management plan as production changes.
- Manure production.
- Manure exports and imports.
- Emergency action plan documents.
- Spill events and their extent should be recorded, including duration and amount of manure reaching surface waters; damages caused to personnel, property and the environment; actions taken in response to the situation; causes of the emergency; and a potential route to correct the issue in the future.
- Nutrient application rates, timing and application methods.
- Detailed schedules and records on calibration of spraying and spreading equipment.
- Maintenance of manure handling and storing facilities, pumps and other machinery.
- Inspections and current capacities on manure storage facilities.



Pesticide Management and Pesticides

Introduction

To preserve the availability of clean and environmentally safe water in Louisiana, contamination of surface water and groundwater by all agricultural and industrial chemicals must be reduced. Some sources of contamination are easily recognizable from a single, specific location. Other sources are more difficult to pinpoint. Nonpoint-source pollution of water with pesticides is caused by rainfall runoff, particle drift or percolation of water through the soil. Pest management practices should be based on current research and extension recommendations. By using these recommendations, pesticide use will follow environmentally sound guidelines.



Pest management procedures

Pesticides should be applied only when they are necessary to protect the crop. The pesticide should be chosen following guidelines to assure that the one chosen will give the most effective pest control with the least potentially adverse effects on the environment.

Water quality, both surface and ground, will be protected by following all label recommendations and guidelines dealing with water quality.

- Carefully read all label statements and use directions designed specifically to protect groundwater.
- Closely follow specific best management practices designed to protect surface water.
- Use erosion control practices (such as pipe drops, etc.) to minimize runoff that could carry soil particles with adsorbed pesticides and/or dissolved pesticides into surface waters.

Pesticide application

Management practices such as the pesticide selected, the application method, the pesticide rate used and the application timing influence pesticide movement. Pesticides should be applied only when needed to prevent economic loss of a crop.

In pesticide application, "the label is the law." Using chemicals at rates higher than specified by the label is ILLEGAL as well as an environmental hazard because more pesticide is exposed to erosion, runoff or leaching. Poor timing of a pesticide application (application just before rain falls) can result in pesticide movement into water sources, as well as give little control of the targeted pest.

Certain areas on your farm, such as streams and rivers, wellheads and lakes or ponds, are sensitive to pesticides. You should create buffer zones around these areas where pesticide use will be reduced or eliminated. By buffering these areas, you may reduce water quality problems. Areas such as roads, off-site dwellings and areas of public gatherings should be identified. You may want to limit the use of pesticides near these types of areas, too.

Follow these practices:

- Select the pesticide to give the best results with the least potential environmental impact outside the spray area.
- Select application equipment with care and maintain it carefully.
- Carefully calibrate application equipment at the beginning of the spray season and periodically thereafter. Spray according to recommendations.

- Minimize spray drift by following the label instructions and all rules and regulations developed to minimize spray drift (the physical movement of spray particles at the time of or shortly after application).
- Before applying a pesticide, make an assessment of all of the environmental factors involved in all of the area surrounding the application site.
- Carefully maintain all pesticide applications, not just restricted use pesticides.

Pesticide selection

When selecting pesticides, consider chemical solubility, adsorption, volatility and degradation characteristics. Chemicals that dissolve in water readily can leach through soil to groundwater or be carried to surface waters in rainfall or irrigation runoff. Some chemicals hold tightly to, or are adsorbed on, soil particles, and these chemicals do not leach as much. But even these chemicals can move with sediment when soil erodes during heavy rainfall. Runoff entering surface waters may ultimately recharge groundwater reserves. Chemicals bound to soil particles and organic matter are subject to the forces of leaching, erosion or runoff for a longer period, thus increasing the potential for water pollution.

When selecting pesticides:

- Base selections on recommendations by qualified consultants, crop advisors and published recommendations of the LSU AgCenter / Louisiana Cooperative Extension Service.
- Select the pesticide to be used based on its registered uses and its ability to give the quality of pest control required.
- Consider the effects a pesticide may have on beneficials (beneficial insects), other non-target organisms and on the general environment.

Pesticide storage and safety

Farmers and commercial pesticide applicators are subject to penalties if they fail to store or dispose of pesticides and pesticide containers properly. Each registered pesticide product, whether general or restricted use, contains instructions for storage and disposal in its labeling. The Louisiana Pesticide Law addresses specific requirements for storage and disposal. The applicator must follow these requirements carefully and ensure that employees follow them as well.

