Chapter 2: System Components and Operation—Type B

Animal waste management systems are composed of structures and devices that collect, transport, recycle (flush), treat, store, and land apply the waste products resulting from the production of animals (Figure 2-1). As an operator of such a system, you will become knowledgeable of these system components and their proper operation and maintenance. Improper operation of any of these components could lead to a spill or runoff of the wastes, both of which are violations of state law discussed further in Chapter 8.

Describe the purpose and components of a Type B animal waste management system.

Describe which wastes are typically handled as a liquid, slurry, or solid.

Figure 2-1. Handling alternatives for animal waste from Type B animal waste management systems.

All barnyard runoff and milking center wastewater must be collected and delivered to a storage or treatment area. Most dairy/cattle lots slope in more than one direction. Because of this, complex collection systems consisting of curbs, diversions, open channels, pipes, or even lift pumps are sometimes needed.
Confinement areas must have a system for collecting and confining waste contaminated runoff. This can be accomplished by using (1) curbs at the edge of paved lots, and (2) reception pits where runoff exits the lot. Paved lots generally produce more runoff than unpaved lots. On unpaved lots, the runoff may be controlled by diversions, sediment basins, or underground outlets. The volume of runoff can be reduced by limiting the size of outdoor confinement areas. Uncontaminated runoff can be diverted through the use of gutters to collect roof runoff.

Gutters should be placed on all buildings where runoff may flow into feedlots, confinement areas, and manure storage areas. A system of gutters and downspouts with underground or open channel outlets will effectively divert runoff from mixing with animal wastes. However, in some instances it may be necessary to divert collected runoff into a slurry storage basin in order to dilute the waste and achieve proper mixing.

Animal waste storage systems are designed to contain animal waste until such time as the waste materials can be land applied to generate the most benefit for the crops and to minimize the potential for environmental degradation.

When cleaning the milking center, use only the amount of water necessary for sanitation. Clean water used solely for milk cooling purposes should be collected and reused for floor cleaning, flushing, or to water cows. Dairies using parlor flush tanks for cleaning floors or prep stalls or cow wash sprinklers in holding areas require large amounts of clean water, greatly increasing the wastewater to be handled.

Both the daily volume and the strength of the milking-center wastewater must be considered in the management of milking facilities. Table 2-1 provides estimated daily quantities of wastewater. As the herd size increases, less water is used per cow because the milking equipment wash water does not increase proportionately. The values given are for facilities with parlors whose holding areas were scraped and not hosed down. Milking in stanchions produces less wastewater per day, and the quantity
of washwater from milkrooms will be only a third or half of the values given in Table 2-1.

<table>
<thead>
<tr>
<th>Cows Milked</th>
<th>Quantity of Wastewater</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 50</td>
<td>7 to 10 gal/cow-day</td>
</tr>
<tr>
<td>50 to 150</td>
<td>4 to 6 gal/cow-day</td>
</tr>
<tr>
<td>More than 150</td>
<td>2 to 4 gal/cow-day</td>
</tr>
</tbody>
</table>

The design of the wastewater collection system in the milking parlor is very important. Poor drain locations, improper floor slopes, or inadequate piping can lead to continual frustration. Floor slopes should be a minimum of 2 percent (1/4 inch per foot). Drains should be recessed below floor level so that water and solids will easily enter the drain without ponding. Drains should be located in corners or at the ends of gutters so that solids can be easily washed (hosed) into them. A water seal trap must also be located in the drain pipe between the waste-disposal unit and the milking center to prevent gases from entering the parlor.

A very acceptable and easy method for handling milking center wastewater is to put it into a liquid-manure system. These systems include wastewater storage ponds, slurry basins, or lagoons. Management of these systems will be discussed later in this chapter.

Another source of polluted water is the leachate (runoff) from stockpiles of silage or other feed sources. This runoff water contains nutrients from the feed, and therefore can cause problems if it is not controlled and is allowed to enter surface waters. This runoff water should be handled in the same manner as runoff from an open feedlot or parlor wash water.

