

# LONE STAR HEALTHY STREAMS

## DAIRY CATTLE MANUAL



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*Keeping Texas Waters  
Safe and Clean...*

# LONE STAR HEALTHY STREAMS

## DAIRY CATTLE MANUAL

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*make every drop count*



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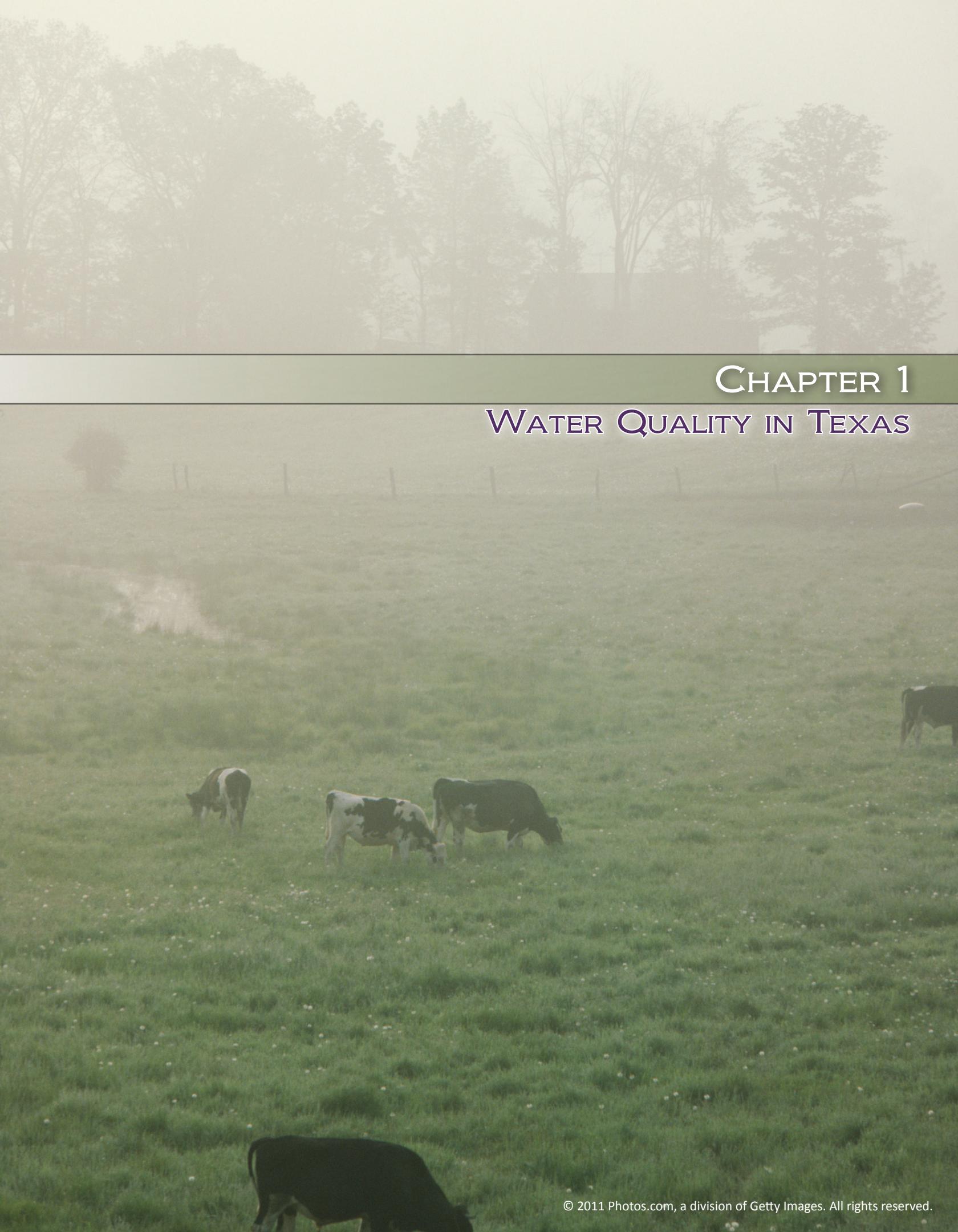
## PREFACE

About 300 Texas water bodies currently do not comply with state water quality standards established for *E.coli* bacteria. Elevated concentrations of *E.coli* bacteria in water are an indicator of fecal contamination and can pose an increased health risk to downstream users.

The Lone Star Healthy Streams program aims to educate Texas livestock producers and land managers on how to best protect Texas waterways from bacterial contributions associated with the production of livestock and feral hogs. To achieve this goal, groups of research scientists, resource conservation agencies, and producers have

collaborated to compile this Lone Star Healthy Streams Manual which includes best management practices (BMPs) known to reduce *E.coli* contributions to rivers and streams. In addition to reducing bacterial contributions, the BMPs listed in this manual will allow livestock and land owners to further protect Texas waterways from sediment, nutrient, and pesticide runoff.

We hope that landowners and livestock producers find the following information helpful in their pursuit of being the best natural resource stewards they can be. For more information about the Lone Star Healthy Streams program, please visit <http://lshs.tamu.edu/>.

A photograph of a rural landscape under a thick fog. In the foreground, several cows are grazing in a green pasture. A wooden fence line is visible through the fog in the middle ground. A dense line of trees marks the horizon.

# CHAPTER 1

## WATER QUALITY IN TEXAS

## WATER QUALITY IN TEXAS

Water is a finite resource that can be significantly polluted by a variety of sources across the landscape. No one person, industry, or activity is to blame, but the agricultural sector often is singled out as a major contributor of pollutants to Texas's waterways. Although many think this claim is unjust, the agricultural community can choose to regulate itself through stewardship and conservation practices rather than have the solutions determined by those who may not understand the industry.

Livestock producers should carefully consider any measures they can take to minimize watershed pollution and reduce the potential for regulation. Pollution in water bodies has led to governmental regulations in the Bosque River watershed in Texas, the Vermillion River watershed in Illinois, the Fourth Creek watershed in North Carolina, the Chesapeake Bay watershed in Delaware, and many others across the United States.

Producers have many management options for improving water quality, some of which are fairly low cost and easy to implement. Several of these options also can improve animal performance and enhance the long-term health of rangeland and pastures.

Livestock producers can more easily make wise choices for reducing pollution originating on their operations if they know the benefits of clean water to agricultural operations, the current laws and policies on water quality, the ways that bacteria can enter water, and the range of solutions that are available for them to reduce water quality problems.

## VALUE OF CLEAN WATER TO TEXAS AGRICULTURE

Clean water is vital to agricultural producers in Texas. Water is used for irrigating crops (Fig. 1) and raising livestock and is the reason why the Texas food and fiber system is valued at nearly \$100 billion each year. Clean water can also improve animal health, gains, and reproduction, as well as increase recreational opportunities on farms and ranches.

For dairy cows, water is second only to oxygen as an essential nutrient necessary to sustain life and optimize growth, lactation, and reproduction of the animal. Clean



Figure 1. Clean water is vital to crops and livestock in Texas.  
Photo courtesy of Blair Fannin, Texas AgriLife Extension Service.

water is also required for digestion and metabolism of nutrients (Beede 2005). Bacteria can severely reduce or even eliminate some of these valuable water-based activities and associated benefits. The costs of poor water quality include degraded ecosystems, limited agricultural production, reduced recreational opportunities, increased government regulation, increased water treatment costs, and threats to human health.

## WATER QUALITY LAW AND POLICY

The foundation for surface water quality protection in the United States is the Federal Water Pollution Control Act, commonly referred to as the Clean Water Act (CWA). Passed in 1972 and amended in 1977, the CWA was enacted to restore and maintain the chemical, physical, and biological characteristics of the nation's waters.

In brief, the Clean Water Act requires that states set standards for surface water quality; it also requires public and private facilities to acquire permits for discharging wastewater. At the federal level, the U.S. Environmental Protection Agency (EPA) is responsible for administering the water quality standards outlined in the Clean Water Act. The EPA delegates water quality management at the state level to the specific state environmental agency.

In Texas, the primary water quality agency is the Texas Commission on

Environmental Quality (TCEQ, Fig. 2). The TCEQ is responsible for:

- Establishing water quality standards
- Determining how water quality will be managed
- Issuing permits for point source dischargers
- Reducing all types of nonpoint source pollution, except those from agricultural and silvicultural (forestry) sources

Point source pollution can be traced to a specific location and point of discharge, such as a pipe or ditch; nonpoint source pollution originates from multiple locations and is carried primarily by precipitation runoff.

In 1991, the Texas Legislature delegated some water quality authority to the Texas State Soil and Water Conservation Board (TSSWCB). The TSSWCB is responsible for administering the state's soil and water conservation law and for managing programs to prevent and reduce nonpoint

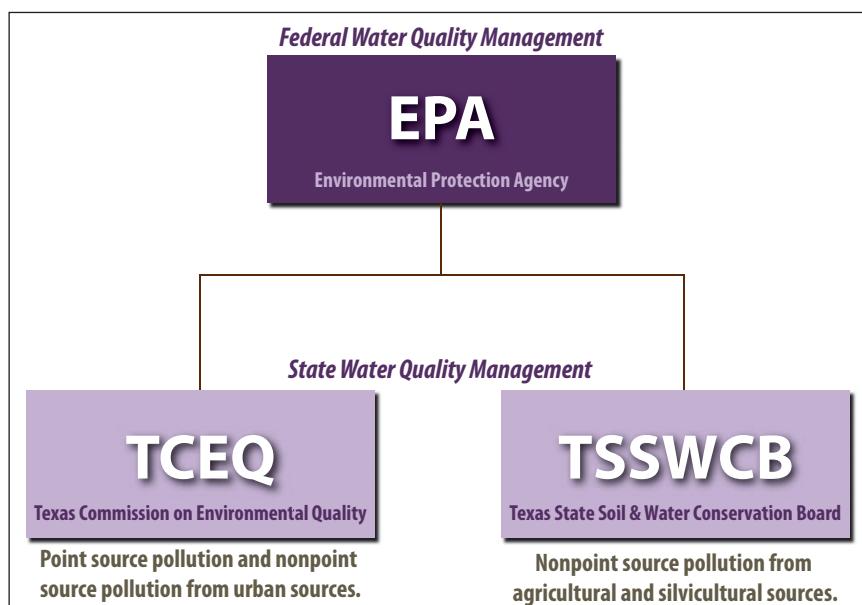


Figure 2. Hierarchy of federal and state agencies primarily involved in water quality management in Texas. Illustration courtesy of Jennifer Peterson.



source pollution from agriculture and forestry.

To comply with Section 303(d) of the Clean Water Act, the TCEQ must report to the EPA on the extent to which each surface water body meets water quality standards. The report must be submitted every 2 years and is known as Texas Integrated Report for Clean Water Act, Sections 305(b) and 303(d).

The Integrated Report describes the status of all surface water bodies that were evaluated and monitored in the state over the most recent 7-year period. This report is the basis for the 303(d) List, which identifies all impaired surface bodies of water that do not meet water quality standards.

Water quality standards specify numeric levels of water quality criteria such as bacteria, temperature, dissolved oxygen, and pH that can be measured in a lake, river, or stream without impairing the designated use(s) assigned to that water body. Designated uses include aquatic life, fish consumption, public drinking water supply, and contact and noncontact recreation. Any water body whose water quality criteria measurements fall outside of the levels set by the standards for each designated use is considered impaired and is placed on the 303(d) List.

The Clean Water Act requires that a calculation be made on the pollution reductions needed to restore an impaired water body to its designated use(s). The calculation is called a total maximum daily load (TMDL). A TMDL must be developed for waters on the 303(d) List of impaired waters within 13 years of being listed. If the state does not develop a TMDL within the required time limit, the EPA will.

In Texas, both the TCEQ and the TSSWCB are responsible for developing and submitting TMDLs to the EPA. After a TMDL is complete, an implementation plan (I-Plan) must be developed. This plan includes a detailed description of the regulatory measures, voluntary management measures, and parties responsible for carrying out identified measures needed to restore water quality in accordance with the TMDL. Unlike the TMDL, the implementation plan must be approved by only the TCEQ or TSSWCB, not the EPA.

Regulatory measures are typically applicable only to point source dischargers such as concentrated animal feeding operations (CAFOs) or wastewater discharges. However, some U.S. watersheds have also imposed regulatory measures on nonpoint sources.

According to the 2010 Texas Integrated Report for Clean Water Act Sections 305(b) and 303(d), there were a total of 621 impairments in Texas. Of these impairments, 51% were due to elevated bacteria. As of February 2012, a total of 206 TMDLs have been developed for 134 water segments in Texas.

Some watersheds may have another option that may be more viable for solving complex water issues. Instead of developing a TMDL, they may be able to develop and implement a watershed protection plan (WPP).

A WPP is a voluntary, stakeholder-driven strategy for improving water quality. These plans are developed and managed through partnerships among federal and state agencies and local groups and organizations. They rely heavily on stakeholder involvement at the local level.



To help communities create WPPs, the EPA has produced a guide, *Handbook for Developing Watershed Plans to Restore and Protect Our Waters*. The handbook outlines nine key elements that each WPP should contain:

- Causes and sources of the water quality problem
- Load reductions needed to restore water quality
- Management measures needed to achieve the load reductions
- Technical and financial assistance needed to implement the management measures
- Information and education programs needed
- Implementation schedule
- Implementation milestones
- Criteria to determine success
- Monitoring needed to determine the effectiveness of implementation

The main difference between the two approaches is that TMDLs are required by federal law, and WPPs are voluntary. In general, a WPP gives communities a way to restore water quality, remove the body of water from the 303(d) List, and avoid regulatory action in the watershed. In some cases, however, development of a TMDL is more appropriate and unavoidable, especially if the impairment causes an emergency situation.

## SOURCES OF BACTERIA IN TEXAS WATERWAYS

Fecal bacteria are microscopic organisms found in the feces of humans and other

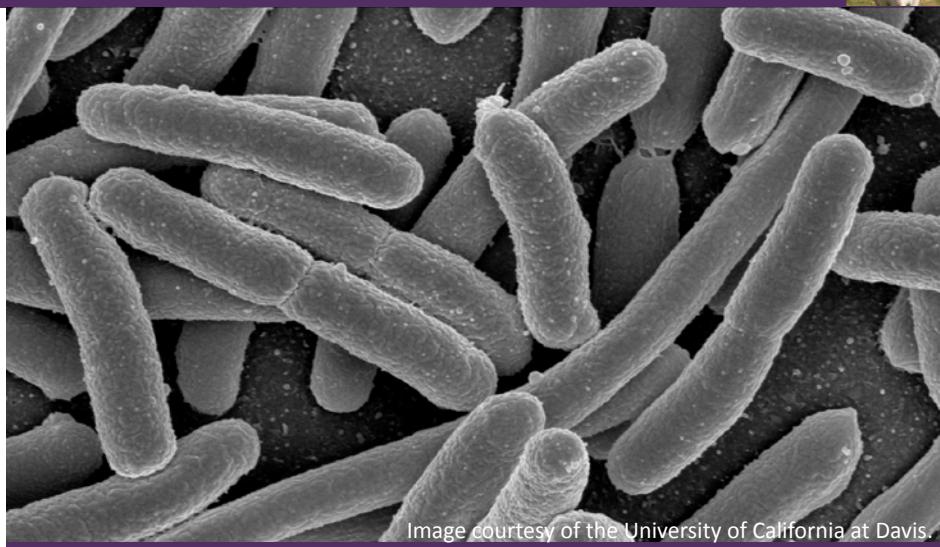


Image courtesy of the University of California at Davis.

*Escherichia coli*, commonly abbreviated as *E. coli*, is a rod-shaped bacterium found in the lower intestine of warm-blooded organisms. It was first discovered in 1885 by German pediatrician and bacteriologist, Theodor Escherich.

Perhaps the most recognized strain is O157:H7 which can cause serious food poisoning in humans and is often the cause of product recalls. In 2006, more than 200 people became sick and 3 people died after consuming spinach contaminated with *E. coli*.

*E. coli* are important in water quality because they act as indicator organisms - their presence in water can indicate the potential presence of other harmful pathogens that are capable of causing disease in humans.

warm-blooded animals. By themselves, they are usually not harmful, but they are important because they are indicator species and can suggest the presence of pathogenic (disease-causing) organisms.

Pathogenic organisms include bacteria, viruses, or parasites that can cause waterborne illnesses such as typhoid fever, dysentery, and cholera. In addition to the potential health risks, elevated bacteria levels can also cause unpleasant odors, cloudy water, and increased oxygen demand.

The most common types of fecal bacteria that are measured to indicate the potential presence of harmful pathogens include:

total coliform, fecal coliform, fecal streptococci, enterococci, and *Escherichia coli* (*E. coli*). The EPA recommends *E. coli* as the most reliable indicator of contamination for freshwater and enterococci as the most reliable indicator in saltwater.

Bacterial contamination of surface waters is a major problem—it is the leading cause of water quality impairment not only in Texas, but also nationwide.

Bacteria in Texas waterways can come from many sources across the landscape (Fig. 3):

- Wastewater treatment plants, especially from plants that are not up to code or functioning properly
- Leaky septic systems
- Pet waste
- Runoff from neighborhood streets and parking lots
- Wildlife, including deer, rodents, and large flocks of birds resting on public waters
- Feral hogs (Table 1)
- Grazing livestock (Table 1)

One method to pinpoint the sources of fecal bacteria is bacterial source tracking (BST). This expensive process examines the DNA structure of bacteria to determine if it originated from human, livestock, wildlife, pet waste, or avian sources. Although still

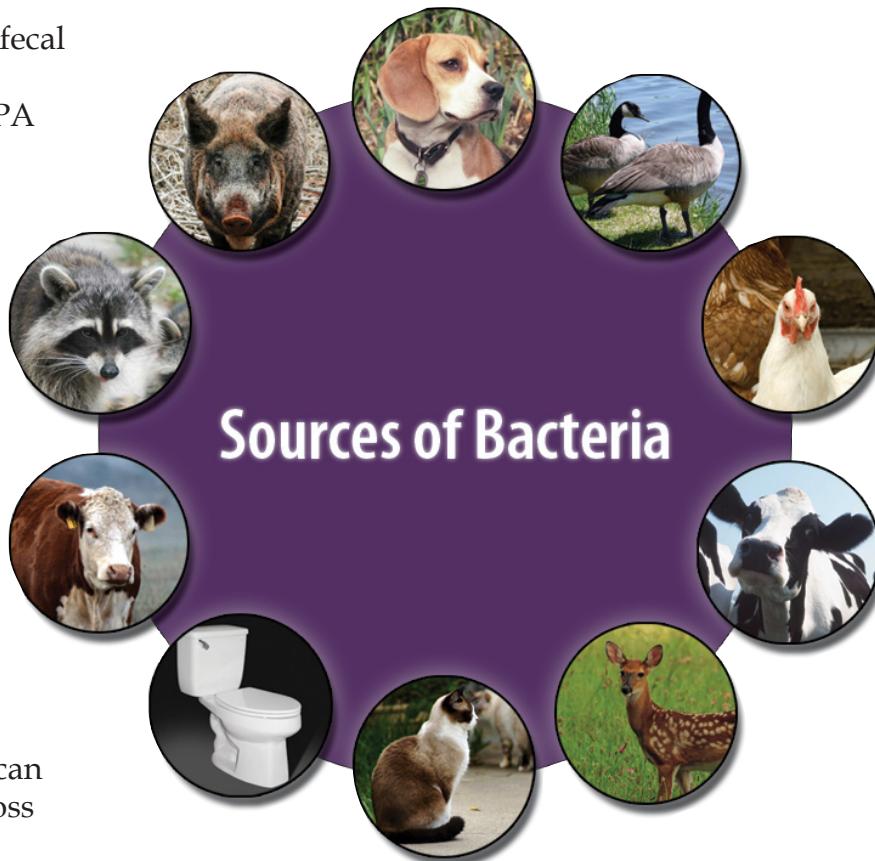


Figure 3. Bacteria in Texas waterways can originate from a variety of sources, including wastewater treatment facilities, wildlife, pets, and livestock. Illustration courtesy of Jennifer Peterson.

in its developmental stages, BST can be a useful tool in watershed planning.

The process was used recently to analyze bacteria found in Peach Creek, Copano Bay, and the Leon River in Texas. It found that, on average, cattle accounted for about 19 percent of the bacterial contamination, wildlife accounted for 26 percent, and humans (septic systems and pets), 23 percent. In Peach Creek alone, cattle accounted for 22 percent of the bacterial contamination.

Regardless of the source, excess bacteria levels are involved in more than 50 percent of the water quality impairments in Texas (Fig. 4).



Table 1. Fecal coliform production for major classes of livestock and feral hogs (Wagner and Moench 2009).