The recommended procedures do not apply to the disposal of single containers of pesticides registered for use in the home and garden. These containers may be disposed of during municipal waste collection if wrapped according to recommendations.

For other containers, storage sites should be chosen to minimize the chance of pesticides escaping into the environment. Pesticides should not be stored in an area susceptible to flooding or where the characteristics of the soil at the site would allow escaped chemicals to percolate into groundwater. Storage facilities should be dry, well ventilated and provided with fire protection equipment. All stored pesticides should be carefully labeled and segregated and stored off the ground. Do not store pesticides in the same area as animal feed. The facility should be kept locked when not in use. Further precautions include appropriate warning signs and regular inspection of containers for corrosion or leaks. Protective clothing should be stored close by but not in the same room as the pesticides to avoid contamination of the protective clothing. Decontamination equipment should be present where highly toxic pesticides are stored.

Exceptions for farmers

Farmers disposing of used pesticide containers for their own use are not required to comply with the requirements of the hazardous waste regulations provided they triple rinse or pressure wash each container and dispose of the residues on their own farms in a manner consistent with the disposal instructions on the pesticide label. Note that disposal of pesticide residues into water or where the residue is likely to reach surface water or groundwater may be considered a source of pollution under the Clean Water Act or the Safe Drinking Water Act and therefore is illegal.

After the triple-rinse procedure, the containers are then "empty," and the farmer can discard them in a sanitary waste site without further regard to the hazardous waste regulations. The empty containers are still subject to any disposal instructions contained within the labeling of the product, however. Disposal in a manner "inconsistent with the labeling instructions" is a violation of EPA guidelines and could lead to contamination of water, soil or persons and legal liability.

Agricultural chemicals and worker safety

The EPA has general authority to regulate pesticide use to minimize risks to human health and to the environment. This authority extends to the protection of farm workers exposed to pesticides. All employers must comply with ALL instructions of the Worker Protection Standard concerning worker safety or be subject to penalties. Labels may include, for example, instructions requiring the wearing of protective clothing, handling instructions and instructions setting a period of time before workers are allowed to re-enter fields after the application of pesticides (Restricted Entry Interval).

Employers should read the Worker Protection Standard regulations governing the use of and exposure to pesticides. The regulations set forth minimum standards that must be followed to protect farm workers and pesticide handlers. The regulations include standards requiring oral warnings and posting of areas where pesticides have been used, training for all handlers and early re-entry workers, personal protective equipment, emergency transportation and decontamination equipment.

The EPA regulations hold the producer on a farm, forest, nursery or greenhouse ultimately responsible for compliance with the worker safety standards. This means the landowner or producer must ensure compliance by all employees and by all independent contractors working on the property. Contractors and employees also may be held responsible for failure to follow the regulations.

The Occupational Safety and Health Act (OSHA)

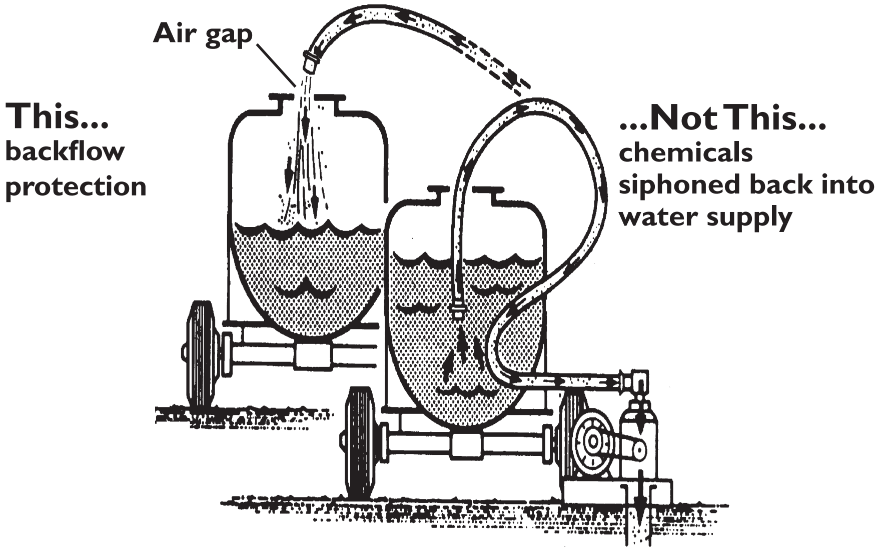
The federal government also regulates farm employee safety under the Occupational Safety and Health Act (OSHA). OSHA applies to all persons (employers) engaged in business affecting interstate commerce. The federal courts have decided that all farming and ranching operations, regardless of where goods produced are actually sold or consumed, affect interstate commerce in some respect and thus are subject to OSHA's requirements. In general, every employer has a duty to provide employees with an environment free from hazards that are causing or are likely to cause death or serious injury.