**FLUSH SYSTEMS**

Flushing free-stall barn alleys is a low-labor, sanitary system for manure handling that emphasizes recycling wastewater from treatment lagoons or storage ponds for paved surface cleaning. Flush systems have tanks that use recycled wastewater to clean free-stall cow lanes, a waste collection tank with chopper-agitator pump, solids separator, retention pond or lagoon, and irrigation equipment. This system has a relatively high investment cost but lower operating costs than other systems.
Free-stall cow lane flush tanks are either tall, cylindrical metal tanks with underground pipes and valves to each alley or low-profile, reinforced concrete tanks. Tank release devices include vertical lift dam, sluice gate, circular orifice, guillotine gate, and high-capacity siphons. The amount of liquid needed to flush these alleys varies depending on slope and flush frequency. Tanks in North Carolina usually have a capacity of approximately 50 gallons per cow. Flushing is done one or two times a day. Cow lane slopes typically range from 3 to 4 percent. As the slope flattens, a greater water discharge rate is needed for cleaning. As the slope gets steeper, cow footing becomes difficult. These lanes should be perfectly level from side to side with the surface grooved lengthwise or in a diamond-shaped pattern, but never sideways.

**COLLECTION**

Flushed manure and wastewater are collected by a narrow sloped channel across the end of the cow lanes and transported to a reinforced concrete tank with enough capacity to hold a two- to four-day accumulation. This tank should have a reinforced roof with scrape-in ports such that manure could be scraped directly into the tank if desired. To remove the tank contents, adequate agitation capabilities are essential to get the manure solids into suspension. This requires either a solids handling centrifugal pump and propeller mixer or a liquid manure chopper-agitator impeller pump.

Because of the fibrous rations fed to cattle, manure solids separation is recommended before manure is added to a treatment lagoon. Commonly used systems for solids separation include: vibrating screen, stationary sloping screen, expression-type mechanical separators, and gravity settling. Solids removal will be covered in more detail later in this chapter.

**PIPES**

Pipes are important because they convey the waste from the barns to the storage structure and from the storage structure to the fields for irrigation or to a slurry truck loading area. Pipes are also used to recycle water used to flush the waste from free-stall barns.
Factors that should be considered when choosing pipes include:

- **Material**—the pipe should be made of a durable material that can withstand contact with the waste. Plastic or concrete is usually more durable than metal.

- **Size**—the pipe must be large enough to carry the volume of waste without backup. Recycling pipes that are too small can cause problems with pumps and motors. Pipes that are too large can allow solids buildup which may clog the pipe.

- **Slope**—pipes that carry waste from the barn to the storage basin or lagoon should be on a slope of approximately 1 percent or greater to reduce the potential for solids buildup which may clog pipes.

- **Location**—pipe discharge should be located where it will not cause problems, such as: erosion of the earthen liner, interference with traffic around the lagoon or basin, or interference with diversion of surface water away from the structure. Pipes should not be installed in the embankment without proper engineering considerations. Pipes through embankments must have anti-seep collars or other devices.

Pipes that are above ground must be properly supported with piers, posts, or a cradle to prevent sagging. To reduce odors, a flexible pipe is required to be attached to the end of waste discharge pipes so that the waste is discharged below the water surface. This minimizes erosion potential on the lagoon interior sidewall as well.

Above ground and shallow pipes may also be damaged by freezing weather. All above ground piping should have some mechanism for drainage to prepare for harsh weather conditions. Another method of freeze prevention is to keep liquids circulating through pipes during very cold weather.

As the operator, you should know where all pipes are located at your facility. You should make a map of your facility with all pipes clearly marked. The map should show the types of pipes, size, and the type of water each pipe carries (such as flush water, drinking water for animals,
and drinking water for office). A color code system for the pipes will help separate the types of pipes and their uses.

Breaks in piping are a common cause of discharges of animal waste. You should keep extra repair pipes and valves in the event of a break. During repair of any pipe which carries waste, some temporary means must be used to ensure that all wastes and flush waters still reach the lagoon or holding pond. Commonly, a small dug trench is used for such temporary situations, being careful not to damage the earthen liner. It is crucial to know where all pipes are so that repair equipment does not cause further pipe breakage.

Frequent inspections of the piping system, including walking the areas where there are underground pipes, cannot be overemphasized. This should be done at least as frequently as you evaluate storage structure levels.