Animal	Daily fecal production (lbs/day/AU)	Daily fecal production (g/day/AU)	Fecal coliform density (cfu/g)	Fecal coliform (cfu/AU/day)
Beef Cattle	82	37,195	2.30E+05	8.55E+09
Horses	51	23,133	1.26E+04	2.91E+08
Goats	40	18,144	1.40E+06	2.54E+10
Sheep	40	18,144	1.60E+07	2.90E+11
Hogs	65	29,484	3.30E+06	9.73E+10
Layers	63	28,576	1.30E+06	3.71E+10
Pullets	63	28,576	1.30E+06	3.71E+10
Broilers	82	37,195	1.30E+06	4.84E+10
Turkey	47	21,319	2.90E+05	6.18E+09
Deer	15	6,804	2.20E+06	1.50E+10
Feral Hogs	65	29,484	4.10E+04	1.21E+09

## BACTERIA FATE AND TRANSPORT

The behavior of bacteria in water is not well understood because it involves many complex factors in the environment and in the organisms themselves. As a result, it can be a challenge to reduce their levels in waterways.

Several processes affect the fate and transport of fecal bacteria (Table 2).

- **Fate processes** include growth (cell division), death by predation, and die-off.
- **Transport processes** include advection (horizontal transport), dispersion, settling, and re-suspension from the sediment bed.

Both processes are altered by temperature, pH, nutrients, toxins, salinity, and sunlight intensity.

Computer models (Soil and Water Assessment Tool, Hydrological Simulation Program-FORTRAN) can be used to simulate the fate and transport of bacteria at the watershed-scale, however, the predictive strength of these models depends highly on the accuracy of the data entered into the model. A better comprehension of the fate and transport of bacteria is needed to understand the potential impact of the contaminant and to more effectively develop management strategies in a watershed.

## BENEFITS OF VOLUNTARY CONSERVATION PRACTICES

Federal and state natural resource agencies are encouraging the voluntary use of effective conservation practices to improve water quality. Farmers and ranchers can do their part to minimize the runoff of agricultural pollutants into waterways

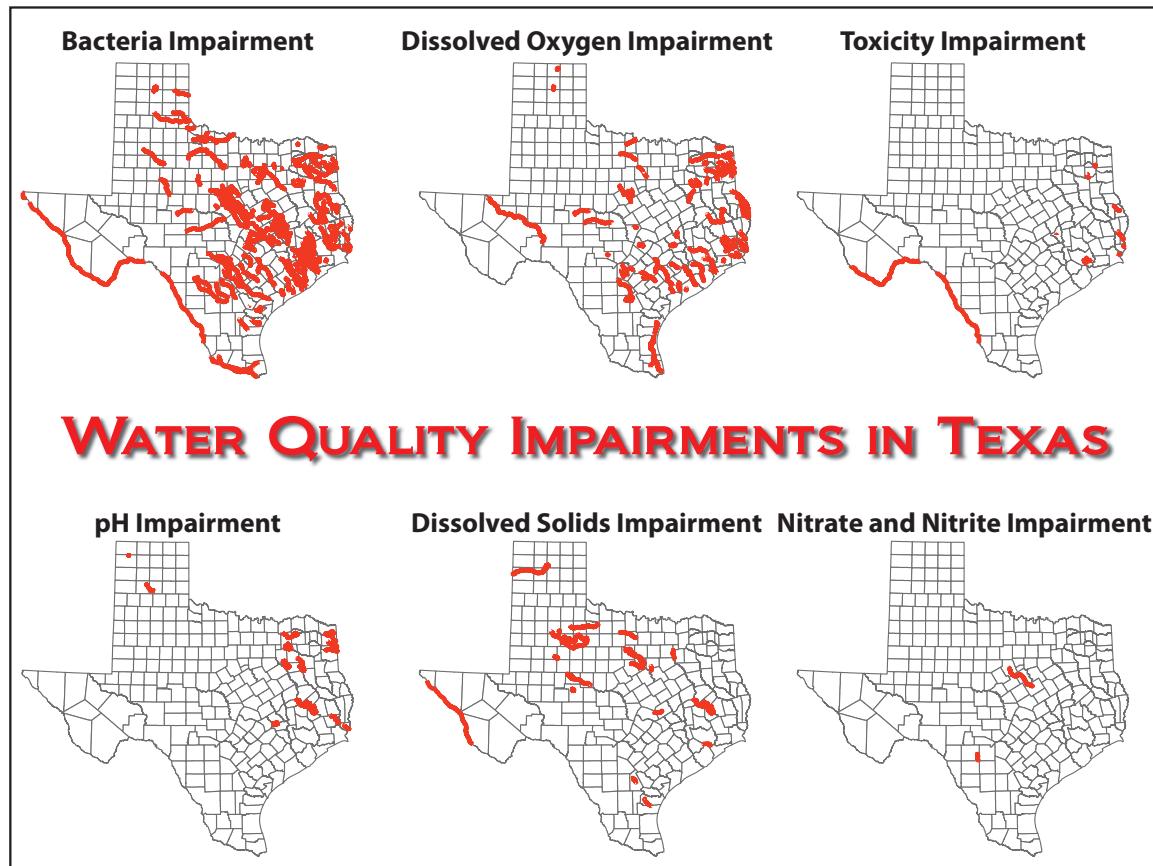


Figure 4. Types and locations of impairments in Texas water bodies. Source: TCEQ, 2008.

Table 2. Potential survival of fecal pathogens in the environment (Olsen 2003).

<b>Material</b>	<b>Temperature</b>	<b>Duration of Survival</b>			
		<i>Cryptosporidium</i>	<i>Salmonella</i>	<i>Campylobacter</i>	<i>E. coli</i> (O157:H7)
<i>Water</i>	Frozen	>1 year	>6 months	2-8 weeks	>300 days
	Cold (5°C)	>1 year	>6 months	12 days	>300 days
	Warm (30°C)	10 weeks	>6 months	4 days	84 days
<i>Soil</i>	Frozen	>1 year	>12 weeks	2-8 weeks	>300 days
	Cold (5°C)	8 weeks	12-28 weeks	2 weeks	100 days
	Warm (30°C)	4 weeks	4 weeks	1 week	2 days
<i>Cattle manure</i>	Frozen	>1 year	>6 months	2-8 weeks	>100 days
	Cold (5°C)	8 weeks	12-28 weeks	1-3 weeks	>100 days
	Warm (30°C)	4 weeks	4 weeks	1 week	10 days
<i>Liquid manure</i>		>1 year	13-75 days	>112 days	10-100 days
<i>Composted manure</i>		4 weeks	7-14 days	7 days	7 days
<i>Dry surfaces</i>		1 day	1-7 days	1 day	1 day



by implementing practices that better manage water use, runoff, and chemical applications.

Although improvements in water quality from livestock producers' efforts can take years to detect, these practices can often result in tangible benefits. In one study, the benefits to water quality benefits from erosion control on cropland totaled over \$4 billion per year. Another study found erosion reduction measures on private lands in the United States increased the value of water-based recreation by about \$373 million.

Although the implementation of conservation practices is currently voluntary and can require financial input by landowners, the benefits of having clean water resulting from these practices far outweigh the associated costs. The goal of the Lone Star Healthy Streams program is to provide information to agricultural producers and landowners on practices that can help reduce bacterial contributions. These practices will enable the agricultural

community to voluntarily do its part to improve water quality.

## THE TEXAS DAIRY INDUSTRY

According to the Texas Association of Dairymen, there are almost 334,000 milk cows in Texas; they produce over 731 million pounds of milk each year. Together, the milk production and processing sectors are valued at \$1.23 billion. Also, it is estimated that for every 100 milk cows, six jobs are created on a dairy farm. Texas dairy farmers are regulated and permitted by state agencies and follow strict federal, national, and local water quality guidelines.

In general, dairy production systems can be grazing or confinement-based. According to the NRCS, grazing-based dairy production systems optimize the intake of forages that are directly harvested by grazing cows. By contrast, confinement-based dairy systems optimize milk production with confined cows consuming harvested forages. Both systems generally use feed supplements to balance the dietary ration.



## CHAPTER 2

### BEST MANAGEMENT PRACTICES FOR DAIRY CATTLE



Like any other livestock, dairy cattle can damage the land on which they are kept. Although there are many ways that runoff from dairy operations can impair water quality, most issues stem from manure, which contains bacteria and nutrients.

Sedimentation from erosion and the excessive use of fertilizers and pesticides can also contribute to the problem. Other sources of ground and surface water pollution include parlor and milk waste, dead animals, and line-cleaning wastewater.

- Parlor waste
- Cattle
- Silage leachate
- Open feed lot operations
- Confinement operations
- Dead animal disposal
- Waste milk handling and disposal
- Line cleaning wastewater

By law, the owner is responsible for managing their operations in a way that minimizes the impact on the surrounding environment. Along the eastern and western coasts of the United States, mandatory regulations have been imposed on dairies to reduce water pollution. To prevent or minimize such regulatory actions in Texas, dairies can adopt proactive approaches to prevent contamination of streams and rivers. These practices not only can improve water quality for you, your livestock, your neighbors, and Texas, but they can also help you:

- Maintain better pastures
- Improve livestock health
- Increase property values

Best management practices (BMPs) are available for both grazing and confined

dairies. The voluntary practices discussed in this manual are designed specifically to reduce bacterial contamination originating from dairies. These practices are not mutually exclusive. Often, a combination of practices will provide the most benefit.

Dairy BMPs that help reduce bacterial concentrations can generally be divided into five categories:

- Pasture management
- Runoff management
- Protection of riparian areas, which are environmentally sensitive areas along streams and rivers
- Manure management
- Mortality management

The Natural Resources Conservation Service (NRCS) has created conservation practice codes that are discussed in detail in the *NRCS Field Office Technical Guide*. The guide is available at all Soil and Water Conservation District Offices, all NRCS field offices, and on the NRCS website at [www.nrcs.usda.gov/](http://www.nrcs.usda.gov/).

## GRAZING-BASED DAIRIES

BMPs for grazing-based dairies include prescribed grazing; access control; heavy-use-area protection; proper carcass disposal; alternative water, feed, salt, and mineral locations; and the installation of filter strips, shade structures, fencing, stream crossings, and in-stream watering points (Table 3).

## PASTURE MANAGEMENT BMPs

### Prescribed Grazing

Poorly managed pasture-based dairies can seriously damage the environment

Table 3. BMPs for grazing dairies organized by category.

Category	Best Management Practices
Pasture Management	Prescribed grazing (NRCS Code 528A)
Runoff Management	Filter strips (NRCS Code 393)
Riparian Area Protection and Management	Shade structure (NRCS Code 717)
	Watering facility (NRCS Code 614)
	Fencing (NRCS Code 382)
	Access control (NRCS Code 472)
	Stream crossing (NRCS Code 578)
	Feed, salt, and/or mineral locations
	Heavy use area protection (NRCS Code 561)
	In-stream watering points
Manure Management	N/A
Mortality Management	Proper carcass disposal

through erosion and direct contamination of streams and rivers. The primary pasture management BMP for dairies to reduce bacterial contamination of waterways is prescribed grazing (Fig. 5).

Prescribed grazing practices optimize livestock production in a way that protects and enhances the local environment. Livestock are rotated to different pastures at regular intervals, which keeps the grass healthy and enables it to establish a dense stand.

Healthy, dense stands of grass help retain soil nutrients and reduce soil erosion, water runoff, contamination of nearby waterways. Other benefits also arise from having a healthy, functional pasture:

- Animal health improves, and the cattle gain more weight.
- Fewer weeds invade the pasture.
- The groundwater in the aquifer is replenished.
- Dust and odors are controlled.

- Manure is distributed more evenly in the field.
- Soils are not compacted as much.
- A more diverse plant community develops.

### Stocking Rate

Stocking rate is the most critical aspect of livestock production that is related to water quality and is under the direct control of the manager. No other single management practice has a greater effect on the sustainability of a livestock production enterprise (Redmon and Bidwell 1997).

Stocking rate is the number of acres required per animal unit for a grazing season that can be sustained on a long-term basis without degrading forage, water, or soil resources. A moderate stocking rate typically provides a good balance between plant and animal performance while maintaining adequate vegetative cover to protect the soil resource.

Although moderate stocking rates differ depending on site and forage species, general guidelines can be obtained from



Figure 5. A pasture where prescribed grazing has been implemented. Photo courtesy of the USDA–NRCS.

Soil Surveys produced by the NRCS. Other information on appropriate stocking rates is available from local Extension and Soil and Water Conservation District offices or from successful producers who have a long history of production in the area.

Many pastures are overstocked, but producers do not realize it. The reasons vary:

- Livestock are larger than in previous years. Forage intake is related to body size, and many species today are larger than some species were two generations ago.
- Woody (brush) species are continually invading and dominating previously productive pastures, thus reducing the carrying capacity of those pastures. Without brush removal, or livestock reduction, overstocking occurs.
- Inappropriate fertilizer and/or weed management inputs have reduced the amount of forage produced on some sites.
- Some producers base stocking rate on total acres instead of *grazeable* acres.

Stocking rates should be adjusted according to factors that reduce the amount of property grazing animals can use. These factors include slope, brush density, rock cover, and distance to water.

To discuss the effect of stocking rate on animal performance, some definitions are necessary:

- **Stocking rate:** the number of animals on a given amount of land over a certain period of time. It is generally expressed as animal units per unit of land area.
- **Carrying capacity:** the stocking rate that is sustainable over time per unit of land area. A critical factor to evaluate is how well the stocking rate agrees with the carrying capacity of the land.
- **Animal unit (AU):** a standard measure of livestock; a 1,000-pound beef cow is the standard measure of an animal unit (Table 4).

For example: Assume that a livestock producer has 50 head of 1,000-pound cows on 200 acres for 12 months. The stocking rate of this operation would be calculated as follows:

#### Example 1: Calculation of Stocking Rate

$$\text{Total Land Area} \div [(\#AUs) \times (\text{Grazing Season})]$$

$$200 \text{ acres} \div [(50 \text{ AUs}) \times (12 \text{ months})]$$

$$\begin{aligned} \text{Stocking Rate} &= 0.33 \text{ acres per AU month (AUM)} \\ &\quad \text{or} \\ &= 4.00 \text{ acres per AU year (AUY)} \end{aligned}$$

Because grazing animals are not all the same size, it is necessary to convert to animal

Table 4. Carrying capacity in terms of the animal unit (AU) concept.

Measure	Definition
Animal Unit (AU)	1,000-lb cow with calf
Animal Unit Day (AUD)	26 lb of dry forage
Animal Unit Month (AUM)	780 lb of dry forage
Animal Unit Year (AYU)	9,360 lb of dry forage

unit equivalents. The term animal unit equivalent (AUE) is useful for estimating the potential forage demand for different kinds of animals or for cattle that weigh more or less than 1,000 pounds. Animal unit equivalent is based upon a percentage (plus or minus) of the standard AU.

Again, assuming an intake of 26 pounds of forage dry matter per day, the 1,000-pound cow is used as the base animal unit to which other livestock are compared. The AUE for cattle that do not weigh 1,000 pounds is calculated as:

$$\text{AUE} = (\text{BODY WEIGHT}) \div 1,000$$

Table 5 lists different kinds and classes of animals, their AUEs, and their estimated daily forage demand. With this information, you can convert different-sized animals to AUEs to determine the number of animals that could be grazed on a specific pasture for a specific period.

An appropriate stocking rate ensures that enough ground cover remains in the pasture for animal performance as well as soil and water conservation.

To achieve the optimal stocking rate, 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.
- Adjust the number of animals that a given pasture can support.

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 (Sheffield et al. 2010).

### Grazing Management

Grazing management involves controlling *where, when, how long, and how much* livestock graze. Close attention to grazing management – primarily stocking rate – is critical for maximizing profit or minimizing loss.

The objective of proper grazing management is to match the availability and nutritional content of the forage with the nutritional requirements of grazing livestock to achieve the optimum production of meat, milk, and fiber. Often the only management change required is to develop a controlled breeding season that matches seasonal forage availability with the nutrient requirements of gestating or lactating females and that of growing animals. If producers are not using a controlled breeding season, this may be a logical place to begin an improved grazing management strategy.



Table 5. Animal unit equivalent (AUE) and estimated daily forage dry matter (DM) demand for various kinds and classes of grazing animals.

Animal Type	AUE	DM Demand (lb/day)
<b>Dairy cattle</b>	-	-
Cow	1,000 lb	1.00
	1,300 lb (last 2 months of gestation)	1.50
Bull, 1,500 lb, mature	1.40	36
Heifer, 550 lb, growing	1.00	26
<b>Beef cattle</b>	-	-
Calves	300 lb	0.30
	400 lb	0.40
	500 lb	0.50
	600 lb	0.60
Cows	1.00	26
Bulls	1.25	32
<b>Horses</b>	1.25	32
<b>Sheep</b>	0.20	5
<b>Goats</b>	0.17	4
<b>White-tailed deer</b>	0.17	4

Well-managed grazing systems for dairy cows offer several advantages including (Fontaneli et al. 2005):

- Year-round grazing
- Forages of comparable or better quality than those harvested under mechanical methods
- Reduced feed and overhead costs

Common grazing systems used in pasture-based dairies are continuous stocking, rotational stocking, and strip grazing. No single grazing system will meet the requirements of all dairies. Some tracts of land lend themselves to one type of grazing system better than others, and

the management philosophies and experience levels of the owners will likewise dictate how livestock will be manipulated.

**Continuous stocking:** In general, continuous stocked systems require the least amount of managerial input and are generally the least expensive to implement. Continuous grazing has several advantages over other grazing systems, including enhanced animal performance.

Individual animal performance – whether measured by live-weight gain, calving percentage, or milk production – is typically higher for livestock in continuous grazing systems under moderately stocked conditions. The improved performance is due to a higher degree of diet selectivity by the animal. If allowed the opportunity, grazing livestock will typically select a more nutritious diet than would be offered by a typical forage sample.

Other grazing systems that involve cattle movement between pastures allow the animal less freedom in diet selection. In those systems, performance is generally reduced because the animal must consume forage that it might not otherwise select. Animal performance varies greatly under different grazing systems, depending on the forage base, stocking rate, time of season, fertility level, moisture availability, and other factors.

The major disadvantage of continuous grazing systems is the variable growth rate of forage crops. For example, during early spring, bermudagrass grows quickly, requiring a relatively heavy stocking rate to harvest it most efficiently. Later in the



summer, when less rain falls, the forage grows more slowly, and animal numbers must be reduced. To optimize forage use under continuous grazing, producers should vary the stocking rate by adjusting either livestock numbers or pasture size.

One way to quickly adjust pasture size and maintain a proper stocking/forage rate is to use inexpensive electric fencing. Another way is to simply open or close gates of a multi-paddock operation. Excess forage from the part of the pasture not being grazed during the rapid growth phase should be cut as high-quality hay. In fact, cutting excess forage for hay or silage is one of the best ways to implement the “variable stocking rate” pasture management approach.

If a variable stocking rate is not used to match varying forage levels, pastures will be overstocked at some times and understocked at other times. Overstocking coupled with a poor fertility program typically leads to an invasion of weeds and undesirable grasses such as broomsedge and threeawn. Animal performance then declines, and the carrying capacity of the pastures drops.

Conversely, understocking results in patch (or spot) grazing – the animals graze the same area repeatedly as soon as regrowth is available. Immature regrowth is more palatable and of higher nutritive value. As a result, the ungrazed areas in the pasture continue to mature, decline in nutritive value, and become increasingly less palatable. Forage is wasted and the profit potential from the livestock operation declines.

The bottom line regarding continuous grazing is that it can be profitable if the

stocking rate is varied to match the variable growth rate of the pasture. If you change the stocking rate to match livestock demand with forage production, the forage is used more efficiently.

**Rotational stocking:** In a rotational grazing system, livestock are moved from one pasture to another for short periods. The concentration of livestock temporarily overstocks the pasture, making the forage harvest more efficient. More of the available forage is consumed, and little is wasted.

When rotationally grazing, producers should pay close attention to determine the best time to move the livestock to another paddock. Timing is the critical element in rotational grazing and requires considerable management expertise. Because climatic conditions change and forage species grow at different rates, grazing time may be as few as 1 or 2 days or as much as 7 to 10 days per pasture. In general, move animals into a pasture when the plants reach 8 to 10 inches tall, and remove them when 3 to 4 inches of forage remains in the pasture.

If you move livestock according to the calendar instead of forage availability, the result may be animal performance or forage use that is less than optimal.

Varying forage levels may require that you skip one or more pastures in the grazing rotation and cut the skipped units for hay if excess forage is produced. This cutting will help control weeds and prevent mowed areas from becoming too mature and less nutritious.

Rotational stocking offers several benefits:

- Harvest is more efficient, which may allow slightly more (10 to 15 percent)



livestock than in a poorly managed continuous grazing system.

- Livestock can be controlled better and potential health problems observed earlier because the producer spends more time with the livestock.
- In the spring, early weed species can be controlled more easily.

The disadvantages of rotational stocking include:

- Individual animal performance is reduced. In a rotational stocking system, livestock do not have the diet selectivity of those in a continuous stocking system. This lack of diet selectivity typically reduces animal performance, especially when animals are grazing warm-season forages.
- More fences must be built, although the expense may be offset somewhat by using low-cost electric fencing.
- Additional water sources may need to be developed.
- Extra labor costs will be required to move the livestock.

Some forage species perform better under a rotational grazing, which can increase harvest efficiency and the nutritive value of warm-season perennial grasses. For example, if weeping lovegrass is not rotationally grazed, it is patch grazed by livestock and quickly becomes excessively mature and unpalatable. The livestock then avoid the plants, and forage is wasted.