Pesticide summary:

- All label directions should be read, understood and followed.
- The Louisiana Department of Agriculture and Forestry (LDAF) is responsible for the certification of pesticide applicators in Louisiana. All commercial and private pesticide applicators applying restricted use pesticides must successfully complete a certification test administered by the LDAF. The LSU AgCenter conducts training sessions and publishes study guides in various categories covered by the test. Contact your LSU AgCenter county agent for dates and times of these sessions.

- All requirements of the Worker Protection Standard (WPS) should be followed, including, but not limited, to:
- Notifying workers of a pesticide application (either oral or posting of the field).
- Abiding by the restricted entry interval (REI).
- Maintaining a central notification area containing the safety poster; the name, address and telephone number of the nearest emergency medical facility; and a list of the pesticide applications made within the last 30 days that have an REI.
- Maintaining a decontamination site for workers and handlers.
- Furnishing the appropriate personal protective equipment (PPE) to all handlers and early entry workers and ensuring that they understand how and why they should use it.
- Assuring that all employees required to be trained under the Worker Protection Standard have undergone the required training.
- Pesticides should be stored in a secure, locked enclosure and in a container free of leaks, abiding by any specific recommendations on the label. The storage area must be maintained in good condition, without unnecessary debris. This enclosure should be at least 150 feet away and down slope from any water wells.
- All uncontained pesticide spills of more than one gallon liquid or four pounds dry weight will be reported to the director of Pesticide and Environmental Programs with the Louisiana Department of Agriculture and Forestry within 24 hours by telephone (225-925-3763) and by written notice within three days. Spills on public roadways will be reported to the Louisiana Department of Transportation and Development. Spills into navigable waters will be reported to the Louisiana Department of Environmental Quality, U.S. Coast Guard, U.S. EPA.
- Empty metal, glass or plastic pesticide containers should be either triple rinsed or pressure washed, and the rinsate will be added to the spray solution to dilute the solution at the time or stored according to the LDAF rules to be used later. Rinsed pesticide containers will be punctured, crushed or otherwise rendered unusable and disposed of in a sanitary landfill. (Plastic containers may be taken to specific pesticide container recycling events. Contact your county agent for dates and locations in your area.)
- All pesticides should be removed from paper and plastic bags to the fullest extent possible. The sides of the container should be cut and opened fully, without folds or crevices, on a flat surface; any pesticides remaining in the opened container should be transferred into the spray mix. After this procedure, the containers may be disposed of in a sanitary landfill.
- Application equipment should be triple rinsed and the rinsate applied to the original application site or stored for later use to dilute a spray solution.
- Mix/load or wash pads (NRCS code 309: Agrichemical Handling Facility) should be located at least 150 feet away and down slope from any water wells and away from surface water sources such as ponds, streams, etc. The pads should be constructed of an impervious material, and there must be a system for collecting and storing the runoff.
- Empty containers will not be kept for more than 90 days after the end of the spray season.
- Air gaps should be maintained while filling the spray tank to prevent back-siphoning.

Pesticide wash pad



The complex nature of nonpoint pollution means programs designed to reduce its impact on the environment will not be easy to establish or maintain. Controlling these contaminants will require solutions as diverse as the pollutants themselves. Through a multi-agency effort, led by the LSU AgCenter, these BMP manuals are targeted at reducing the impact of agricultural production on Louisiana's environment. Agricultural producers in Louisiana, through voluntary implementation of these BMPs, are taking the lead in efforts to protect the waters of Louisiana. The quality of Louisiana's environment depends on each of us.

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