**DRY STACK SYSTEMS**

In terms of initial investment for handling manure, lot scraping directly into a spreader for daily field spreading or into a short-term dry stack or storage area is probably the least expensive system. Disadvantages of this system, however, include:

- high labor requirements for daily spreading, particularly for larger herds;
- lack of field access during inclement weather conditions;
- inflexible nutrient management options due to crop selection and timing; and
- difficulties in containment of semisolid manure in storage.

A tractor scraper is usually used to move the manure from paved lots to a reinforced concrete loading ramp. Mechanical alley scrapers can be used in free-stall barns to automate manure collection, but they require substantial maintenance. When labor is available, manure is loaded from the ramp directly into a specialized manure spreader which is equipped with an end gate to prevent spillage, a side-delivery flail, or impeller tank.
spreader to be land applied. During inclement weather or when labor is scarce, a manure storage area located beneath the loading ramp is used to store manure for up to 90 days.

The manure may have to be moved every seven days or an adequate fly control program practiced during warm weather to break the fly breeding cycle. About 1.5 cubic feet of storage per cow per day is adequate when the structure is built on a concrete slab and liquids are allowed to drain through a section of porous fence in one side wall. Liquids from dry stack storage areas need to be collected and managed in a wastewater storage system. Covering storage areas with a roof prevents rainwater from mixing with the stored manure.

**LIQUID-MANURE SYSTEMS**

The following section will discuss storage ponds, concrete and glass-lined steel slurry storage tanks, earthen slurry basins and lagoons. Proper design and construction of storage facilities are required to meet the requirements of N.C. Dam Safety Laws. A failure of your facility could affect the life, health, property, and public well-being of others in varying degrees, depending on the size and location of the storage structure. If your dam is over 15 feet in height or your storage structure has greater than 10 acre-feet of capacity, you are subject to the dam safety regulations. Proper design and construction will also minimize the risk to surface water or groundwater as a result of overflow or seepage.

Animal waste storage structures should not be placed in low areas or wet areas where the potential exists for groundwater seepage into the facility. You should also check for areas where subsoil drainage tile has been installed. Either situation could cause the structure to remain full of water, regardless of how much irrigation pumping or waste hauling is done. If located within a floodplain, lagoons and storage ponds must be designed to prevent inundation during a 100-year flood event.
Liners

Liners are used to reduce the permeability (seepage) of the bottom and sidewalls of an earthen waste structure (lagoon or earthen slurry basin/pond). This prevents or restricts the potential for downward and lateral seepage of the wastes from the facility. The types of liners used are:

- **Clay**—can usually be found near site; requires careful installation with proper compaction at the proper moisture content.
- **Bentonite**—is blended with existing soil; has to come from sources outside North Carolina; freight is expensive.
- **Synthetic membrane**—normally some type of plastic; requires careful installation by experienced contractor; easy to damage.

The need for a liner depends on the soils that are used for the construction of the lagoon. Natural Resources Conservation Service SNTC Technical Note 716 (Revision 1) has guidelines for proper design.

**Slurry Storage Ponds and Basins**

Prolonged storage of liquid manure is a good option for many Type B animal waste management systems. Slurry and wastewater storage systems are designed to collect and store liquid manure until it can be land applied to crops. Although the storage structures provide an anaerobic condition for waste storage, their primary function is to store liquid manure for a designed period, usually 6 to 12 months. Unlike anaerobic lagoons, these structures need to be drained of all liquids at least once per year. Advantages of liquid manure storage include:

- timely use of manure for fertilizer;
- efficient use of available labor and equipment;
- flexibility to avoid spreading during inclement weather; and
- complete containment of semisolid or slurry manure.
Figure 2-2. Schematic of a waste storage pond (note that this drawing is not to scale).

Storage

Liquid manure storage structures consist of underground concrete tanks, aboveground tanks (concrete or glass-lined steel), or earthen holding basins. For many crop rotations, it is desirable to store manure for 6 to 12 months for maximum nutrient management flexibility. Wastewater generated from the milking center plus lot runoff should be routed so that it can be added to the slurry storage structures if additional dilution water is needed for agitation and pumping. During other times it can bypass the storage pit and be handled by a separate wastewater system. Slurry storage structure design volumes of 3 cubic feet per cow per day are usually adequate for North Carolina conditions.