For cool-season forage crops, rotational grazing is

more important for the plants than for the animals. Rest between grazing events may increase the plants' dry-matter production. Also, reseeding annual clover species should be rotationally grazed to promote seed production and stand persistence.

Rotational stocking can help ensure that enough forage remains in the paddocks to serve as filter strips that protect waterways by trapping contaminants.

**Strip grazing:** In a strip grazing system, two portable fences (typically electric) allot a small area of the pasture for grazing (Fig. 6). The livestock are confined to an area smaller than that required for the entire herd. This technique is an intensive form of rotational grazing that requires somewhat more labor. As with other rotational grazing systems, the temporarily overstocked condition results more forage being used; however, animal performance is typically reduced.

Although any forage may be used, the forages best suited for strip grazing are forage sorghums, sorghum-sudan hybrids, and millets.

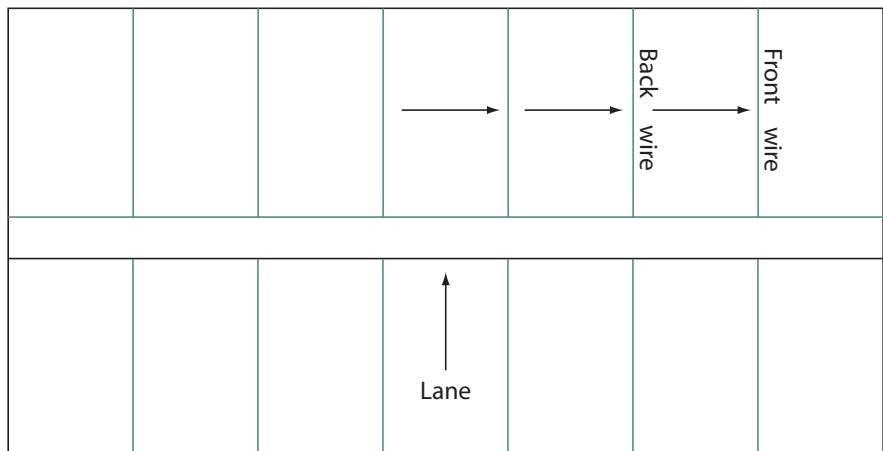


Figure 6. Large pasture divided down the center length-wise with lane in the middle. Paddocks are strip-grazed by moving temporary front wire and back wire across the pasture. This design allows for flexible paddock size and easier machinery work. Source: NRCS 2007.



Strip grazing allows the forage to be consumed with a minimum amount of trampling of good forage. The use of one portable fence ahead of the animals prevents them from trampling and thus wasting the field-cured forage.

Potential bacterial reductions with prescribed grazing: Grazing management evaluations done at Texas A&M University found that rotational grazing, if timed appropriately, was a very effective practice for reducing *E. coli* runoff. The impact of grazing timing in relation to a runoff event was much more significant than the impact of level of grazing (i.e. moderately stocked or heavy stocked) or stocking rate. When runoff occurred more than two weeks following grazing, *E. coli* levels in runoff were decreased more than 88 percent. Based on these findings, upland sites should be grazed during rainy seasons when runoff is more likely to occur and creek pastures and other hydrologically connected areas should be grazed during periods when runoff is less likely (e.g. summer and winter in much of Texas).

Changing the grazing intensity from heavy to moderate can reduce *E. coli* levels by 200 percent over a 7-month period (Tate et al. 2004). The EPA has found that *E. coli* can be reduced by 72 percent when prescribed grazing is implemented with other practices such as contour farming, grassed waterways, nutrient management, and pest management.

In another study, fecal coliform was reduced by 90 to 96 percent when the grazing intensity was reduced from heavy to no grazing (Tiedemann et al. 1987, 1988). The studies were conducted on land where beef and/or dairy cattle were present.

## Additional Pasture Management Practices

Other pasture management practices that can help you reduce bacterial contamination are soil testing, installing laneways, installing loafing and feeding pads, controlling weeds, mowing/clipping pastures, and dragging pastures.

Soil testing: An inexpensive soil test can help you determine the types and amounts of fertilizer and lime needed for good pasture growth. Applying fertilizer at the appropriate rate and time will help prevent nutrient runoff from over-fertilized pastures. Applying fertilizer at the appropriate rate and time will save money because only the amount needed is applied.

It is best to soil test least once every 3 years to determine the types and amounts of fertilizer and limestone needed before seeding. Your local Texas AgriLife Extension county office (<http://agrilifeextension.tamu.edu/>) has information available to help you with this process.

Install laneways: Laneways between paddocks help confine cattle traffic and minimize soil compaction. They protect water quality by reducing sedimentation and allowing the water to filter into the soil instead of running off.

Laneways that are well planned and constructed will also (Wrigley and Bell 2006):

- Reduce lameness and environmental mastitis
- Reduce the amount of teat cleaning required
- Improve milk quality
- Enable easier and faster stock and vehicle movement



- Provide all-weather farm access
- Increase milk production by minimizing cow transit time
- Allow easy access for drain cleaning, fence maintenance, etc.

Install loafing and feeding pads: Loafing and feeding pads provide a place for cattle to be held and fed during wet weather. They can be made of porous material such as sawdust or impervious concrete. The pads reduce soil compaction and help protect the pasture.

Weed control: The presence of weeds in a pasture can often indicate overgrazing, poor forage density, or inadequate fertilization. Weeds can out-compete the forage for water, nutrients, and sunlight. Over time, they can reduce the pasture's longevity and nutritional value.

For the best weed control, maintain a dense, healthy stand of grasses and legumes through proper soil fertility, cutting/mowing management, and higher seeding rates.

Mowing/clipping pastures: Livestock can be spot grazers that, if left uncontrolled, can result in a very uneven forage growth pattern in a pasture. Dairy cattle prefer to eat shorter plants because they have less fiber and more protein and nutrients.

Mowing and clipping pastures occasionally during the growing season will discourage weed growth, spur new grass growth, prevent weeds from reproducing, encourage the livestock to use the pasture more uniformly, and prevent the grass from becoming too mature. Pastures may need to be clipped three or more times per year.

Dragging pastures: Areas where excessive manure collects in a pasture can contribute to uneven grazing—livestock typically do not graze near these areas. Use chain or link harrows to help distribute the manure more evenly across the pasture.

This practice can reduce the parasite and bacterial populations by exposing them to air and sunlight; it can also help smooth over areas that the livestock have dug up with their hooves. Dragging pastures helps water and air penetrate the soil.

A good time to drag a pasture is immediately after it has been clipped or mowed.

Burning pastures: Burning can help control undesirable vegetation, prepare for harvesting or seeding, control plant disease, reduce wildfire hazard, improve wildlife habitat, improve plant production, remove debris, and increase seed production.

Burns must be planned carefully. The plan should address the location/description of the burn area, pre-burn vegetation cover, management objectives, required weather conditions, notification list, equipment list, personnel assignments, post-burn evaluation criteria, firing sequence, and ignition method. It should have all necessary approval signatures. Burning should be conducted only by those who have the experience and knowledge necessary to maintain the safety of the people involved.

For more information on prescribed burning, see Planning a Prescribed Burn, available from the Texas AgriLife Extension Service at <https://agrilifebookstore.org/>.

## Consequences of Improper Pasture and Grazing Management

Poor pasture and grazing management can increase soil erosion, reduce forage production, and reduce water conservation.

**Soil erosion:** Erosion displaces topsoil and washes it away. Often the runoff ends up in waterways, where it deposits sediment and nutrients such as nitrogen, phosphorus, and potassium, which can contaminate water.

Soil erosion begins with raindrop impact: A raindrop falling on bare ground dislodges soil particles and destroys the soil structure (Brady 1990, Branson et al. 1981). Dislodged soil particles become suspended in the water and are washed away by overland flow (runoff).

Dislodged soil particles can also seal the soil surface by plugging the tiny pores between soil particles (micropores). This plugging reduces water infiltration rates and increases runoff.

Vegetative groundcover can dramatically reduce erosion. Plants intercept the raindrops, absorbing the energy of impact and protecting the integrity of the soil surface. Groundcover also reduces erosion by diminishing the energy of runoff water (Fig. 7).

After a raindrop makes impact, one of three things can happen (Holechek et al. 1998):

- **Infiltration**, or movement of water into the soil. Infiltration is determined primarily by the soil's

texture. Water infiltrates and percolates faster through coarse-textured soils such as sands than through fine-textured soils such as clays.

- **Evaporation**, which can be positive or negative, depending on the amount of moisture in the soil.
- **Runoff**, which occurs when precipitation rates exceed infiltration rates of the soil.

Soil is lost when it is detached and transported from the site in runoff (Fig. 8). This can occur uniformly as sheet, or interrill, erosion. Extreme interrill erosion

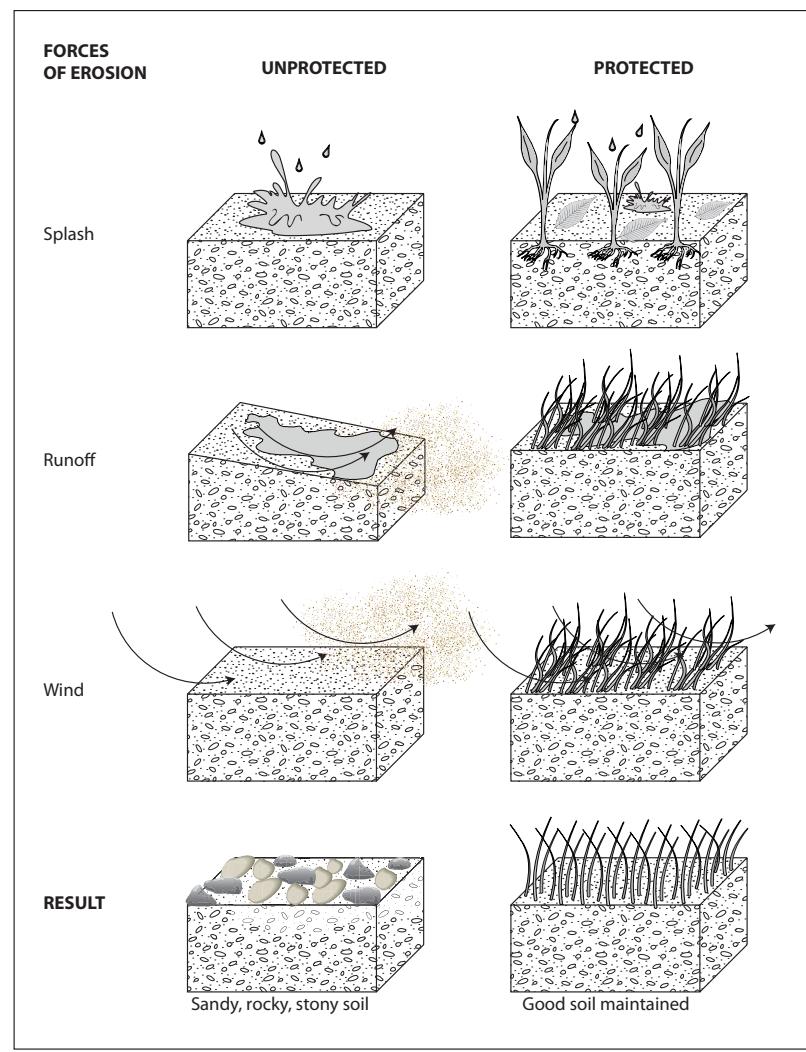


Figure 7. Vegetation effects on reducing soil erosion. Illustration by Jennifer Peterson (adapted from Nebel 1981 as used by Holechek et al. 1998).



can create soil pedestals around areas covered by materials (such as rock) that resist raindrop impact. This phenomenon illustrates the highly erosive nature of raindrop impact (Thurow 1991).

Further erosion creates small, distinct flow paths (rill erosion) that can be corrected with tillage. However, if the erosion continues unabated, it may create deep channels (gully erosion). At this point, tillage may be unable to repair the damage, and vehicles may not be able cross the channels.

**Overstocking** pastures reduces the vegetative groundcover and makes the land vulnerable to rainfall erosion. Water flows rapidly over the land, carrying sediment, bacteria, and pesticides into nearby waterways. Eventually, sediment reduces the capacity of surface water reservoirs.

When proper stocking rates are used, the ground always has enough plant cover to reduce runoff and soil erosion and to protect water quality.

**Forage production:** Heavy grazing pressure and high stocking rates decrease the vigor and viability of forage plants on rangeland and pastures. If livestock remove more than 50 percent of the aboveground plant, photosynthesis is slowed, which in turn reduces root development and the amount of moisture and soil nutrients that plants can take up (Fig. 9).

Over the long term, forage plants become weaker and less abundant, undesirable plants take over, and the amount of bare ground increases. Ultimately, the rangeland or pasture is completely degraded.



Figure 8. Typical erosion due to unprotected soil. Photo by Lynn Betts, USDA-NRCS.

If the stocking rate is not reduced, carrying capacity will diminish, animal performance will decrease, and the potential for profit will be eliminated. Input costs will rise—for more herbicides and winter feeding, for instance—making the bad situation worse.

**Water conservation:** Perennial groundcover increases the amount of precipitation captured by the soil and decreases the amount lost in runoff. When a pasture is overused, undesirable plant species move in. These species generally do not provide the type of groundcover necessary to reduce runoff and increase infiltration. As a result, much of the precipitation is lost from the site, reducing forage production (Fig. 10) and minimizing the recharge of underground aquifers. In clayey soils, the soil becomes compacted, which further reduces the infiltration rate.

Many studies have found that stocking rates affect infiltration rates (Holechek et al. 1998, Gifford and Hawkins 1978). Research findings conclude that:

- Ungrazed plots have higher infiltration rates than do grazed plots.

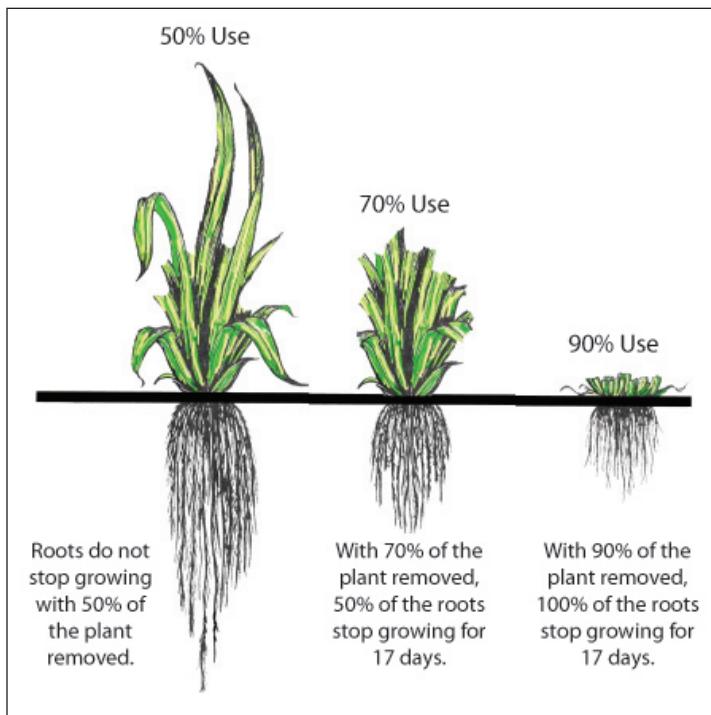


Figure 9. Effect of intensity of defoliation on root production.  
Illustration courtesy of the Texas USDA-NRCS.

- Lands that are moderately or lightly grazed have similar infiltration rates.
- Heavily grazed land has lower infiltration rates than does moderately and lightly grazed land.

### Summary of Pasture Management BMPs

A well-managed pasture and grazing system can provide adequate nutrition as well as the safest and most economical care for cattle. Simple, inexpensive, low-maintenance practices will help ensure the health of your animals, the pasture, and the environment by reducing soil erosion and preventing bacteria from contaminating surface water and groundwater.

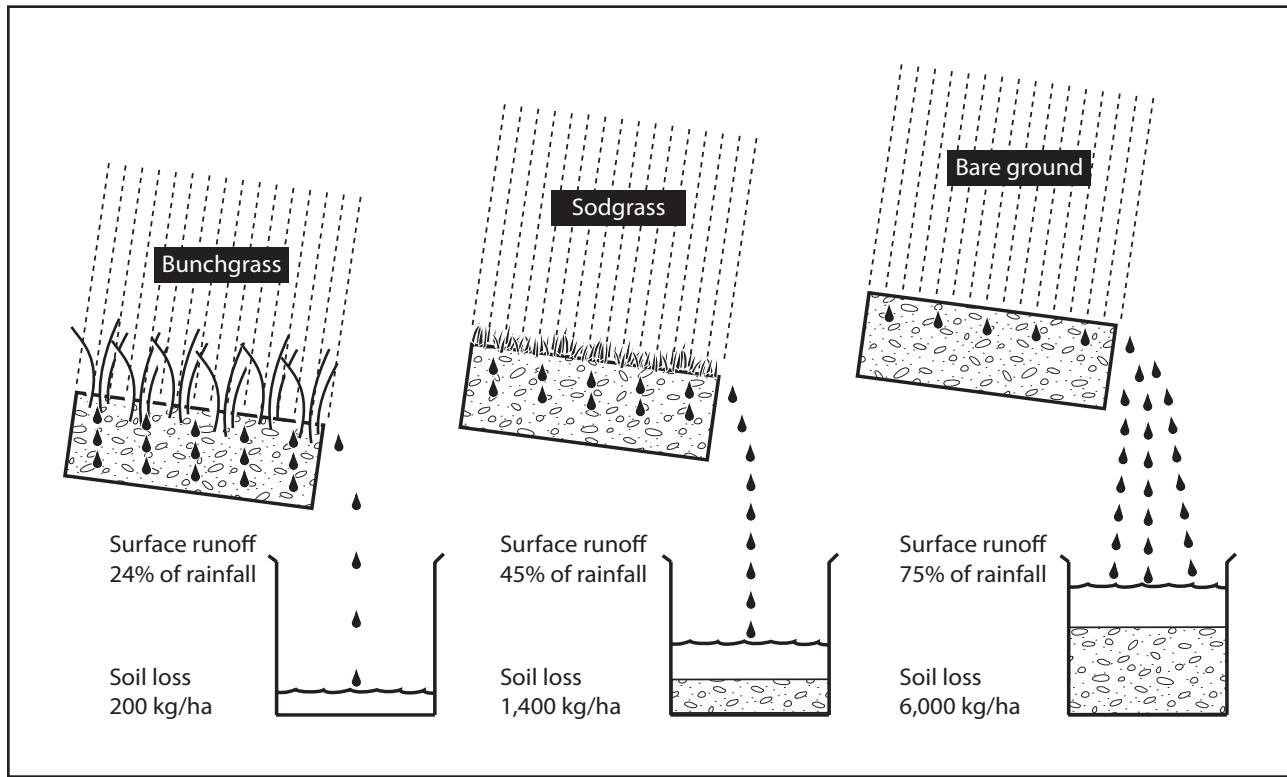


Figure 10. Influence of vegetation type on sediment loss, surface runoff, and rainfall infiltration from 4 inches (10cm) of rain in 30 minutes (adapted from Blackburn et al. 1996, by Knight 1993, and as used by Holechek et al. 1998).



## RUNOFF MANAGEMENT BMPs

Runoff management BMPs help reduce the amount of water moving across the landscape as well as the amount of pollutants being moved into water bodies. For grazing dairies, the primary BMP to manage runoff is filter strips (NRCS Code 393).

### Filter Strips

A filter strip is an area of herbaceous vegetation that is established between a body of water and cropland, grazing land, or disturbed land. It is designed to remove sediment, bacteria, organic material, nutrients, and chemicals from overland water flow (Fig. 11). A filter strip works by slowing runoff, which allows the contaminants to settle out, infiltrate, and be dispersed across the width of the strip.

In addition to protecting water quality, filter strips can also improve soil aeration, create wildlife habitat, provide shade that improves soil moisture content, recycle nutrients that promote plant growth, and help protect riparian areas. If riparian areas are protected from overstocking and overgrazing, they will naturally develop effective vegetative filter strips that further protect the stream from runoff containing bacteria, nutrients, pesticides, and sediment (Fig. 12).

For adequate protection, filter strips should have specific minimum widths, which vary according to the slope of the land (Table 6). Their effectiveness of filter strips depends on:

- The amount of sediment that reaches the filter strip
- The amount of time that water is retained in the filter strip

Table 6. Minimum widths for vegetative filter strips. Standards and Specifications No. 393, USDA-NRCS Field Office Technical Guide, 2004.

Slope	Minimum Width of Buffer Strip
1–3%	25 ft
4–7%	35 ft
8–10%	50 ft

- The steepness, length, and slope of the filter strip
- The infiltration rate of the soil
- The type and density of vegetation used in the filter strip
- The uniformity of the water flow through the filter strip
- The correct installation and maintenance of the filter strip (Smith 2000)



Figure 11. Filter strip. Photo courtesy of the USDA-NRCS.

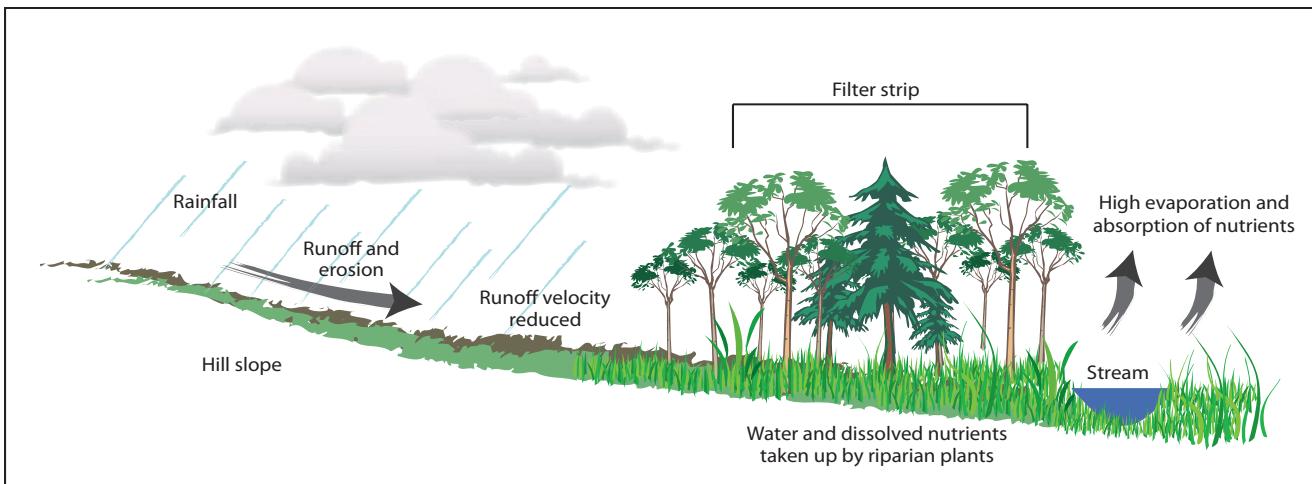


Figure 12. Conceptual model of how vegetative filter strips protect a stream from contaminants and the riparian area from erosion. Illustration by Jennifer Peterson.

Research has found that filter strips can reduce up to 99.995 percent of bacteria in runoff from land where beef and/or dairy cattle are present (Table 7). In addition, filter strips are effective in removing other contaminants, including atrazine, herbicides, nitrate-nitrogen, sediment, soil, and total phosphorus (Fig. 13). They also

stabilize the soil, provide shade to help the soil hold moisture, and protect it from the eroding forces of wind, water, and raindrop impact.

The costs of establishing a filter strip vary according to seed, fertilizer, labor, and equipment costs. The NRCS estimates that

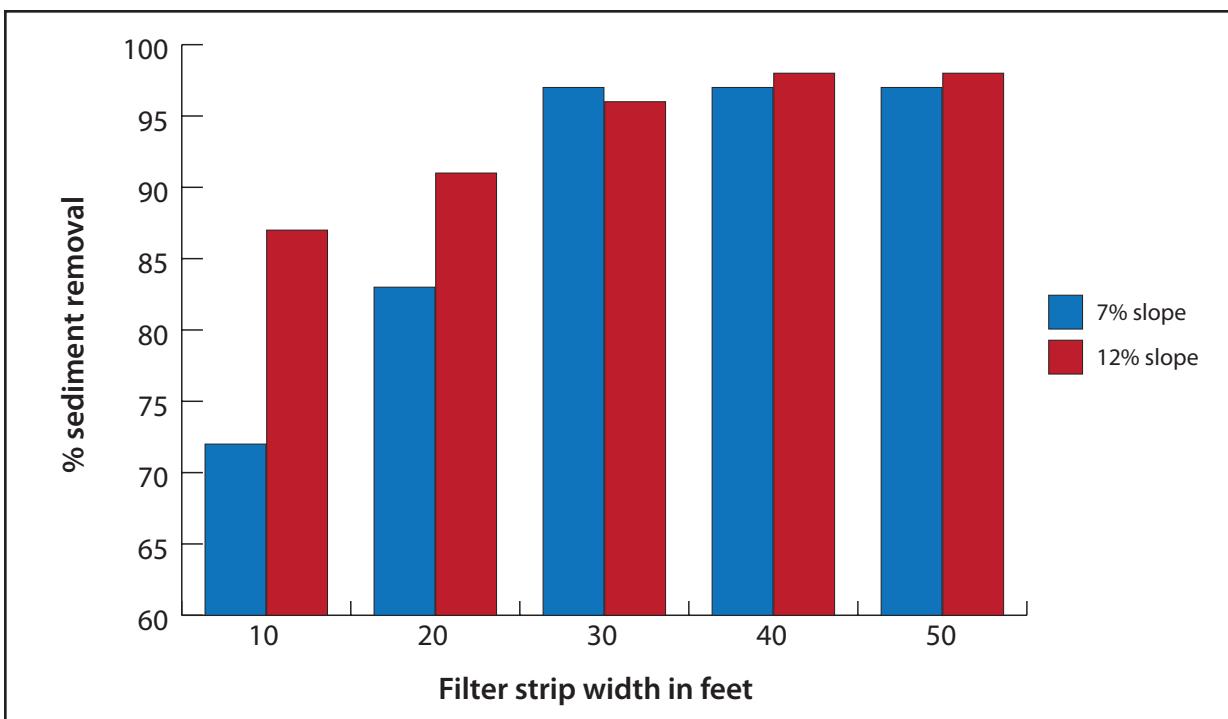


Figure 13. Percent sediment removed by a vegetative filter strip based on the width of the filter strip (Schultz et al. 1992).



Table 7. Effectiveness of filter strips in removing different kinds of bacteria from runoff.

Type of Bacteria	Reduction	Source
<i>E. coli</i>	99.7%	Casteel et al. 2005
	94.8%-99.995%	Tate 2006
	91%	Mankin and Okoren 2003
	57.85%-98.9%	Goel et al. 2004
Total coliform	97%-99.4%	Casteel et al. 2005
	81%	Cook 1998
	69%	Young 1980
	66.89%-92.12%	Goel et al. 2004
Fecal coliform	100%	Lim et al. 1998
	99%	Sullivan 2007, Lewis et al. 2010
	87% and 64%	Fajardo et al. 2001
	83.5%	Mankin and Okoren 2003
	83% and 95%	Larsen et al. 1994
	81%	Stuntebeck and Bannerman 1998
	75% and 91%	Coyne et al. 1998
	69%	Young 1980
	67%	Roodsari et al. 2005
	55.59%-99.78%	Goel et al. 2004
Fecal streptococci	43% and 72%	Coyne et al. 1995
	83.5%	Mankin and Okoren 2003
	76%	Cook 1998
	74% and 68%	Coyne et al. 1998
<i>Cryptosporidium parvum</i>	70%	Young 1980
	99.9%	Atwill et al. 2002
	99.4%	Trask et al. 2004
	99%	Mawdsley et al. 1996
	97%	Miller et al. 2008
<i>Giardia</i>	93.5% to 99.4%	Tate et al. 2004
	26%	Winkworth et al. 2008

filter strip installation can cost from \$275 to \$310 per acre, depending on whether native or nonnative plants are used. However, in many instances, a landowner need only change the stocking rate and/or grazing system to encourage filter strips to develop naturally.

The NRCS offers technical and financial assistance programs to offset up to 50 percent of the cost of implementation. For more information, contact the NRCS at <http://offices.sc.egov.usda.gov/locator/app?agency=nrcs>.

## Summary of Runoff Management BMPs

Filter strips can offer many benefits: They can help control runoff across your property, protect the well-being of your livestock, and minimize the amount of contaminants that reach neighboring bodies of water. Assess your situation and your goals, and implement the practices that work best for you.

## RIPARIAN AREA PROTECTION AND MANAGEMENT BMPs

Riparian areas are environmentally sensitive areas along streams and rivers that require special protection from grazing livestock. To protect these areas, adopt BMPs that control the amount of time animals spend in and near riparian areas. These practices range from strategies for modifying animal behavior to total exclusion from the riparian area. BMPs include:

- Shade structures (NRCS Code 717)
- Watering facility (NRCS Code 614)
- Exclusionary fencing (NRCS Code 382)
- Access control (NRCS Code 472)
- Stream crossings (NRCS Code 578)
- Feed, salt, and/or mineral locations
- Heavy use area protection (NRCS Code 561)
- In-stream watering points

### Shade Structures

A shade structure is a permanent or portable framed structure that provides shade for livestock away from the riparian area and improves grazing distribution (Fig. 14). When temperatures are high during the spring through fall months, grazing livestock may benefit from shade and cooling, and some studies indicate



Figure 14. Shade structures constructed with a tin roof (top) and a shade cloth (bottom). Photos courtesy of The Samuel Roberts Nobel Foundation Inc. (top) and Larry Redmon, Texas AgriLife Extension Service.

an increase in animal performance due to shade in the grazing pastures (Paul and Turner 2000).

Exposure to hot summer temperatures can affect the behavior and physiology of dairy cattle and can influence animal welfare (Schütz et al. 2010). Studies done on dairy cattle have shown negative effects when the temperature-humidity-index (THI) increases above 72. At this level, milk fat, milk protein, and reproductive performance declined (Granzin 2004). Heat stress has also been shown to cause a 10 to 25 percent reduction in milk production (Roman-Ponce et al. 1977).

Natural shade is generally most abundant in riparian areas, which increases the opportunity for livestock and other animals to make direct fecal deposition



into the waterways, thereby increasing the fecal coliform levels in the stream. Using constructed shade facilities, or better yet, having trees in your pasture to provide natural shade, is a valuable BMP that can help reduce the time cattle spend in the riparian area. Producers should consider providing natural shade, especially when clearing and establishing new grazing pastures. Leaving several shade trees in a pasture is a BMP that has zero establishment cost.

Shade structures should be constructed with solid rather than slatted shade. The roof height should be between 11 and 14 feet to maximize solar radiation and 38 to 48 square feet of shade should be provided per cow (Jordan 2005). Shade structures should be oriented north and south to allow sunlight to dry moist areas beneath the structure. To help prevent disease, areas beneath shade structures should be groomed so cattle have a dry place to lie down (Jordan 2005).

Dairy cattle are highly motivated to use shade in warm temperatures (Schütz et al. 2008). Shade structures are recommended in most states and by the EPA as an effective BMP. Research suggests that phosphorus, sediment, and *E. coli* contamination can be reduced in streams if cattle have access to alternative shade and water sources. One study found that *E. coli* in runoff dropped by 85 percent when both shade structures and alternative water sources were used (Franklin et al. 2009). Preliminary research conducted by Texas A&M University found an 11 percent to 30 percent reduction in the percent time that cattle spend in the creek when a shade structure was made available.

In addition to reducing bacterial levels in runoff and changing animal behavior, shade

structures have also been found to provide the following benefits:

- Reduced rectal temperature of cows (Granzin 2004)
- Increased feed intake and lower respiration rates (Mader et al. 1997)
- Increased milk production (Granzin 2004)
- Decreased loss of water and minerals/electrolytes through sweating (Thesing 2006)
- Improved animal health and appetite (Thesing 2006, Porr 2007)
- Increased utilization of stored fat (Thesing 2006)
- Improved grazing distribution and pasture use (McIlvain and Shoop 1970, Higgins et al. 1999)

The costs of shade structures vary with size and building materials. Prefabricated models require only assembly and cost about \$1,200. Others require welding and other special construction skills and cost about \$6.50 per square foot. Table 8 provides a cost-benefit analysis of shade structures for dairies. For more information on shade structures, contact the NRCS at <http://offices.sc.egov.usda.gov/locator/app?agency=nrcs>.

### **Watering Facility**

A watering facility is a permanent or portable off-stream water supply, such as a trough or pond system, that provides drinking water for livestock and/or wildlife. Off-stream watering facilities can dramatically reduce the amount of time that cattle spend in and near streams, even when cattle have full access to the waterway.

If a riparian area is completely protected by exclusionary fencing, the livestock must

Table 8. Benefit and costs of livestock shade structures for dairies. Source: NRCS 2007b.

Benefits							
Number of Cows Served Under	Average Milk	Increase in Milk Production Annually with Shade	Increase in Milk Production Annually with Shade (lbs)	CWT	CWT Affected by Total Annual Hours of Exposure	Average Price Received per CWT**	Average Annual Benefit
53	18,213	8%	77,223	772	378	\$17.40	\$6,585.00
Costs							
Average Per Unit Cost	Unit	Quantity (ft <sup>2</sup> )	Total Installation Cost	Operation & Maintenance Cost	Amoritization Rate	Average Annual Cost	
\$1.60	ft <sup>2</sup>	800	\$1,280.00	4%	0.1490	\$242.00	
Average Annual Net Benefit							\$6,343.00
Average Net Benefit per Month							\$528.00
Break-Even 1 <sup>st</sup> Month							-\$752.00
Break-Even 2 <sup>nd</sup> Month							-\$224.00
Break-Even 3 <sup>rd</sup> Month							\$304.00

\* Based on typical 20' x 40' dimensions. (20' x 40' = 800 ft<sup>2</sup>) (800 ft<sup>2</sup> ÷ 15ft<sup>2</sup>/head = 53.33 head per shade structure)

\*\* 10 Year State Average

\*\* Based on 8% Interest Rate and 10 Year Lifespan

be provided an alternative water source. The most essential nutrient for dairy cattle is water; it is the main component of milk and waste products and constitutes 56 to 81 percent of a dairy cow's total weight. Dairy cattle require a substantial amount of water each day (Table 9).

Alternative water sources take several forms and may require drilling a water well. Where electricity is available, electric water pumps can pump water from a well, and it can then be gravity-fed to satellite watering locations. One well of appropriate capacity can provide water to several locations on the ranch.

If electricity is not available, as is generally the case, windmills (Fig. 15) or solar-powered pumps (Fig. 16) can deliver water from groundwater aquifers to the soil

surface. Again, the water can be gravity-fed from a central holding location to several additional sites so that one well, if situated appropriately on a high point of the ranch, can gravity-feed several satellite water locations.

In areas where the complete exclusion of riparian pastures is not warranted, alternative water sources can significantly reduce the amount of time that cattle spend in the water loafing and therefore how much fecal material they deposit into the waterway. Studies have shown that where alternative water sources were established but cattle still had full access to riparian pastures, bacteria levels were 51 percent to 94 percent lower than in those pastures where an alternative water source was not provided (Table 10).

Table 9. Water consumption of dairy cattle<sup>a</sup>.

Class of Cattle	Age or Condition	Gallons per Day <sup>b</sup>
-Drinking Water Only-		
Holstein Calves	1 month	1.3 to 2.0
Holstein Calves	2 months	1.5 to 2.4
Holstein Calves	3 months	2.1 to 2.8
Holstein Calves	4 months	3.0 to 3.5
Holstein Heifers	5 months	3.8 to 4.6
Holstein Heifers	15 to 18 months	5.9 to 7.1
Holstein Heifers	18 to 24 months	7.3 to 9.6
Jersey Cows	30 lbs milk/day	13.0 to 15.5
Guernsey Cows	30 lbs milk/day	13.8 to 16.0
Ayrshire, Brown Swiss, and Holstein Cows	30 lbs milk/day	14.5 to 17.0
Ayrshire, Brown Swiss, and Holstein Cows	50 lbs milk/day	24.0 to 27.0
Dry Cows	Pregnant, 6 to 9 months	9.0 to 13.0
-Water Intake From Feed and Drinking Water-		
Milk Cows	4.5 to 5.0 lbs/lb milk produced daily	

<sup>a</sup>Adapted from Dairy Reference Manual, Pennsylvania State University.

<sup>b</sup>Consumption at air temperatures of 50 to 80F, intake depends upon water content of the forage ration. Higher levels apply to an all hay ration. One gallon of water weighs 8.34 pounds. A cubic foot of water weighs 62.4 pounds.

Table 10. Bacteria reductions in streams where alternative water sources were available.

Type of Bacteria	Reduction	Reference
<i>E. coli</i>	85%	Byers et al. 2005
Fecal coliform	94%*	Hagedorn et al. 1999
	51%	Sheffield et al. 1997
Fecal streptococci	77%	Sheffield et al. 1997

\* when combined with other practices.

Even when cattle have full access to a waterway, an alternative water source can be an effective tool for protecting the riparian area and improving water quality because it can dramatically change the amount of time cattle spend in and

near a stream. In one study, GPS collars were used to demonstrate that cattle spent from 43 percent to 57 percent less time in streams when provided an alternative water source (Wagner and Redmon 2011). Another study found a 51 percent reduction in cattle use of the stream area (Sheffield et al. 1997). Miner et al. (1992) found a 90 percent reduction in the amount of time cattle spent in the stream when provided access to an off-stream trough.

In addition to benefiting riparian areas, alternative water sources may improve cattle performance. Water in troughs is generally of higher quality and contains less sediment and fecal coliform than water found in streams and rivers. Studies have found that when presented with alternative water sources, cattle spend much more time drinking from troughs than they do from streams, and calves gained 9 percent more weight from cows drinking clean water compared with pond water (Willms et al. 2002).

An alternative water supply alone, however, will not achieve the targeted improvements in water quality unless it is implemented in conjunction with good grazing management (McIver 2004).

An off-stream alternative water supply improves animal distribution and reduces:



Figures 15 and 16. One of the oldest alternative water sources, the windmill, is still popular in many parts of Texas. Solar-powered water wells are becoming increasingly popular for developing alternative water sources. Photos courtesy of Oklahoma Farm Bureau (left) and Cheney Lake Watershed Inc.

- The amount of direct livestock use of stream for drinking and other activities by up to 90 percent (Miner et al. 1992)
- Stream bank erosion by 77 percent, total suspended solids by 90 percent, and total nitrogen by 54 percent (Sheffield et al. 1997)
- Total and fecal phosphorus

Costs for watering facilities vary depending on the system design and materials used.

The NRCS lists these materials costs:

- Watering troughs: \$450 to about \$7,600, depending on the size and material (plastic, galvanized metal, fiberglass, or concrete)
- Electric water pumps: \$1,900 to \$4,000, depending on the size
- Solar water pumps: \$5,700 to \$12,000, depending on well depth

- Windmills: \$8,200 to \$17,800, depending on fan diameter
- Ponds: \$2.08/cubic yard to \$10.08/cubic yard, depending on size

Financial assistance programs can help cover some of the implementation costs. For more information, contact the NRCS office at <http://offices.sc.egov.usda.gov/locator/app?agency=nrcs>.

### Exclusionary Fencing

According to the EPA (2003), excluding and/or controlling livestock access to sensitive areas, such as stream banks, wetlands, and estuaries, through the use of exclusionary practices, is one grazing management measure to consider when managing rangeland, pasture, and other grazing lands to protect water quality and aquatic and riparian habitat.



Exclusionary fencing (Fig. 17) may not completely protect the riparian area unless adequate vegetative filter strips are maintained along the waterway. As long as the land is not overstocked and overgrazed, the filter strips will protect streams from runoff that might carry bacteria, nutrients, pesticides, and sediment after heavy rains.

Producers should carefully plan the length of the stream segment to be fenced out and be prepared to maintain the fence, especially in areas subject to periodic flooding. Many ranchers place exclusionary fences above flood-prone areas. The fenced-out area could be used for hay production.

Many studies have been conducted on the effect of exclusionary fencing. They have found reductions in bacteria levels of 30 to 94 percent (Table 11).

In addition to helping minimize bacteria levels in runoff, exclusionary fencing offers these benefits:

- Herds have lower risks of health problems, such as leg injuries and foot disease, caused by unstable footing associated with livestock standing in muddy areas and climbing steep and unstable stream banks.
- Water quality improves because less sediment, nutrients, and organic and inorganic reaches the stream.
- Stream banks are not destabilized or eroded by trampling and overgrazing.
- Plants in the riparian zone act as a full or partial buffer.
- Grazing distribution of grazing and forage use improve.



Figure 17. A barbed wire fence separates a riparian buffer on the right from a grazed pasture on the left. Photo courtesy of the USDA-NRCS.

- Streams have less sediment and cloudiness.
- The riparian vegetation is taller and healthier.
- Soil loss is reduced by 40 percent (Owens et al. 1996).
- Total phosphorus levels drop by 76 percent (Line et al. 2000).
- Fish production increases by 184 percent (Bowers et al. 1979).

Fencing costs depend on the material used, the length needed, and the terrain on which the fencing is installed. According to the NRCS, permanent electric fence costs about \$1.80 per foot on normal terrain, while four-strand barbed-wire fence costs about \$2.16 per foot on normal terrain and about \$3.05 per foot on steep or rocky terrain.

The NRCS and the TSSWCB offer financial assistance programs to help landowners with exclusionary fencing, as well as additional incentives in the form of rental fees for the areas excluded (up to \$259 per acre). For more information contact the

Table 11. Effectiveness of exclusionary fencing in removing different kinds of bacteria from runoff.