Manure is loaded into the top of slurry storage structures by mechanical or tractor scrapers. A floating mat or crust forms on the surface except near the top loading area, reducing ammonia losses and odor emissions during storage. A few systems use gravity or pumped loading points near the
bottom of the storage structure to maintain a complete surface crust. Also, since the storage environment is anaerobic, flies do not tend to breed on the surface and are not regarded as a problem.

A waste storage structure (as shown in Figure 2-2) is designed for (1) waste storage for a predetermined length of time, based on the cropping system at the farm, (2) storage for the 25-year, 24-hour storm, and (3) a minimum of one foot of freeboard. A permanent marker must be installed at the level of maximum design storage to indicate that pumping is required.

Agitation

Total solids concentrations of liquid manure slurries average from 7 to 10 percent for dairy and beef cattle. Since solids tend to settle to the bottom or float to the top of basins over time, the basin contents need to be mixed before emptying. Tractor-mounted PTO (power take-off) propeller mixers provide the most vigorous and effective agitation of manure slurries. Tractor PTO-driven chopper-agitator pumps are also used to mix and pump the slurry from storage structures. A 6-month accumulation of slurry might require up to 12 hours of agitation before pumping. To prevent pump clogging, long-stemmed vegetation and material other than manure, spilled feed, or wastewater should be kept out of slurry basins.

LAGOON SYSTEMS

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

Treatment of animal waste in lagoons is performed by bacteria that decompose organic matter in an anaerobic environment. Anaerobic means the waste is treated without aeration or mixing devices in an oxygen limiting environment. Anaerobic lagoons are used because of their efficiency and cost advantages. A properly sized and operated lagoon reduces organic material (which is the source of the majority of the odor), reduces the nitrogen concentration of the waste, allows treated liquid to be
used for flushing of production facilities, and allows solids to settle out. Most of the phosphorus will accumulate in the sludge in the bottom of the lagoon.

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

The capacity of an anaerobic lagoon (as shown in Figure 2-3) includes volumes designed for:

1. **Sludge**—organic solids which cannot be further degraded by anaerobic bacteria and accumulates in the bottom of a lagoon.
2. **Permanent liquid treatment**—the amount of liquid which should always be present in a lagoon for optimal bacterial activity.
3. **Temporary liquid storage**—this volume should be based on the amount of wastewater, rainfall, and extra wash water that will enter the lagoon during periods when liquid cannot be irrigated onto a growing crop.
4. **25-year, 24-hour storm**—the most rainfall likely to occur in a 25-year period over a 24-hour duration (5 to 9 inches of rainfall for North Carolina).
5. **Heavy rainfall factor**—as a minimum must be equal to or greater than the depth of a 25-year, 24-hour storm on the lagoon surface.
6. **Freeboard**—the required distance from the top of the lagoon dam or dike elevation (at its lowest point) to the highest allowed waste liquid elevation (at least 1 foot). This distance is in addition to the 25-year, 24-hour storm and the heavy rainfall factor.

*Note: Heavy rainfall factor not required for lagoons designed before September 1, 1996. Although not required, it is recommended to maintain storage to accommodate the heavy rainfall factor. See your original lagoon design or a technical specialist for more information.*
The **Permanent Storage Volume** is the sum total of the sludge storage volume and the permanent liquid treatment volume.

**Liquid Level Gauging Device**

You must install and maintain permanent markers inside the lagoon to assist with liquid level management. Mark the absolute maximum and minimum operating levels to indicate when pumping is needed and when pumping should stop. The markers should be routinely cleaned so you can easily observe the available storage. The markers’ location relative to the lagoon storage design can be seen in Figure 2-3.

*Figure 2-3. Schematic of an anaerobic waste treatment lagoon (note that this drawing is not to scale).*
Lagoon Operation

Startup:

1. Immediately after construction, establish a complete sod cover on bare soil surfaces to avoid erosion.

2. Fill new lagoon permanent liquid treatment volume at least half full of water before waste loading begins, taking care not to erode lining or bank slopes.

3. Drainpipes into the lagoon must have a pipe extender on the end of the pipe to discharge near the bottom of the lagoon during initial filling, or another means of slowing the incoming water to avoid erosion of the liner and minimize odors.

4. When possible, begin loading new lagoons in the spring to maximize bacterial establishment (due to warmer weather).

5. It is recommended that a new lagoon be seeded with sludge from a healthy working lagoon in the amount of 0.25 percent of the full lagoon liquid volume. This seeding should occur at least two weeks prior to the addition of wastewater.