Type of Bacteria	Reduction	Reference
<i>E. coli</i>	46%	Meals 2001
	37%	Meals 2004
Total coliform	81%	Cook 1998
Fecal coliform	94%*	Hagedorn et al. 1999
	90%	Line 2002
	70%	Lombardo et al. 2000
	66%	Line 2003
	52% <sup>1</sup>	Meals 2001
	42%	Meals 2004
	41%	Brenner 1996
	30%	Brenner et al. 1994
Fecal streptococci	30% <sup>2</sup>	Cook 1998
Fecal enterococci	76% <sup>2</sup>	Cook 1998
	73%	Galeone 2006
	51% <sup>1</sup>	Meals 2001
	30%	Meals 2004
Fecal <i>enterococci</i>	57%	Line 2003

\* when combined with in-pasture water stations.

<sup>1</sup> when combined with protected stream crossings and stream bank bioengineering.

<sup>2</sup> when combined with alternate water sources, filter strips, and manure management.

NRCS office at the local USDA Service Center (<http://offices.sc.egov.usda.gov/locator/app>).

### Access Control

Closely related to exclusionary fencing is the practice of access control, which simply means excluding livestock, people, or vehicles from environmentally sensitive areas. Access control tools include fences, gates, signs, or other barriers.

One type of barrier is rip-rap (large rocks), which can be used to restrict livestock from

riparian areas, trails, stream crossings, or other sensitive parts of a ranch (Fig. 18). Livestock tend to avoid areas where large stones comprise 30 percent or more of the ground cover (Hohlt et al. 2009), so rip-rap can alter animal movement patterns away from riparian areas.

Preliminary data from research conducted by Texas A&M University found rocks measuring 4-8 inches in diameter were slightly effective in hindering cattle whereas rocks measuring at least 12 inches in diameter were highly effective. Understanding this aspect of cattle behavior, producers may be able to use rip-rap in specific instances to alter cattle movement and afford some riparian protection. In fact, these large stones may help strengthen these heavily used areas and reduce the time cattle spend loafing around watering areas (Ziehr 2005).

Rip-rap has not been fully tested as an exclusionary device; more research is needed on height, width, and percent cover parameters needed to effectively alter cattle behavior for riparian area protection.

Practices that limit direct access to a water body by livestock, people, and machinery have the same benefits as exclusionary fencing. They help prevent pollution and erosion and improve the aesthetics of the land. Rip-rap slows the flow of runoff so that less sediment and other pollutants enter the water body (Massachusetts Department of Environmental Protection, 2003).

Implementation costs for access control measures depend on the method used. Fencing will cost about \$1.80 to \$3.05 per foot. Non-grouted rip-rap costs about \$35 to \$50 per square yard, whereas grouted rip-rap costs \$45 to \$60 per square yard (Mayo



Figure 18. This stream bank has been stabilized from erosion with rip-rap. Photo courtesy of the USDA-NRCS.

et al., 1993). For more information on access control practices and financial assistance programs, contact the NRCS office at your local USDA Service Center (<http://offices.sc.egov.usda.gov/locator/app>).

### **Hardened Stream Crossings**

A stream crossing is a stabilized area or structure constructed across a stream to provide a travel way for people, livestock, equipment, or vehicles. Geotextile and gravel can be used to establish hardened stream crossings, which facilitate cattle movement, reduce loafing time in the stream, and reduce stream turbidity and sediment loading (Fig. 19).

If these crossings are established in conjunction with exclusionary fencing (Fig. 17), cattle readily use them, preferring the hardened surface over cattle trails up and down stream banks.

Stream crossings can be built in several different ways using different kinds of materials. Regardless of the design and materials used, the NRCS requires multi-use crossings to be at least 10 feet wide and cattle-only crossings to be at least 6 feet wide. Width is measured from the upstream end to the downstream end of the stream crossing and doesn't include the side slopes.

Most important in the construction design is to slope the stream banks on each side and to provide a firm streambed. Other considerations:

- Flatten the banks enough for livestock or equipment to move safely down them.
- Protect banks with gravel and filter fabric.
- Make the streambed firm enough so livestock or equipment will not cause ruts. For gravel or bedrock streams, additional streambed work may not be needed.

If constructed properly, very little maintenance of the stream crossing should be required. Checking the stream crossing on a regular basis is important to ensure the crossing is functioning properly. Regularly check for eroded areas and repair them right away before the problem expands.

Hardened stream crossings improve water quality by reducing erosion and restricting direct access to waterways. They minimize pollution such as sediment, nutrients, bacteria, and organic matter in the surrounding water bodies.



Figure 19. Hardened crossing points constructed of geotextile fabric, concrete panels, and fine gravel to facilitate cattle movement across specific points in the stream. Photo courtesy of Chenago County Soil and Water Conservation District.

When combined with other BMPs, stream crossings can reduce the levels of these bacteria:

- *E. coli* by an average of 46 percent (Meals, 2001)
- Fecal coliform by 44 to 52 percent
- Fecal streptococci by 46 to 76 percent (Inamdar et al., 2002)

Hardened stream crossings can be used in conjunction with other practices such as fencing which have been shown to reduce concentrations of bacteria. Refer to this practice description on page X in this resource manual for more in depth information on bacterial removal efficiencies.

Stream crossings can also provide these benefits:

- Easier travel way for equipment and vehicles
- Clearer water in the stream
- Reduced risks of herd health problems, such as foot diseases and leg injuries, associated with unstable footing

- Improved water quality by reducing sediment, nutrient, organic, and inorganic loading to the stream
- Reduced stream bank destabilization and associated erosion due to trampling and overgrazing of banks
- Regeneration of riparian zone vegetation to act as a full or partial buffer

The cost of building and maintaining hardened stream crossings is moderate if the stream is small to moderate sized. Larger stream crossings may cost much more to build. Expenses may include the costs of:

- Labor for grading the stream banks and bottom
- Gravel and filter fabric
- Hog panels, stone, or other material to go in the bed of the stream
- Fencing to lead the livestock to the crossing
- Required building permits

According to the NRCS, a concrete crossing (3,000 psi concrete with rebar) and associated permits costs about \$325 per cubic yard. A 120-foot-long crossing made of 4-inch rock over non-woven geotextile costs \$60 per ton installed. Both estimates include all costs associated with labor, equipment, and installation.

### Salt, Mineral, and Feeder Locations

This practice involves the placement of feed, salt, and/or mineral locations off-stream as an attempt to improve grazing distribution and encourage livestock to move away from sensitive riparian areas (Fig. 20). This



Figure 20. A feeder can be used to help draw cattle away from unprotected riparian areas. Photo courtesy of Socha Farms.

practice is often used in conjunction with providing an alternative water source. However, cattle are unlikely to respond if they must travel far to access feeding sites, or if the feeding sites are too far from a water source.

Dolev et al. (2010) used GPS collars to track livestock use of external feeding sites placed more than 500 meters away from a water source. They found a decrease of 50 percent to 100 percent in utilization of the areas surrounding the water source. Furthermore, off-stream salt and mineral locations can help improve grazing distribution and reduce stream bank destabilization and associated erosion due to trampling and overgrazing of banks (McInnis and McIver 2001).

Supplemental feeding locations resulted in the following benefits:

- Gains in beef cattle increased by 0.2 to 0.4 pound per day
- Annual net returns increased by \$4,500 to \$11,000, depending on cattle prices and precipitation levels
- Cattle distribution improved

- The development of uncovered and unstable stream banks was reduced by 9 percent over two grazing seasons

Many different types of off-stream supplements can be used to feed dairy cattle and to better disperse grazing away from critical riparian areas. Energy supplements including corn gluten meal, barley, and wheat as well as protein supplements including soybean meal and cottonseed meal are all good choices. Salt and molasses supplements can also be used effectively.

The costs of these supplements vary greatly. For the latest hay prices, see the National Hay Feed and Seed Weekly Summary at <http://www.ams.usda.gov/mnreports/lswfeedseed.pdf>.

### **Heavy Use Area Protection**

Heavy-use areas include locations used frequently and intensively by people, animals, or vehicles. Examples are feeding areas, watering facilities, animal trails, and loafing lots.

These areas can be stabilized by establishing vegetative cover, surfacing them with suitable materials, and/or installing needed structures (Fig. 21). Typically, vegetation, geotextile fabric, rock, and concrete are used to stabilize these areas.

Establishing a vegetative cover will help stabilize the soil and filter runoff from the surrounding landscape. Research has shown that stabilizing heavy-use areas with mulch, straw, and seed can reduce fecal coliform by 92 to 99 percent (Lennox et al. 2007).

Studies have shown that several types of materials can benefit areas that are used heavily:



Figure 21. A water tank is an example of an area that receives heavy use. The soil surface can be protected by using geotextile materials and a layer of gravel. Photo by Gary Wilson, NRCS.

- Bank erosion dropped by 50 percent after a grade control structure was installed to protect stream banks from heavy use by cattle (Trimble 1994).
- Woven geotextile fabric reduced total phosphorus levels in runoff by nearly 50 percent (Singh et al. 2007).
- Geotextile pads retained over 99 percent of nutrients.
- A wheat straw mulch reduced soil erosion by 75 to 80 percent compared to that of an unmulched plot (Lattanzi et al. 1974).
- A mulch cover increased surface water storage and protected the soil surface from raindrop impact (Bonsu 1983).
- Rice straw increased soil porosity by 48 to 59 percent (Lal et al. 1980).
- A combination of geotextile fabric and highly porous gravel reduced total nitrogen concentrations in runoff by 86 percent (Gold et al. 2010).
- A compost/mulch blend reduced sediment discharge by 98 percent (Eck et al. 2010).

The NRCS estimates that protecting heavy-use areas costs about \$4.98 per square foot to install; the costs will vary depending on the materials used and the size of the area being protected. For more information, contact your local county AgriLife Extension agent, Soil and Water Conservation District (<http://www.tsswcb.state.tx.us/swcds>), or the Natural Resources Conservation Service (<http://www.usda.nrcs>).

### In-Stream Watering Points

An in-stream watering point gives livestock limited access to a waterway while preventing access to as much of the surrounding riparian area as possible (Fig. 22). This technique allows cattle to drink from the stream, but reduces the amount of time that they spend loafing there, thereby reducing the amount of fecal material deposited in the waterway. In most cases, the entry points that livestock already use can be upgraded by properly sloping the access point and by providing a stable surface for livestock to stand on.

Allowing some access by cattle may be warranted in areas where a pasture is next to or includes a stream or where it is impractical to totally exclude cattle from the riparian area. For example, cattle may need to access pastures on both sides of a stream, or other sources of water may be unavailable.

The watering point should be narrow to discourage loafing in the stream area. Confined areas encourage cattle to simply water and move on. Large herds may need multiple in-stream water points.

For these watering points, a hardened surface is typically extended to the stream at access points. The surface also protects



the stream bottom and reduces the amount of sediment stirred up by the cattle. In turn, water quality improves, aquatic habitats are maintained, and reservoirs downstream receive less sediment.

Avoid creating livestock access points where (Berg and Wyman 2001):

- The channel grade or alignment changes abruptly
- The channel bed is unstable
- There are overfalls, which are turbulent sections of a stream where strong currents pass over underwater ridges
- Large tributaries enter the stream
- There is a newly located or constructed channel
- A culvert or bridge is immediately upstream or downstream
- The water is deep and moving fast

No research could be found specifically on the effect of in-stream watering points on bacteria reductions. However, one of the main goals of this BMP is to limit the amount of time that cattle spend loafing in the stream. In consequence, less fecal matter will be deposited directly into the stream, and less bacteria will enter the waterway.

In-stream watering points can also:

- Prevent or minimize water degradation from sediment, nutrients, and organic materials
- Reduce stream bank erosion
- Enable livestock to cross or provide them a stable area to drink from the stream



Figure 22. Example of an in-stream watering point installed on a local farm pond to prevent cattle from disturbing the adjacent riparian area. Photo by Jeff Vanuga, USDA-NRCS.

Costs should be similar to those for a stream crossing. For more information, contact your local county AgriLife Extension agent, Soil and Water Conservation District (<http://www.tsswcb.state.tx.us/swcds>), or the Natural Resources Conservation Service (<http://www.usda.nrcs>).

### **Summary of Riparian Area Protection and Management BMPs**

If you own land next to a body of water, it is critical that you protect the riparian area. Act now to prevent costly erosion problems in the future.

Perhaps the biggest line of natural defense against contaminants in a waterway is vegetation along the shoreline. Other BMPs include controlling direct access to the waterway, erecting fences, and providing shade structures and off-stream watering facilities.

Assess your situation and goals, and implement the practices that work best for you and your land.

## CONFINED DAIRY

In confined dairies, best practices for reducing bacterial contamination of waterways focus on managing runoff, manure, and mortality (Table 12). Runoff Management BMPs.

Table 12. BMPs for confined dairies organized by category.

Category	Best Management Practices
Pasture Management	N/A
Runoff Management	Filter strips (NRCS Code 393)
	Field borders (NRCS Code 386)
	Roof runoff structure (NRCS Code 558)
	Grassed waterways (NRCS Code 412)
	Diversion (NRCS Code 362)
Riparian Area Protection and Management	N/A
Manure Management	Waste treatment lagoon (NRCS Code 359)
	Waste utilization (NRCS Code 633)
	Soil testing and nutrient management (NRCS Code 590)
	Composting (NRCS Code 317)
Mortality Management	Proper carcass disposal

## RUNOFF MANAGEMENT BMPs

Runoff management BMPs for confined dairies include field borders, filter strips, roof runoff structures, diversions, and grassed waterways.

### Field Borders

Field borders are a strip of permanent vegetation established at the edge of or around a field (Fig. 23). The border is managed as a non-crop plant community and is often used in addition to fence rows and drainage ditches. Field borders vary

in widths and species, depending on the objectives for their establishment.

Field borders:

- Eliminate the need to plant end rows up and down a hill
- Can control the spread of salinity into non-saline soils
- Act as a filter strip between a field and road or drainage ditch
- Reduce erosion from wind and water
- Protect air, soil, and water quality

Although field borders and filter strips provide similar benefits, the main difference between them is their size (Fig. 24). Unlike filter strips, field borders can be developed around an entire field margin instead of just along a downslope edge.

In intensive agricultural landscapes, field borders can provide nesting, foraging, roosting, loafing, and escape cover for birds. They can also increase the number and diversity of local wildlife species.

For field borders to improve water quality, the NRCS suggests that they be 30 feet wide and that the plants be able to resist water flow about as well as would a good stand of wheat. To reduce erosion as much as possible, the vegetation should be maintained at 1 foot tall.



Only a few studies have been conducted specifically on the effects of field borders on water quality. In a study of field borders in conjunction with other runoff management BMPs, fecal coliform bacteria concentrations were reduced by 40 percent within a 4-year period.

Because field borders and filter strips both use dense stands of vegetation to help control runoff, in most cases the bacterial removal by filter strips also apply to field borders (Table 7).

Field borders offer many benefits:

- Populations of bobwhite quail and important grassland songbirds are increased
- Insect pest populations are reduced by interrupting migration paths.
- Runoff is dispersed across the pasture or field
- The amount of sediment reaching a stream is reduced by up to 75 percent
- Nitrogen is reduced in surface ground water by up to 50 percent or more
- Crop yields are increased by 10 to 30 percent, depending on the crop and the buffer
- Fields are protected from flood damage and flood debris
- The costs of maintaining drains and road ditches are reduced
- Wildlife food and cover are increased
- Carbon storage increases

According to the NRCS, field borders cost about \$456 per acre (a 1-mile long, 15-foot-wide field border equates to 1.82 acres). They are designed to last 10 years. This



Figure 23. A field border planted along a field can help save soil. Photo by Lynn Betts, USDA-NRCS.

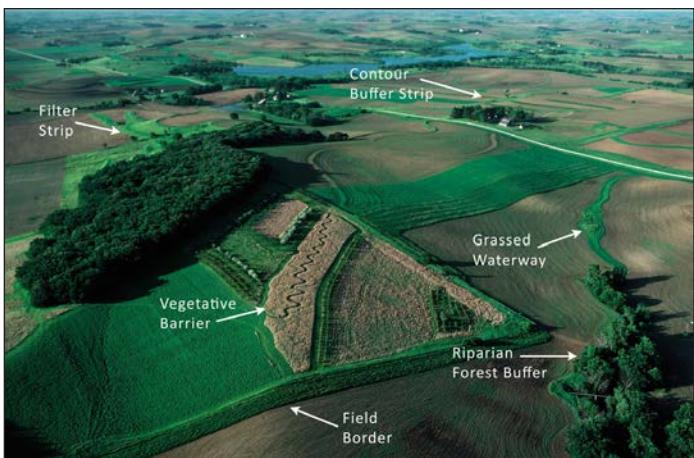


Figure 24. Schematic illustration of several in-field and edge-of-field vegetated buffers. Photo courtesy of the USDA-NRCS.

cost estimate is for a field border planted around a 160-acre field that is relatively flat and designed primarily for water quality benefits. Costs include seed as well as forgone income for acreage taken out of crop production. They will vary, depending on labor, seed, and the size of the field border.

### Roof Runoff Structures

Roof runoff structures are gutters, downspouts, and outlets that collect, control, and transport precipitation from roofs (Fig. 25). During heavy rains, large amounts of water drain off the roofs of



Figure 25. A roof runoff structure like the one pictured helps collect, control, and transport precipitation from roofs. Photo courtesy of the King Conservation District.

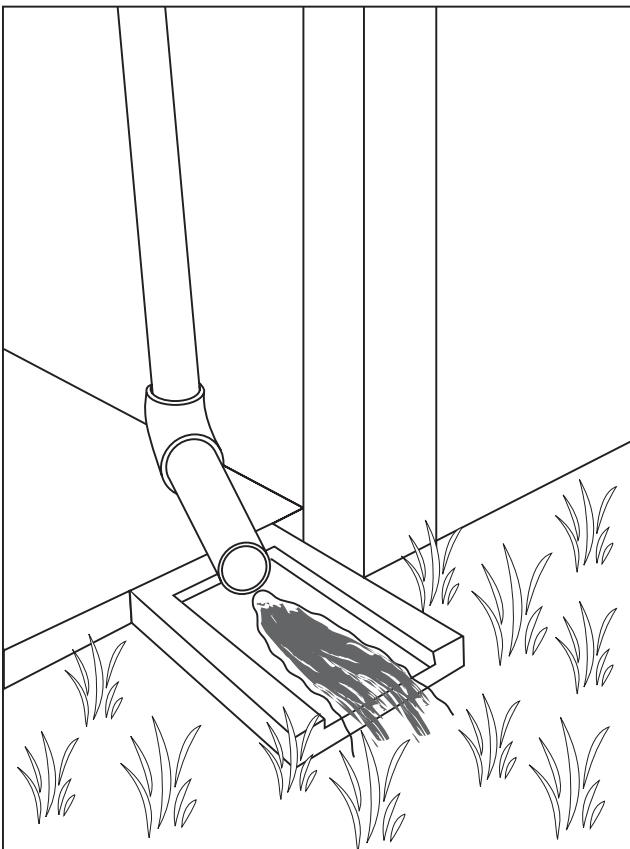


Figure 26. Protect the soil surface below the downspout from the water's force by having water fall onto splash blocks, into a surface drain, or into a stable rock outlet. Illustration by Jennifer Peterson adapted from the USDA-NRCS.

farm houses, barns, and other buildings. Flooding, erosion, and pollution problems can result, but can be greatly minimized simply by keeping roof rainwater away from buildings and other important areas on the farm.

One way to collect roof runoff is to direct the water via roof downspouts to cisterns, rain barrels, or other types of water catchment. The runoff is stored temporarily and released later for irrigation or infiltration between storms.

If the runoff will not be collected or stored, direct the flow away from the building to a vegetated area such as a filter strip. To minimize the water's force from the downspouts, protect the ground directly below the spout with rocks, a splash block, or a surface drain (Fig. 26).

Roof runoff structures improve water quality by reducing water flow across impervious surfaces and waste areas, which reduces the amount of pollutants (sediment, nutrients, bacteria, organic matter) that reach surrounding water bodies.

Roof runoff structures also offer these benefits:

- Better property aesthetics and increased property value
- Less soil erosion
- Prevention of water flow into barns, stables, and animal waste areas
- Control of runoff to downslope areas and protection for buildings and structures from undercutting their foundation
- More water filtering into the soil
- Better livestock management and health with less mud around barns and outbuildings



The cost of installing a roof runoff structure will vary depending on the materials and system selected. According to the NRCS, installation of roof runoff structures can range from \$6.70 per linear foot for gutters and downspouts to \$20.60 per linear foot for collection pipelines.

The NRCS offers technical assistance and financial assistance programs to offset up to 50 percent of the cost of implementation. For more information, contact the NRCS at <http://offices.sc.egov.usda.gov/locator/app?agency=nrcs>.

### Grassed Waterways

A grassed waterway is a shaped or graded channel that is established with suitable vegetation to carry surface water at a non-erosive velocity to a stable outlet (Fig. 27). The vegetation traps bacteria, sediment, nutrients, and other pollutants, preventing them from reaching a waterway.

Grassed waterways have several functions:

- Prevent erosion and flooding
- Reduce gully erosion
- Protect or improve water quality

Factors to consider before installing a grassed waterway include (Green and Haney 2005b):

- Types and concentrations of pollutants for which they are being designed
- Soil characteristics, such as clay content, organic material and infiltration rate
- Size of contributing area
- Previous or existing vegetation
- Steepness of slope/irregularity of topography



Figure 27. Grassed waterways carry runoff from fields helping prevent erosion and protect water quality. Photo by Lynn Betts, URDA-NRCS.

- Dimensions of the surrounding watershed that will be draining into the grassed waterway
- Types of vegetation adaptable to the area
- Climatic conditions at planting times
- Possible combinations of conservation practices to improve water quality
- Dominant wind direction

The effectiveness of grassed waterways in removing pollutants depends on several factors: the vegetation, soil characteristics, land slope/topography, area of establishment, shape of the waterway, and construction and maintenance practices.

Grassed waterways are typically designed to be broad and shallow (Fig. 28). Because of its larger surface area and increased contact time with runoff, a grassed waterway is more effective at trapping sediment and other pollutants if it is wide and has well-established vegetation (Green and Haney 2005b).



Figure 28. Grassed waterway. Photo courtesy of the USDA-NRCS.

In most cases, grassed waterways control runoff and remove bacteria about as well as do filter strips (Table 7).

- Improved soil aeration
- Less runoff volume and sediment content by up to 97 percent (Finer and Auerswald 2003a)
- Lower total phosphorus levels
- Reduced herbicide residues in runoff by up to 56 percent (Briggs et al. 1999)
- Stabilized soil
- Reduced gully erosion by 60 to 80 percent (NRCS 1989)
- Soil protected from the eroding forces of wind, water, and raindrop impact
- Increased shade, which helps hold moisture in the soil

Costs associated with the installation of grassed waterways depend on the equipment, fertilizer, grading, labor, and seed required. Potential returns include the revenue from harvesting and marketing the hay from grassed waterways.

The NRCS estimates that the cost to install and maintain grassed waterways is \$800 an acre, plus the costs associated with the forgone income from the land taken out of crop production. The cost to plant sprigged grasses and perform mechanical and/or chemical weed control is estimated at \$150 an acre; seeding with native species and using weed control is about \$110 per acre.

Financial and technical assistance programs are available at the federal, state, and local levels to help landowners install grassed waterways. For more information, contact the local county AgriLife Extension agent, Soil and Water Conservation District (<http://www.tsswcb.state.tx.us/swcds>), or the Natural Resources Conservation Service (<http://www.usda.nrcs>).

### Diversions

Diversions are ridges of soil or channels with a supporting ridge on the lower side (Fig. 29). They are built across the land slope to allow interception and disposal of runoff at a selected location. Typically, they are used to break up long slopes, to move water away from active erosion sites, to direct water around barnyards or other sites, and to channel surface runoff to suitable outlet locations. Their primary purpose is to protect land or water below the structure. They often are used in combination with contour strip-cropping, grassed waterways, sediment filters, or other sod filters that can trap nutrients and fecal bacteria in the runoff water (Hairston 2001).

There are three basic types of diversions: ridge, channel, and a combination of both (Fig. 30).

Diversions help slow runoff, trap sediment, and increase infiltration. They reduce erosion as well as the movement of bacteria,



nutrients, sediment, and other pollutants from fields and pastures. They also can help prevent pollutants in areas such as waste storage structures from reaching streams. Because diversions are typically established with permanent vegetation, they are like filter strips in their ability to capture and reduce bacteria in runoff (Table 7).

According to the NRCS, diversions can also:

- Direct water away from active gullies and critically eroding areas
- Break up concentrations of water on land that is too flat or irregular for terracing
- Divert water away from farmsteads, agricultural waste systems, and other improvements
- Collect or direct water for water-spreading or water harvesting systems
- Protect terrace systems by diverting water from the top terrace
- Protect flat land from upland runoff and from overland flow
- Reduce sediment in runoff

The NRCS estimates that a diversion costs about \$1.60 per cubic yard to build. The



Figure 29. This ridge diversion collects runoff from water above and safely diverts it away from land that might otherwise be damaged by the runoff. Photo by Lynn Betts, USDA-NRCS.

estimate includes costs associated with operation and maintenance, labor, and equipment. The practice is designed to last 10 years assuming that the practice is properly maintained after installation occurs.

For more information, contact your local county AgriLife Extension agent, Soil and Water Conservation District (<http://www.tsswcb.state.tx.us/swcds>) or the Natural

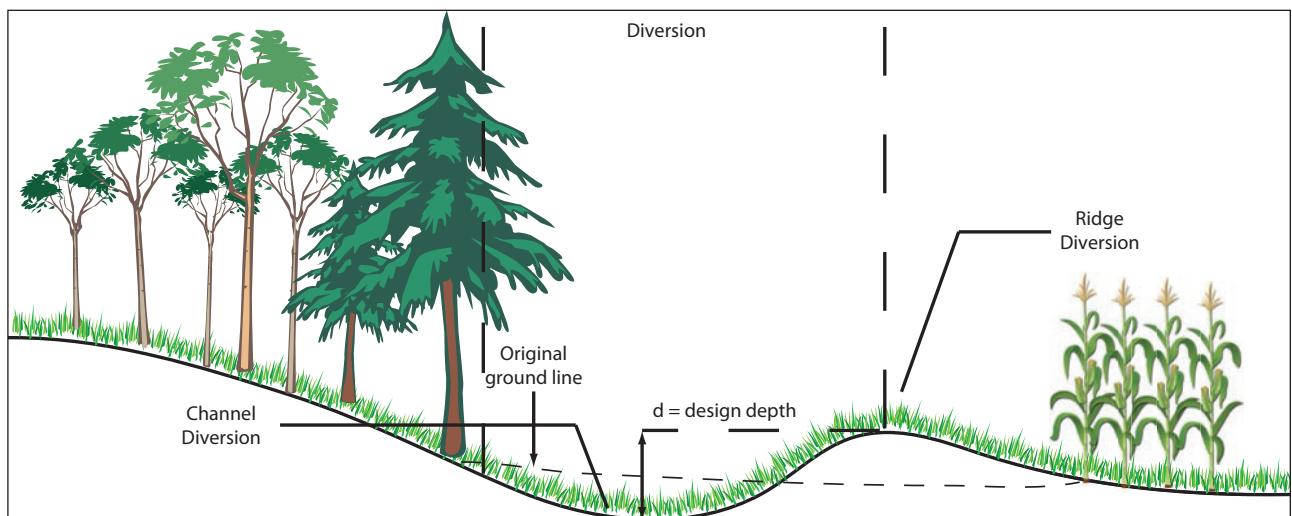


Figure 30. Diagram showing a combination of ridge and channel diversions. Source: NRCS 2009b.

Resources Conservation Service (<http://www.usda.nrcs>).

### **Summary of Runoff Management BMPs**

The use of diversions, field borders, filter strips, and grassed waterways can help control runoff across your property, protect the well-being of your livestock, and minimize the amount of contaminants that reach neighboring bodies or water. Assess your situation and goals, and implement the practices that work best for you.

## **MANURE MANAGEMENT BMPs**

Manure has long been used to improve the soil and to provide nutrients for plants. However, manure contains bacteria and other pathogens that can contaminate waterways and impair livestock and human health. Manure management BMPs minimize pathogens through proper storage, handling, recycling, and disposal techniques.

Livestock can be infected by parasitic roundworms, such as strongyles, from manure. Human diseases can be caused by pathogens such as *E. coli*, *Listeria monocytogenes*, *Salmonella* spp., *Clostridium tetani*, *Giardia* spp. and *Cryptosporidium* spp.

On average, a 1,000-pound lactating dairy cow produces about 80 pounds of manure per day, which adds up to 12 to 14 tons of manure every year (NRCS 1992). If this manure is not properly managed, the bacteria and other contaminants in it can severely impair water quality.

Manure management BMPs include waste treatment lagoons, proper waste utilization, soil testing, nutrient management, and composting.

### **Waste Treatment Lagoon**

A waste treatment lagoon is an impoundment made by building an embankment and/or excavating a pit or dugout to biologically treat waste (Fig. 31). It treats animal wastes and reduces their potential to pollute land and water. These lagoons use biological, physical, and chemical processes to treat wastewater during storage before being dispersed onto crops, pasture, or other types of land (Fig. 32).

Most agricultural treatment lagoons are anaerobic—they treat waste without dissolved oxygen in the wastewater. Anaerobic bacteria digest the organic waste and convert it to carbon dioxide, methane, ammonia, and hydrogen sulfide.

Lagoons typically vary from 6 feet to 20 feet deep. They must be located properly to prevent water contamination and other environmental harm (Table 13).

Waste treatment storage and lagoons, when managed properly, can reduce these bacteria:

- *E. coli*: 97-99 percent (Meals and Braun, 2006)



Figure 31. A waste treatment lagoon on a dairy operation.  
Photo by Lynn Betts, USDA-NRCS.

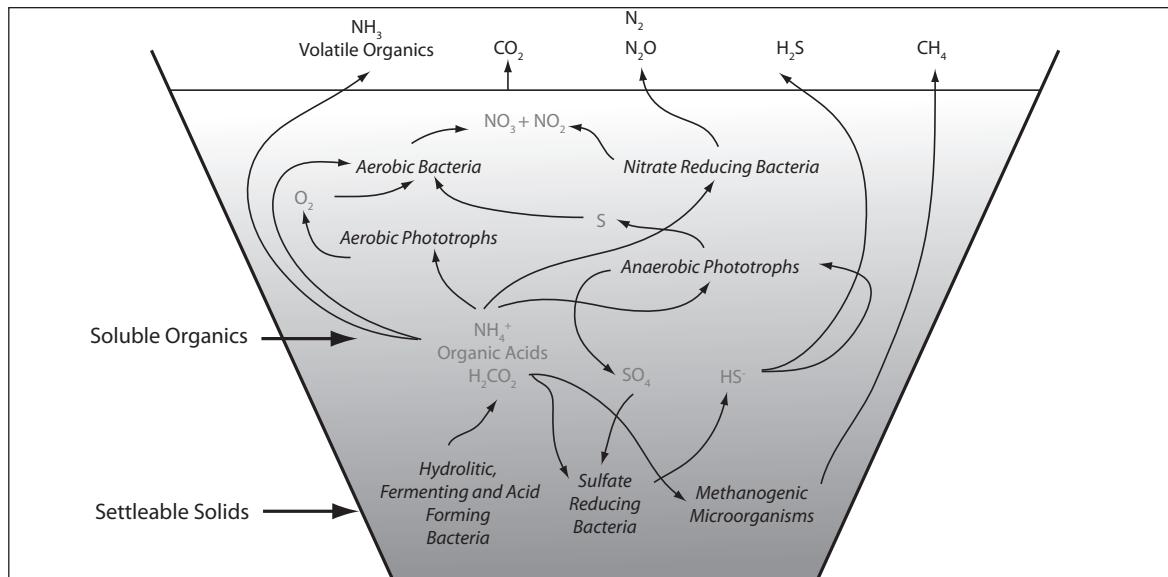


Figure 32. Chemical and biological reactions in a waste treatment lagoon (Hamilton 2011).

- Total coliform: more than 99 percent (Patni et al., 1985)
- Fecal coliform: 44 percent when used in combination with fencing, stream crossings, water troughs, nutrient management, conservation tillage, and grassed waterways (Inamdar et al., 2007)
- Fecal *streptococci*: 46 to 76 percent when used in combination with other management practices
- *Salmonella*: 90 percent

In addition to reducing bacteria levels, waste treatment lagoons also provide these benefits:

- Reduce total solids, total nitrogen, and total phosphorus
- Decrease the viability of weeds
- Enhance the availability of nitrogen and potassium
- Improve soil

The NRCS estimates that a waste treatment lagoon costs \$2.73 a cubic yard to install. This estimate includes the costs

of equipment, installation, maintenance, materials, permits, and operation. Lagoons are designed to last 20 years.

For more information, contact your local AgriLife Extension agent, Soil and Water Conservation District (<http://www.tsswcb.state.tx.us/swcds>), or the NRCS (<http://www.usda.nrccs>).

### Waste Utilization

This BMP concerns the proper use of agricultural wastes such as manure, wastewater, and other organic residues (Fig. 33). Manure is often applied to pastures, cropland, and landscapes because it is a soil conditioner and a good source of plant nutrients (Kelly 2011). Manure applied to pastures and cropland can improve soil structure and fertility. But it must be applied properly to protect water bodies.

On pastures, manure can be spread evenly to a depth of  $\frac{1}{2}$  to 1 inch without suppressing pasture vegetation. On cropland, a 2-inch layer of manure can be applied; to prevent losses of nutrients



Table 13. Minimum distance requirements for waste treatment lagoons.

Public or Private Use Facilities	Minimum Distance from Lagoon
Any public use area or dwelling, church, school, hospital, or park	700 feet
Well, down gradient from lagoon	300 feet
Well, up gradient from lagoon	150 feet
Natural water courses	200 feet
Milking parlor	100 feet
Drainage ditches	100 feet
Area specified by state or local ordinance	Greater of state or local distance or distance shown above.



Figure 33. A manure slurry is applied to this field to help manage the animal waste and to add nutrients to the soil. Photo courtesy of the USDA-NRCS.

and bacteria in runoff, the manure should be incorporated into the soil by shallow disking or harrowing immediately after spreading. In landscaped areas, manure can be used as a mulch to suppress weeds and conserve soil moisture.

The most important aspect of this practice is applying the manure at the proper rate and time to avoid potentially catastrophic water quality problems. Because manure can contaminate rainfall runoff, maintain at least 100 feet of vegetative buffer between water bodies and areas where manure is applied. Also leave a buffer between manured areas and drinking water supplies – 150 feet for private wells and 500 feet for public wells. Calibrate your manure spreader properly to avoid over-application. Apply manure and compost to actively growing pasture in the spring so the plants can use the nutrients efficiently. If the manure is applied during the dormant season, excess nutrients can accumulate in the soil because plants cannot use them.

Studies have shown that runoff has the most bacterial contamination when rain falls within 48 hours of manure application (Mishra and Benham 2008). Therefore, do not apply manure when rain is expected. In areas of high rainfall, or if the manure must be applied in the rainy season, have enough conservation practices in place to keep runoff from entering and contaminating water bodies.

Waste use goes hand in hand with soil testing and nutrient management. To use manure efficiently, you must know the nutrient content of stored manure and obtain a soil test to determine how much of each nutrient your soil needs. Then you can select the correct application rate to ensure that the soil and plants absorb the manure nutrients.



Research has found that after manure is deposited on land through manure application, or directly by animals, approximately 3 to 23 percent of the fecal coliform content is lost in runoff (Robbins et al. 1971). However, applying the waste at the appropriate time and rate will prevent excessive runoff of bacteria, nutrients, and other contaminants, and will protect water quality.

The survival rate of bacteria in animal wastewater applied to crops and pastures depends on pH, soil moisture, temperature, and other environmental factors. One study found that 50 hours of bright sunlight was enough to destroy virtually all fecal coliforms that were in the wastewater when it was applied to the land (Bell and Bole 1976). Other research found that total and fecal coliform numbers declined 10-fold every 7 to 14 days after the waste application (Entry et al. 2000). At about 90 days, total and fecal coliforms had been eliminated.

The NRCS estimates the cost of waste utilization to be \$20.45 per acre (on-farm) to \$44.74 per acre (off-farm). This includes the costs of a soil test, calculating a nutrient budget, record keeping, transport, and application.

Contact the NRCS office at the local USDA Service Center for more information on using waste and financial assistance programs (<http://offices.sc.egov.usda.gov/locator/app>).

### **Soil Testing and Nutrient Management**

These practices involve managing the amount, source, placement, form, and timing of the application of plant

nutrients and soil amendments and require both a soil test and a manure test.

Once you know the nutrient needs of your soil and the nutrient content of the manure, you can calculate a nutrient budget for nitrogen, phosphorus, and potassium that considers all potential sources of nutrients, including manure deposited by the animals, wastewater, commercial fertilizer, crop residues, legume credits, and irrigation water. Then you can determine the amount of stored manure that can be applied safely without the risk that excess nutrients will pollute surface water and groundwater.

Before spreading manure, have the soil analyzed by a laboratory to determine its fertilizer needs and to establish a baseline for future monitoring (Fig. 34). Testing is especially important if manure has been applied to a pasture for many years. Because nutrients such as nitrogen and phosphorus are released over time, a field that has been used for manure disposal may already



Figure 34. A soil sample being placed into a soil sample bag. Photo courtesy of Mark McFarland, Texas AgriLife Extension Service.



have high levels of nutrients and salts (San Francisco Bay Resource Conservation and Development Council 2001).

In Texas, soil sample bags, sampling instructions, and information sheets for mailing samples to the Soil, Water, and Forage Testing Laboratory at Texas A&M University (<http://soiltesting.tamu.edu>) can be obtained from your county Extension office. See Appendix A for information on collecting and sending soil samples.

In addition to a soil test, have a laboratory analyze the manure to determine its nutrient content. This analysis will help ensure that manure application meets but does not exceed plant nutrient requirements.

For example, some of the nitrogen in manure may not be in a form that is immediately available for plant use, or more fertilizer may be needed to supply specific nutrients (San Francisco Bay Resource Conservation and Development Council 2001).

Manure samples also can be sent to the Soil, Water, and Forage Testing Laboratory at Texas A&M University. See Appendix B for information on taking manure samples. More information on manure testing is also available from your county Extension office.

Using soil testing and nutrient management practices on your farm or ranch will help minimize bacterial contamination of waterways by ensuring that the proper amount of manure is applied at the appropriate time. This BMP also helps reduce nutrient contamination, which causes algae blooms and eutrophication (low dissolved oxygen in water). Without laboratory analyses of your soil and manure, it is impossible to know the nutrient

requirements of your soil and the nutrient and bacterial composition of your manure. Thus, the over-application of manure becomes a real concern.

When manure is applied according to soil test recommendations, it can offset the cost of fertilizer, improve plant growth and animal health, minimize nonpoint source pollution of surface and groundwater, protect air quality by reducing nitrogen emissions (ammonia and nitrous oxide compounds) and the formation of atmospheric particulates, and maintain or improve the physical, chemical, and biological condition of soil.

A routine soil analysis can be obtained for as little as \$10 per sample from the Texas AgriLife Extension Service Soil, Water, and Forage Testing Laboratory at Texas A&M University. The laboratory also does other soil analyses (Table 14). A manure analysis costs \$15 per sample. This test analyzes levels of calcium, copper, magnesium, manganese, nitrogen, phosphorus, potassium, sodium, zinc, and percent moisture.

### Composting

Many farmers, ranchers, and landowners spread manure straight to the land after removing it from the housing, either because of inadequate storage capacity or simply for convenience. This practice can be harmful because fresh manure contains more pathogens than does stored or treated manure (Smith et al. 2000).

A good option for dairymen is to compost manure. Composting reduces the volume of the material and makes it more useful on-site (Fig. 35). Composting is a managed process that accelerates the decomposition and conversion of organic matter into stable



Table 14. Description and costs of soil tests available through the Texas AgriLife Extension Service Soil, Water, and Forage Testing Laboratory at Texas A&M University.

Test	Description	Cost per Sample
Routine Analysis (R)	pH, NO <sub>3</sub> -N, Conductivity and Mehlich III by ICP P, K, Ca, Mg, Na, and S.	\$10
R + Micronutrients (Micro)	DTPA Zn, Fe, Cu, and Mn.	\$15
R + Micro + Hot Water Soluble Boron (B)	Primarily for sandy or eroded soils, low in organic matter for the crops, alfalfa, cotton, peanuts, and root crops.	\$20
R + Detailed Salinity (Sal)	Saturated paste extractable Ca, Mg, K, Na, conductivity and pH	\$25
R + Micro + Sal	See above.	\$30
R + Micro + Detailed Limestone Requirement (Lime)	The limestone recommendation is based on the amount of exchangeable acidity measured in the soil and the optimum soil pH level for the crop.	\$20
R + Micro + B + Lime + Organic Matter + Sal	This analysis gives the percent organic matter in soil or compost determined by the loss on ignition. Most plants do best in soils with organic matter contents between 4 and 8 percent. Finished composts usually range from 40 to 60 percent organic matter.	\$50
R + Textural Analysis	The total amounts of sand, silt, and clay sized particles are determined. Soils are categorized according to USDA soil textural classifications.	\$20
R + Organic Matter	See above.	\$20

humus, which can improve pastures, fields, and/or gardens.

Composting cattle manure can take 30 to 60 days; adding bedding to the manure may require as long as 6 months to compost. Although composting requires extra time and expense, the benefits far outweigh the costs.

Successful composting depends on the following factors (Warren and Sweet 2003):

**1. Air:** Microorganisms need oxygen to decompose manure properly. Therefore, manure should be combined with bulkier materials such as wood shavings, lawn clippings, straw bedding, or hay.

**2. Moisture:** Microorganisms also need moisture. The composting material should have about 50 percent moisture.

**3. Particle size:** Because small particles decompose faster than do larger ones, shred bulky materials before adding them to the compost pile.

**4. Temperature:** Effective composting requires temperatures of 131 to 149°F.

**5. Pile size:** Smaller compost piles stay cooler and dry out faster than larger ones. A pile at least 3.5 by 3.5 by 3.5 feet (1 cubic meter) will stay hot enough for year-round composting, even in the winter.



Figure 35. Multiple bin compost system. Photo courtesy of O<sub>2</sub> Compost.

- 6. Nutrients:** Microorganisms need nutrients such as carbon and nitrogen for proper decomposition. The ideal carbon-to-nitrogen ratio (C:N) for effective composting is about 30:1. A mixture of one part manure to two parts bedding (by volume) will usually provide this ratio, although it can be altered depending on the amount and type of bedding material used (Table 15).

An on-farm composting system can be designed in several ways, and no single design is appropriate for all sizes and types of dairy facilities. Tailor your composting system to accommodate the number of livestock, the space and equipment available, and the amount of time and effort you will commit to managing the pile.

To protect water quality, the most important factor to consider is the physical location of the pile. Select a fairly flat site, avoid low-lying areas, and locate the pile away from

groundwater and surface water sources.

Composting can effectively reduce pathogens to levels that are acceptable in organic soil amendments. When the temperature of a compost pile is at least 113°F for more than 3 days, almost 100 percent of *E. coli*, total coliform, fecal coliform, and *Salmonella* will be killed (Crohn et al. 2000, Larney et al. 2003, Millner et al. 2010, Sobsey et al. 2001). Reduce management and increase pathogen die-off by adding straw to the pile, which increases aeration, self-heating capacity, and heat retention (Millner et al. 2010).

Besides eliminating bacteria, composting manure reduces levels of ammonia-nitrogen, water-soluble phosphorus, water-soluble organic matter, total soluble salts, weed seeds, and parasite eggs and larvae. It also reduces odor and

Table 15. Carbon to nitrogen ratios for manure and bedding materials (Warren and Sweet 2003).

Material	C:N Ratio
Raw dairy manure	10-15:1
Grass clippings	25:1
Dairy manure with bedding	20-30:1
Grass hay	30-40:1
Straw	40-100:1
Paper	150-200:1
Wood chips, sawdust	200-500:1

\* C:N ratios represent comparative weights. For example, 20 pounds of dairy manure would contain 1 pound of nitrogen, while 500 pounds of sawdust would contain 1 pound of nitrogen. To estimate the C:N of a mixture, average the ratios of the individual materials. For example, a mixture of equal parts dairy manure and straw might have a C:N of 30:1 ((20 + 40)/2 = 30).



breeding sites for flies. Composted manure has 40 to 50 percent less volume than does fresh manure. It is an excellent soil amendment that can be used on the ranch or given or sold to others.

The cost of constructing a compost facility depends on its size and the materials used. According to the NRCS, a 6-bin composter with 1,440 cubic feet of bin space costs about \$19.74 per cubic foot to build, operate, and maintain (including materials and labor). For more information on composting and financial assistance programs, contact the NRCS office at the local USDA Service Center (<http://offices.sc.egov.usda.gov/locator/app>).

**Summary of Manure Management BMPs**  
Proper manure management should be an important concern for every livestock owner. Manure must be stored, handled, recycled, and disposed of properly to protect water quality and keep animals, people, and the surrounding environment healthy.

Storing manure, applying it to land at the proper rate and time according to soil and manure tests, and composting it are all responsible ways to control the spread of pathogens to groundwater and surface water. As always, assess your situation and goals, and implement the practices that work best for you and your land.

## MORTALITY MANAGEMENT BMPs

Animal mortality must be managed to protect the health of people, animals, and the environment (Gould et al. 2002), so it is important to know your options and plan ahead. Disposing of carcasses properly

reduces odors, bacterial contamination, and the spread of disease. Mortality management will provide the following benefits:

- Less pollution of groundwater and surface water.
- Reduced odors from improperly handled carcasses.
- Reduced damage to crops and forages.
- Decreased risk of diseases spreading to animals feeding on the carcass.
- Provide contingencies for normal and catastrophic mortality events.

Large numbers of animals can die from a disease epidemic or natural disaster, but these events are rare. This section focuses on the normal, day-to-day deaths from illness or injury that every operation must deal with. Several methods discussed may be applicable to the management of large-scale mortalities if scaled appropriately and conducted under the guidance and supervision of pertinent state and environmental agencies. See Appendix C for information from the TCEQ regarding the disposal of domestic and exotic livestock carcasses.

The on-farm disposal of dead animals should always be done in a manner that protects public health and safety, does not create a nuisance, prevents the spread of disease, and prevents harm to water quality (TCEQ 2005). To determine the requirements for using any of the following options, contact the local regulatory agency (in Texas, the TCEQ or the Texas Animal Health Commission).

Acceptable ways for managing mortality include the following methods (Gould et al. 2002):

1. Rendering
2. Composting
3. Incineration
4. Sanitary landfills
5. Burial

### Rendering

Rendering recycles the nutrients contained in the carcasses of dead animals, most often as an ingredient in animal food, especially for pets. The meat can also be used to feed large carnivorous animals in zoos. In the process of rendering, carcasses are exposed to high temperatures (about 265°F) from pressurized steam to destroy most pathogens (Rahman et al. 2009).

The rendering market has changed in recent years because of the falling prices of meat and bone meal and concerns over bovine spongiform encephalopathy (BSE, or mad cow disease). In Texas, a person must be licensed by the state to pick up dead animals for rendering. There are a handful of rendering facilities in Texas, and most require that animals be removed within 24 hours of death.

Depending on the distance to the facility, the cost of rendering ranges from \$25 to about \$200 per animal. Proper biosecurity measures must be used to minimize the spread of disease from farm to farm by rendering plant vehicles and personnel.

For a list of rendering facilities in Texas, visit <http://nationalrenderers.org>.

Although rendering can be a cost-effective way of dealing with a livestock carcass, it might not be an option for all livestock owners. The biggest challenges in using this disposal method are the lack of timely pickup service and long distances between

rural areas and rendering plants (Rahman et al. 2009). In many areas, the numbers of rendering facilities are limited and in many cases are declining due to increased costs and biosecurity risks associated with transporting mortalities (Glanville et al. 2009).

### Composting

Composting uses the natural decomposition process in which microorganisms, bacteria, and fungi break the carcass down into basic elements (organic matter). The biosecurity agencies in the United States and other countries consider composting an effective way of managing routine and emergency mortalities (Wilkinson 2007).

Composting has advantages over other methods of carcass disposal when conducted properly. It costs less; the piles and windrows are easy to prepare with machinery available on the farm; and it is less likely to pollute air and water. Proper composting will destroy most disease-causing bacteria and viruses. Composting is popular in areas where burial and incineration are restricted or impractical.

To compost a carcass, select a site where surface water will not run off into the compost pile, where leachate from the pile will not run off the site, and where raw or finished compost nutrients will not leach into groundwater.

Other requirements (Gould et al. 2002):

- The carbon-to-nitrogen ratio must be between 15:1 and 35:1.
- The moisture content must be between 40 and 60 percent.
- Enough oxygen must be available to maintain an aerobic environment.
- The pH must range from 6 to 8.



- Temperatures must range between 90 and 140°F.

Large carcasses can be composted in bins or static windrows (Keener et al. 2000). Bins are three-sided compartments; compost material is cycled through the bins as different decomposition stages are reached.

Windrows are long, continuous rows of compost material. For large animals, pile or windrow composting is usually easier and more effective. In this practice, the compost pile or windrow is constructed in the open on a concrete floor or a compacted soil surface such as clay. The pile is aerated by natural air movement and is turned periodically to encourage decomposition. The cost of composting a whole animal is about \$4 per carcass (Looper 2007).

### **Incineration**

Incineration destroys carcasses by burning them with fuel such as propane, diesel, or natural gas. The incineration of a 1,000-pound animal can cost from \$600 to \$1,000, depending on the location and current price of fuel.

Despite the relatively high cost, incineration/cremation is one of the most environmentally friendly ways to dispose of a carcass. Air and water quality are protected because of strict state and federal environmental regulations that apply to incinerators. The remaining ashes pose no environmental threat and can be returned to the owner for burial or sent to a landfill for disposal.

Burning carcasses in a pit on site also is an acceptable method of disposal in Texas. Open-pit or open-pile burning should be a method of last resort, however. Make sure that personnel and property will be safe,

and choose a proper location away from public view.

According to the TCEQ, burning must take place downwind of or at least 300 feet from occupied structures. If possible, the burning must take place during the day when winds are 6 to 23 mph. It must be monitored closely, and all burning must be completed on the same day.

Incineration may actually be required for certain disease diagnosis and may not be available due to burn bans or air quality restrictions.

### **Sanitary Landfills**

Landfills are an alternative to burial. However, not all municipal landfills accept animal carcasses. Some landfills that accept livestock carcasses will not take the remains of a chemically euthanized animal.

The cost is usually about \$80 to \$150. Contact your local landfill for more information.

### **Burial**

Although burial is a common method of carcass disposal, it can harm surface water and groundwater if done improperly. According to the TCEQ, the burial site should not be located in an area with a high water table or with very permeable soils.

For example, areas with sandy or gravelly soils and a shallow groundwater table must not be used as burial sites. Furthermore, animals should be buried at least 300 feet from the nearest surface water, at least 300 feet from the nearest drinking water well, and at least 200 feet from adjacent property lines.



A backhoe will be needed to dig a hole at least 6 feet deep. Renting a backhoe costs \$100 to \$200.

Texas law requires notification 48 hours prior to any excavation to assure utilities are properly marked. To locate all your utility services before you dig, call 1-800-dig-tess. In addition, deeds must be marked with burial sites according to TCEQ as well. Most studies on pathogen reduction and mortality management have focused on composting and incineration. The key is to maintain temperatures that are high enough to eliminate pathogens. Composting controls nearly all pathogenic viruses, bacteria, fungi, and protozoa (Wilkinson 2007).

Potential bacterial reductions with proper mortality management: Most studies on pathogen reduction and mortality management have focused on composting and incineration. The key is to maintain temperatures that are high enough to eliminate pathogens. Composting controls nearly all pathogenic viruses, bacteria, fungi, and protozoa (Wilkinson 2007).

Bin and static pile composting systems can dramatically reduce bacteria levels: A study by Mukhtar et al. (2003) found that even with little maintenance of the piles, levels of *Salmonella* and fecal coliform bacteria were almost undetectable after 9 months. The study concluded that a low-maintenance bin-composting operation can successfully dispose of livestock carcasses and bedding in temperate climates during seasons of normal precipitation.

Other studies of horse, deer, cow, and other animal carcass composting have found similar results (Sander et al. 2002, Jones and Martin 2003, Blake 2004, Schwarz et al. 2008).

### **Summary of Mortality Management BMPs**

When deciding on a disposal method for your livestock, consider your emotional and financial needs and carefully research local regulations. By weighing all aspects of the various options in advance, you will be prepared with a method that is both humane and environmentally responsible. Of utmost importance is disposing of the animal carcass correctly to avoid environmental, health, or legal problems.



## CHAPTER 3

### SOURCES OF TECHNICAL AND FINANCIAL ASSISTANCE FOR BMP IMPLEMENTATION

## SOURCES OF TECHNICAL ASSISTANCE FOR BMP IMPLEMENTATION

Many agencies offer free consultations on issues you may be facing or plans you would like to implement. These agencies also routinely conduct free seminars and short courses on current information and management practices in agriculture. The agencies include the local Soil and Water Conservation District, the Texas State Soil and Water Conservation Board, the USDA-Natural Resources Conservation Service, and the Texas AgriLife Extension Service.

### **Soil and Water Conservation Districts**

Soil and Water Conservation Districts are independent political subdivisions of state government, like a county or school district. The first SWCDs in Texas were organized in 1940 in response to the widespread agricultural and ecological devastation of the Dust Bowl of the 1930s. There are currently 216 SWCDs organized across the state. Each SWCD is governed by five directors elected by landowners within the district.

SWCDs serve as the state's primary delivery system through which technical assistance and financial incentives for natural resource conservation programs are channeled to agricultural producers and rural landowners. SWCDs work to bring about the widespread understanding of the needs of soil and water conservation. SWCDs work to combat soil and water erosion and enhance water quality and quantity across the state by giving farmers and ranchers the opportunity to solve local conservation challenges. SWCDs instill in landowners and citizens a stewardship ethic and individual responsibility for soil and water conservation.

SWCDs assist federal agencies in establishing resource conservation priorities for Federal Farm Bill and CWA programs based on locally-specific knowledge of natural resource concerns. SWCDs work with the USDA NRCS, USDA Farm Service Agency, USEPA, Texas AgriLife Extension Service, TFS, and others when necessary to assist landowners and agricultural producers meet natural resource conservation needs.

### **Texas State Soil and Water Conservation Board**

The Texas State Soil and Water Conservation Board (TSSWCB) offers technical assistance to the state's 216 SWCDs. The TSSWCB was created in 1939 by the Texas Legislature and is the lead agency in Texas for planning, implementing, and managing programs and practices to reduce agricultural and silvicultural nonpoint source pollution.

The primary means for achieving this goal is through water quality management plans (WQMPs), which are site-specific plans developed through and approved by SWCDs for agricultural or silvicultural lands. Five regional offices (Fig. 36) help local districts and landowners develop these plans.

The TSSWCB also works with other state and federal agencies on nonpoint source pollution issues as they relate to the state water quality standards, Total Maximum Daily Loads, Watershed Protection Plans, and the Coastal Management Plan.

### **Natural Resources Conservation Service**

The USDA Natural Resources Conservation Service (NRCS), a federal agency, helps landowners and managers improve and protect their soil, water, and other natural



resources. For decades, private landowners have voluntarily worked with NRCS specialists to prevent erosion, improve water quality, and promote sustainable agriculture.

The agency employs soil conservationists, rangeland management specialists, soil scientists, agronomists, biologists, engineers, geologists, engineers, and foresters. These experts help landowners develop conservation plans, create and restore wetlands, and restore and manage other natural ecosystems.

### Texas AgriLife Extension Service

The mission of the Texas AgriLife Extension Service is to provide community-based education to Texans. Its network of 250 county Extension offices, 616 Extension agents, and 343 subject-matter specialists makes expertise available to every resident in every Texas county. These specialists and agents are a technical resource for agricultural producers throughout the state.

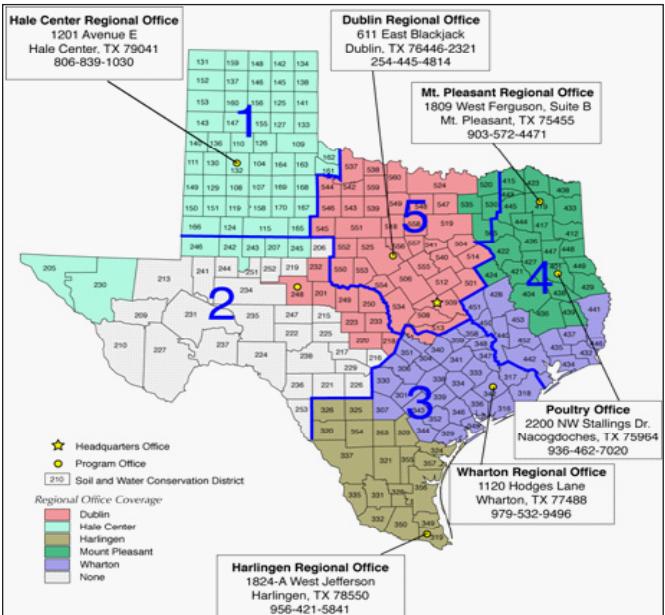


Figure 36. Map showing the five regions of the Texas State Soil and Water Conservation Board. Illustration courtesy of the Texas State Soil and Water Conservation Board.

## SOURCES OF FINANCIAL ASSISTANCE FOR BMP IMPLEMENTATION

Financial assistance for implementing BMPs is provided primarily through the Texas State Soil and Water Conservation Board, Natural Resources Conservation Service, and USDA Farm Service Agency.

### Texas State Soil and Water Conservation Board

In addition to technical assistance, the TSSWCB can also offer financial assistance for the implementation of BMPs. Two programs offered by the TSSWCB provide financial assistance for the implementation of water quality management plans (WQMP) and the installation of BMPs:

- **Water Quality Management Plan Program:** Provides financial assistance to eligible landowners for WQMP implementation of up to 75 percent with a maximum of \$15,000 per plan. Landowners and operators may request the development of a site-specific water quality management plan through local SWCDs. Plans include appropriate land treatment practices, production practices and management and technology measures to achieve a level of pollution prevention or abatement consistent with state water quality standards.
- **The Clean Water Act Section 319(h) Nonpoint Source Grant Program:** The U.S. Environmental Protection Agency distributes CWA 319 funds to state agencies involved in water quality management (in Texas, the TCEQ and TSSWCB). This assistance provides funding for various types of projects that work to reduce nonpoint source water pollution. Funds may be used to conduct assessments, develop and implement



TMDLs and watershed protection plans, provide technical assistance, demonstrate new technology, and provide education and outreach.

### Natural Resources Conservation Service

The Environmental Quality Incentives Program (EQIP) is the primary program offered by the NRCS for implementing BMPs.

EQIP is a voluntary conservation program that supports production agriculture and environmental quality. The program provides financial assistance to farmers and ranchers to implement BMPs. It is designed to address both locally identified resource concerns and state priorities. In FY 2011, the Texas allocation for EQIP was just under \$58 million.

The amount of funding available for EQIP varies among counties. To be eligible for this program, a person must be involved in livestock or agricultural production and develop a plan of operations. This plan defines the objective to be achieved by the conservation practice proposed and a schedule of practice implementation. Applications are then ranked by the environmental benefits achieved and the cost effectiveness of the proposed plan.

The NRCS also offers other programs for BMP implementation:

- The Conservation Security Program provides financial and technical assistance to promote conservation and natural resource improvement.
- The Grassland Reserve Program is a voluntary program that helps landowners and operators restore and protect grassland.

- The Wetlands Reserve Program provides technical and financial support for landowners restoring wetlands.
- The Wildlife Habitat Incentives Program offers financial incentives to develop habitat for fish and wildlife on private lands.

For more information, see the NRCS website at <http://www.nrcs.usda.gov/>.

### USDA Farm Service Agency

The Farm Services Agency administers several programs that can help in BMP implementation, including the Conservation Reserve Program, Conservation Reserve Enhancement Program, and Source Water Protection Program.

Conservation Reserve Program: This program provides annual rental payments and financial assistance to establish long-term, resource-conserving ground covers on eligible farmland. It helps agricultural producers safeguard environmentally sensitive land through practices that improve the quality of water, control soil erosion, and enhance wildlife habitat.

After enrollment, the agency will pay an annual per-acre rental rate and provide up to 50 percent cost-share assistance for practices that accomplish the above goals. The portions of property to be submitted to the program will be under contract for 10 to 15 years and cannot be grazed or farmed.

To be eligible for the program, agricultural producers must have owned or leased the land for at least 1 year before the application. Also, the land submitted must be suitable for these BMPs:

- Riparian buffers
- Wildlife habitat buffers



- Wetland buffers
- Filter strips
- Wetland restoration
- Grass waterways
- Contour grass strips

#### Conservation Reserve Enhancement

Program: This voluntary land retirement program helps agricultural producers protect environmentally sensitive land, decrease erosion, restore wildlife habitat, and safeguard ground and surface water.

Source Water Protection Program: This program helps prevent source water pollution through voluntary practices implemented by producers at the local level.

## CONCLUSION

Texas is projected to have exponential population growth in the near future.

Concurrently, our water supply is projected to decline, making water conservation and protection all the more important. As the population increases, more development and fragmentation of large tracts of land are expected. This trend will contribute to runoff and decrease the ability of our land

to filter it effectively. Increasing numbers of bacteria will continue to find a way into our surface waters as more livestock are applied to the land whether for recreational or commercial purposes.

This guide is primarily focused on the contribution to nonpoint source pollution from dairies, but there are other sources such as wastewater treatment facilities, failing septic systems, and urban runoff that contribute to water quality impairments as well. This confirms the need to educate all aspects of society on the importance of maintaining and conserving the quality of water necessary for good health.

As discussed, there are many important aspects to animal care that extend beyond simply owning and feeding livestock. Controlling runoff, managing manure, and maintaining pasture and facilities can take a considerable amount of time and effort, but result in far more benefits not only to the animal and operation, but to the surrounding land. The collective impact of mismanagement of dairy facilities can be environmentally harmful. The management practices that minimize these impacts will result in a farm that is healthy, saves money, and is aesthetically pleasing.

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## ADDITIONAL RESOURCES

- Animal Waste Management*: L-5043, Texas AgriLife Extension Service.
- Biosecurity Practices for Dairy Operations*: B-6213, Texas AgriLife Extension Service.
- Dairy Biomass as a Renewable Fuel Source*: L-5494, Texas AgriLife Extension Service.
- Dairy Outreach Training and Continuing Education Program*: E-14, Texas AgriLife Extension Service.
- Feeding Waste Milk to Dairy Calves*: L-5391, Texas AgriLife Extension Service.
- Improving Air Quality of Animal Feeding Operations with Proper Facility and Manure Management*: E-585, Texas AgriLife Extension Service.
- Low Stress Cattle Handling in Dairy Environments*: E-568, Texas AgriLife Extension Service.
- Managing Milk Composition: Evaluating Herd Potential*: L-5387, Texas AgriLife Extension Service. *Measuring the Effect of Organic Residuals on Water Quality*: E-248, Texas AgriLife Extension Service.
- Monitoring Feed Efficiency in Dairy Herds*: L-5296, Texas AgriLife Extension Service.
- Routine and Emergency Burial of Animal Carcasses*: E-599, Texas AgriLife Extension Service
- Silage Production and Feeding for Dairy Cattle*: L-2417, Texas AgriLife Extension Service.
- Technologies for Reducing Nutrients in Dairy Effluent*: B-6196, Texas AgriLife Extension Service.
- Tracking Dairy Efficiency*: L-5195, Texas AgriLife Extension Service.

## APPENDIX A

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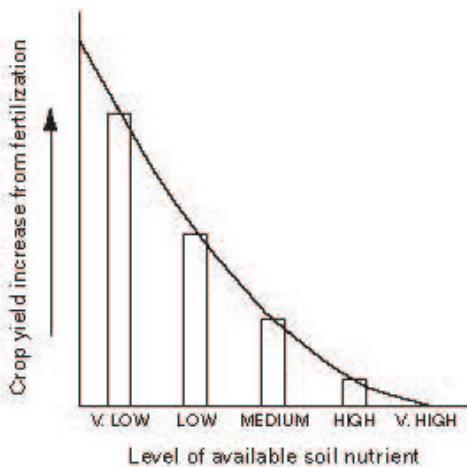
# TESTING YOUR SOIL

## How to Collect and Send Samples

T. L. Provin and J. L. Pitt\*

**S**oil tests can be used to estimate the kinds and amounts of soil nutrients available to plants. They also can be used as aids in determining fertilizer needs. Properly conducted soil sampling and testing can be cost-effective indicators of the types and amounts of fertilizer and lime needed to improve crop yield.

The effects of adding a fertilizer often depend on the level of nutrients already present in the soil (Fig. 1). If a soil is very low in a particular nutrient, yield will probably be increased if that nutrient is added. By comparison, if the soil has high initial nutrient levels, fertilization will result in little, if any, increase in yield.



**Figure 1.** The probability of a crop yield increase resulting from fertilization depends on the initial amount of available nutrients in the soil.

\*Assistant Professor and Soil Chemist/Laboratory Director, Program Specialist-Laboratory Manager, Soil, Water, and Forage Testing Laboratory, The Texas A&M System.

There are three steps involved in obtaining a soil test:

- 1) obtain sample bags and instructions,
- 2) collect composite samples,
- 3) select the proper test, and complete the information sheet and mail to the Soil, Water, and Forage Testing Laboratory at 2478 TAMU, College Station, TX 77843-2478 for U.S. mail or 2610 F&B Road, College Station, TX 77845 for commercial deliveries. Contact the lab at (979) 845-4816, FAX (979) 845-5958, or at the Web site <http://soiltesting.tamu.edu> for additional information.

### Obtain sample bags and instructions

**C**ounty Extension offices provide soil sample bags, sampling instructions and information sheets for mailing samples to the Soil, Water, and Forage Testing Laboratory of the Texas Agricultural Extension Service.

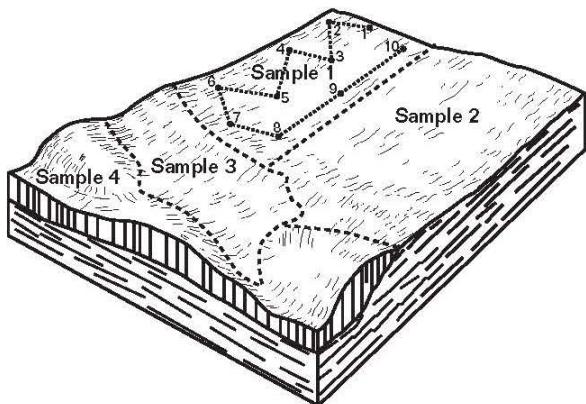
Sample bags provided by the Extension service hold a sufficient amount of soil for use in most soil tests. Fill the sample bag or other suitable container with approximately 1 pint of a composite soil sample. Any suitable container can be used for the sample, but it is important to complete the information sheet and follow the instructions for collecting and mailing samples.

### Collect composite samples

**T**he objective in sampling is to obtain small composited samples of soil that represent the entire area to be fertilized or limed. This composited sample is comprised of 10 to 15 cores or slices of soil from the sampling area.



To sample a field or pasture, make a map that identifies each area in the field where subsamples were taken (Fig. 2). Fields or tracts of land with differences in past cropping, fertilization, liming, soil types or land use will require several composite samples. The field identification map should be used each time samples are collected from that field to compare results over time.

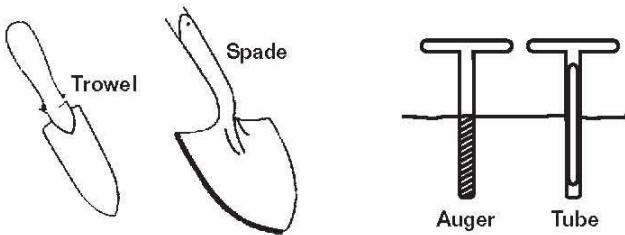


**Figure 2.** Fields should be subdivided into sampling units as needed and a composite sample should be collected from each unit.

Factors that will affect results include sampling tools, number of subsamples, depth of sampling, and soil compaction and moisture.

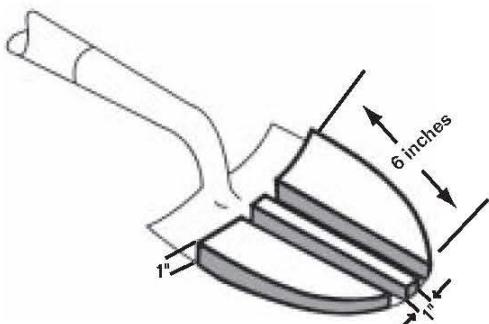
#### ***Sampling tools***

Several tools can be used to collect samples (Fig. 3). The choice depends on soil conditions and sampling depth.



**Figure 3.** These tools can be used to collect soil samples.

The selected tool must be able to cut a slice or core through the desired layer of soil as illustrated in Figure 4. The objective is to obtain a cross section of the plowlayer or layer being subsampled.



**Figure 4.** Collect a slice or core of soil to the desired depth.

#### ***Number of samples***

In fields up to 40 acres, collect at least 10 to 15 cores or slices of soil per composite sample. Composite samples should represent the smallest acreage that can be fertilized or limed independently of the remaining field or acreage.

The development of precision agriculture has allowed some producers and fertilizer suppliers to manage soil fertility levels on 1- to 3-acre parcels. In small gardens and lawns, five to six cores may be adequate. Because soils are variable, it is important to obtain enough subsample to ensure a representative composite sample. A greater number of cores makes the sample more representative of the field.

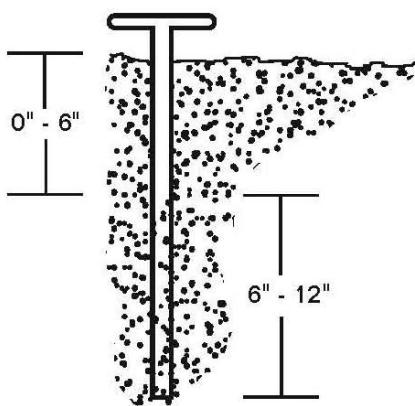
Unusual problem areas should be omitted or sampled separately. To properly diagnose the causes of poor crop production, collect separate composite samples from the good and poor growth areas. Do not include soil from the row where a fertilizer band has been applied.

#### ***Depth of sample***

Traditionally, soil samples are collected to a depth of 6 inches. This depth is measured from the soil surface after non-decomposed plant materials are pushed aside. This sampling depth can be significantly altered based on tillage or fertilization practices.

Stratification (accumulation at the surface) of phosphorus and lime from prior surface applications can dramatically alter soil test data. Stratification is of particular concern in reduced tillage and nonirrigated fields that receive limited rainfall. In these instances, subsurface sampling depths may vary from 2 to 8 inches or 3 to 9 inches below the surface. Also, deviations from the traditional 6-inch sampling depth may be required if fertilizer has been placed deeper in the soil.

Deep rooted perennial crops can require deeper subsurface sampling. The slow movement of most plant nutrients prevents any dramatic manipulation of subsurface nutrient levels, however sampling data can be useful to assess pH or salinity problems. Subsurface sampling is illustrated in Figure 5.



**Figure 5.** A sampling tube or auger is needed to collect subsurface samples.

When sampling perennial sod crops, sample to a depth of 4 inches. Discard the surface  $\frac{1}{2}$  inch of soil before mixing the subsamples. Use this sampling method in all established lawns, golf greens and similar turf applications.

The Texas Natural Resource Conservation Commission (TNRCC) requires extensive soil sampling for some land uses. Individuals sampling soil for TNRCC compliance should follow TNRCC protocols and directions.

### Select the proper test

Several different soil tests are available at the Extension Soil, Water, and Forage Testing Laboratory. These include tests for routine nutrients, micronutrients, boron, detailed salinity, lime requirement, texture and organic matter. After taking the soil sample, select the appropriate test to obtain the desired information.

The **routine** test determines the soil pH, salinity, nitrates ( $\text{NO}_3\text{-N}$ ), and levels of the primary nutrients (P - phosphorus, K - potassium, Ca - calcium, Mg - magnesium, Na - sodium, and S - sulfur) available to plants. The routine test will provide the basic N-P-K fertilizer recommendation for selected crops. This test meets most application needs.

The **micronutrient** test estimates the levels of zinc (Zn), iron (Fe), manganese (Mn) and copper (Cu) in the soil that are available to plants. Conduct this test for specialty crops, in soils with high pH on which corn or sorghum is being grown, or to provide general guidelines for troubleshooting deficiencies.

The **boron** test determines the level of water extractable boron (B) in the soil. Conduct the test where clover, alfalfa or other legumes are grown on sandy soils or when soils are being irrigated and water quality is of concern.

The **detailed salinity** test uses a saturated paste extract to measure the pH, electrical conductivity and water soluble levels of the major cations in the soil. From these levels, the Sodium Adsorption Ratio (SAR) is calculated. Conduct this test when water quality is of concern; in soils in the western part of the state where the rate of evaporation or transpiration exceeds the rainfall; when previous soil tests have shown an increase in sodium or salinity; or in areas where brine and salt water spills have occurred. Some TNRCC permits also may require a detailed salinity test.

The **lime** requirement determines the amount of lime needed to raise the soil pH to a desired level. This determination is needed on very acidic ( $\text{pH} < 5.2$ ) or acidic soils ( $\text{pH} < 6$ ) where alfalfa or other legumes are grown.

**Texture and organic matter** are specialty tests for specific applications. The texture determines the amount of sand, silt and clay in the soil. This test may be requested when installing a septic system. The organic matter may be requested for general information. Both tests often are requested for environmental or research purposes.

The information form, obtained from the county Extension office, requests information about soil conditions, acreage sampled, past cropping, fertilization and an estimate of the expected yield. All information is important in relating soil test results to suggested fertilization and liming. The expected yield is an indication of intended management, past production levels and local environmental factors that control yields. Uncontrolled production factors such as nematodes and disease should be considered in estimating a yield goal or expected yield. In areas where samples are collected from problem fields, the condition of plants should be described along with observations that would aid in relating soil test results to the problem.



Soil samples should not be stored for long periods of time prior to shipping to the laboratory. The levels of nitrate-nitrogen in the soil may change if the samples are stored wet. In addition, the nitrate-nitrogen data from properly dried samples may be of little value if environmental conditions and plant growth have altered levels in the soil. Air drying samples in the shade on clean brown paper is strongly recommended. Do not oven dry the samples because high drying temperatures can alter test results.

Instructions for mailing are provided with the sampling instructions. The fee for each sample should be noted and payment should accompany the samples. The information sheet and payment should be attached to the sample package. Between 5 and 7 days are required to obtain results for routine analyses from the laboratory. In-depth analyses of samples require additional testing and processing time. Therefore, it is important to conduct sampling early in the season. This will ensure that test results are available in time to make necessary fertilizer and lime applications.

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## APPENDIX B



Soil, Water and Forage Testing Laboratory  
Department of Soil and Crop Sciences

### Manure and Effluent Sample Collection

#### **Manure and litter samples**

- Collect at least 5, and preferably 10, subsamples from piles. Be sure to sample throughout the pile, not just the outside surface.
- Mix subsamples thoroughly in clean plastic bucket.
- Transfer sample to suitable container (see below).
- Label sample container using a permanent marker.
- Separate samples should be taken for each type or age of manure and litter.

#### **Effluent samples**

- Collect at least 5, and preferably 10, subsamples from the lagoon.
- Sample the lagoon using a plastic cup (8 ounce) secured to an aluminum rod (6 to 10 feet long).
- Samples collected with depth will better represent effluent.
- Collect subsamples and mix in clean plastic bucket.
- Transfer sample to suitable container (see below).
- Label sample container using a permanent marker.
- Separate samples should be taken for each lagoon.

#### **Sample containers**

- Biosolids, manure and litter samples should be collected in sealable plastic bags.
- Liquid samples (i.e., lagoon or effluent samples) should be collected in plastic bottles (16 ounce) with at least 50% headspace. Failure to provide adequate headspace may result in rupture of container.
- Do not use cola bottles or other containers containing phosphorus or nutrients to be analyzed.

## APPENDIX C

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

# Disposal of Domestic or Exotic Livestock Carcasses

RG-419, PDF version  
(revised 3/05)

This document is a summary of suggested guidelines from the Texas Commission on Environmental Quality (TCEQ) and the Texas Animal Health Commission (TAHC) for disposal of farm or ranch animals.

This document does not explain requirements that apply to veterinarians or commercial chicken or duck operations. For information about chicken or duck carcass disposal, see TCEQ publication RG-326, How to Dispose of Carcasses from Commercial Chicken or Duck Operations.

For rules that apply to veterinarians disposing of carcasses, refer to Title 30 Texas Administrative Code (30 TAC) Section 111.209(3).

By planning in advance how you will dispose of carcasses, your facility will be better prepared to deal with environmental and health issues. Emergency cases may be handled differently. Contact your regional TCEQ office in the event of an emergency.

## Why is disposal of carcasses regulated?

On-farm disposal of dead animals should always be done in a manner that protects public health and safety, does not create a nuisance, prevents the spread of disease, and prevents adverse effects on water quality.

## Who is responsible for making sure the carcasses are properly disposed of?

The owner or operator of the farm or facility is responsible for disposal in a timely and sanitary manner. Please be aware that under 30 TAC Section 335.4 this means there can be no discharge into or adjacent to waters in the state. There can be no creation or maintenance of a nuisance and there can be no endangerment of public health and welfare.

## How soon must they be disposed of?

TAHC rules require that animals that die from a disease recognized as communicable by the veterinary profession must be disposed of within 24 hours by burial or burning. Animals dying from anthrax or ornithosis must be killed, then burned on-site within 24 hours.

## How can I dispose of the carcasses?

There are several options including on-site burial, composting, or sending the carcass to a municipal solid waste landfill, renderer, or commercial waste incinerator. TCEQ rules allow animals to be burned when burning is the most effective means to control the spread of a communicable disease. The animal must be burned until the carcass is thoroughly consumed. The cover requirements described in 30 TAC Chapter 330, Section 136(b)(2) should be adequate for burial of farm and ranch animals in most cases. Some diseases are reportable, and you are required to contact the TAHC at 1-800-550-8242 prior to disposing of animals with these diseases. TAHC can also provide a list of reportable animal diseases.

## Where can I bury?

If you decide to bury the animal, the burial site should not be located in an area with a high water table or with very permeable soils. The TCEQ suggests that animals be buried far enough from standing, flowing, or ground water to prevent contamination of these waters, and in an area not likely to be disturbed in the near future.

### Suggested Setbacks for Burial

- Drinking water wells - At least 300 feet from the nearest drinking water well.
- Surface water - At least 300 feet from the nearest creek, stream, pond, lake, or river, and not in a floodplain.
- Neighbors - At least 200 feet from adjacent property lines.

## Where can I burn?

When burning, do not do so in an area where a nuisance or traffic hazard would be created.

### Suggested TCEQ Setbacks for Burning

- Adjacent properties - Downwind of, or at least 300 feet (90 meters) from, occupied structures.
- Weather conditions - If possible, burn during the day when the wind speed is > 6 mph or < 23 mph. Monitor the fire, and complete the burn the same day.

## Notification Requirements

Notify the TCEQ by letter if you expect to bury animal carcasses on your farm. Your letter should contain your full

The TCEQ is an equal opportunity/affirmative action employer. The agency does not allow discrimination on the basis of race, color, religion, national origin, sex, disability, age, sexual orientation or veteran status.

name and address, the type of animals, and a short description of the locations on your farm where the carcasses will be buried. Information on the anticipated capacity of the burial areas as well as the use of daily and/or final cover should be included, and a map showing the general location of the area would be useful. This letter will be considered as your compliance with 30 TAC Section 335.6 and will be acknowledged by the TCEQ. Mail your notification to the address listed under the “Additional Information” section of this document.

Once you notify us, do not send additional letters. However, if you have more than 10 animals die at one time, it is recommended that you contact the TCEQ regional office near you since multiple mortalities are handled on a case-by-case basis. If the location of burial changes, or if additional burial areas are used, then an updated Section 335.6 notification should be provided.

## Disclaimer

This document is intended as guidance to identify the requirements for the disposal of animal carcasses; it does not supersede or replace any state or federal law, regulation, or rule. It is the responsibility of the owner to be knowledgeable and to remain abreast of guideline or regulation developments. Please refer to the “Additional Information” and “Recommended References” sections for more specific information.

## Additional Information

**Rules regarding carcass disposal:** Rules that are directly related to carcass disposal are in 30 TAC Chapters 335 and 111 including Sections 335.4 – 335.6, which deal with general waste disposal requirements, and 111.209(2) “Exception for Disposal Fires”

**Rules for poultry disposal:** 30 TAC Chapter 335—including Section 335.6, “Notification Requirements,” and especially Section 335.25, “Handling, Storing, Processing, Transporting, and Disposing of Poultry Carcasses”

**Disposal rules that apply to veterinarians:**  
30 TAC Section 111.209(3)

**Water quality rules for concentrated animal feeding operations (CAFOs):** 30 TAC Chapter 321, Subchapter B; For composting operations: 30 TAC Chapter 332; For municipal solid waste (landfills): 30 TAC Chapter 330

**Nuisance Rules, General Rules:** 30 TAC Chapter 101  
Section 4 and CAFO Rules: 30 TAC Subchapter B Section 321.31

**Public Health Rules:** Sections 81.081-81.086 of the Texas Health and Safety Code

**Texas Animal Health Commission:** Texas Agriculture Code Chapters, 161 to 168. Contact: 1-800-550-8242 prior to

disposing of diseased animals. TAHC also can provide a list of reportable animal diseases.

**Notification for onsite burial of carcasses:** Industrial and Hazardous Waste Permits Section, MC-130, TCEQ, P.O. Box 13087, Austin, Texas 78711-3087 ; Phone: 512/239-6595 Fax: 512/239-6383. It is recommended you contact your TCEQ Regional Office if you have more than 10 animals die at one time and you plan to dispose of them on-site.

**TCEQ Rules:** Rules and publications are available at [www.tceq.state.tx.us](http://www.tceq.state.tx.us) or 512/239-0028

**TAHC Rules:** Rules and publications are available at [www.tahc.state.tx.us](http://www.tahc.state.tx.us)

## Recommended References

*How to Dispose of Carcasses from Commercial Chicken or Duck Operations* (TCEQ RG-326; April 2000) explains carcass disposal rules and options for anyone who hatches, raises, or keeps chickens or ducks for profit.

*Catastrophic Animal Mortality Management (Burial Method), Technical Guidance*, USDA/Natural Resources Conservation Service, Texas State Soil and Water Conservation Board, February 11, 2002

NRCS TX Conservation Practice Standards: Code 316 - Animal Mortality Management

OSHA Construction rules: [www.osha-slc.gov/OshStd\\_toc/OSHA\\_Std\\_toc\\_1926.html](http://www.osha-slc.gov/OshStd_toc/OSHA_Std_toc_1926.html)

OSHA Excavation Rules: [www.osha-slc.gov/OshStd\\_toc/OSHA\\_Std\\_toc\\_1926\\_SUBPART\\_P.html](http://www.osha-slc.gov/OshStd_toc/OSHA_Std_toc_1926_SUBPART_P.html)

Title 2, Texas Water Code, Chapter 26,  
Subchapter H, Poultry Operations: [www.capitol.state.tx.us/statutes/statutes.html](http://www.capitol.state.tx.us/statutes/statutes.html)

Senate Bill 1339, and House Bill 3355 (77th Legislature, 2001): [www.lrl.state.tx.us/isaf/lrlhome.cfm](http://www.lrl.state.tx.us/isaf/lrlhome.cfm)

Texas Occupations Code, §801.361, Disposal of Animal Remains (78th Legislature, 2003):  
[www.capitol.state.tx.us/statutes/oc.toc.htm](http://www.capitol.state.tx.us/statutes/oc.toc.htm)

### CALL BEFORE YOU DIG

Call 1-800-344-8377 to make sure you will not accidentally hit a gas or utility line on your property when digging a hole to bury animal carcasses.





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