6. Maintain a periodic check on the lagoon liquid pH. If the pH falls below 7.0, dose with agricultural lime at the rate of 1 pound per 1000 cubic feet of lagoon liquid volume, and thoroughly mix until the pH rises above 7.0. Optimum lagoon liquid pH is between 7.5 and 8.0.

7. A dark color, lack of bubbling, and excessive odor signal inadequate biological activity. Consultation with a technical specialist is recommended if these conditions occur for prolonged periods, especially during the warm season.

Describe the proper startup procedure for an anaerobic lagoon.

Describe the conditions in an anaerobic lagoon that indicate the lack of biological activity.
Chapter 2: System Components and Operation—Type B

Loading:

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

- Practice water conservation (water reuse)—minimize water usage and spillage from leaking waterers, broken pipes, and washdown through proper maintenance and water conservation. This reduces freshwater consumption and reduces the volume of wastewater that ultimately must be land applied.

- Minimize feed wastage and spillage. This will reduce the amount of solids entering the lagoon.

- Minimize additions of sand and straw used as bedding materials.

Management:

- Maintain lagoon liquid level between the permanent storage level and the full temporary storage level.

- Place highly visible markers or stakes on the lagoon bank to show the minimum liquid level and the maximum liquid level (Figure 2-3).

- Start irrigating at the earliest possible date in the spring based on nutrient requirements and soil moisture so that temporary storage will be maximized for the summer thunderstorm season. Similarly, irrigate in the late summer/early fall to provide maximum lagoon storage for the winter.

- The lagoon liquid level must never be closer than 1 foot plus the 25-year, 24-hour storm storage to the lowest point of the dam or embankment. For lagoons constructed after September 1, 1996, storage for the heavy rainfall factor must also be maintained.

- Do not pump the lagoon liquid level lower than the permanent storage level unless you are removing sludge.
• Do not lower the lagoon liquid level below the seasonal groundwater table (see your system design or contact the local office of the Natural Resources Conservation Service for this level).

• Locate float pump intakes approximately 18 inches underneath the liquid surface and as far away from the drainpipe inlets and embankments as possible.

• Prevent additions of bedding materials, long-stemmed forage or vegetation, molded feed, plastic syringes, or other foreign materials into the lagoon.

• Frequently remove solids from catch basins.

• Maintain strict vegetation, rodent, and varmint control over the entire embankments.

• Do not allow trees or large bushes to grow on lagoon dam or embankments.

• Remove sludge from the lagoon either when the sludge storage capacity is full or before it fills 50 percent of the permanent storage volume.

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

**Sludge Removal:**

Rate of lagoon sludge buildup can be reduced by:

• proper lagoon sizing,

• mechanical solids separation of flushed waste,

• gravity settling of flushed waste solids in an appropriately designed basin, and

*Describe methods to reduce sludge buildup.*
minimizing feed wastage and spillage.

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

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

Removal techniques:

• Hire a custom applicator.
• Mix the sludge and lagoon liquid with a chopper-agitator impeller pump; pump through large-bore sprinkler irrigation system onto nearby cropland and soil incorporate.
• Dewater the upper part of lagoon by irrigation onto nearby cropland or forageland; mix remaining sludge; pump into liquid sludge applicator; haul and spread onto cropland or forageland and soil incorporate.
• Dewater the upper part of lagoon by irrigation onto nearby cropland or forageland; dredge sludge from lagoon with dragline or sludge barge; berm an area beside lagoon to receive the sludge so that liquids can drain back into lagoon; allow sludge to dewater; haul and spread with manure spreader onto cropland or forageland and soil incorporate.

Regardless of the method, you must have the sludge material analyzed for waste constituents just as you would your lagoon water. The sludge will contain different nutrient and metal values from the liquid. The application of the sludge to fields will be limited by the crop requirement for these nutrients as well as any previous waste applications to that field. Waste application rates will be discussed in detail in Chapter 3.
When removing sludge, you must also pay attention to the liner to prevent damage. Close attention by the pumper or drag-line operator will ensure that the lagoon liner remains intact. If you see soil material or the synthetic liner material being disturbed, you should stop the activity immediately, contact a technical specialist, and not resume until you are sure that the sludge can be removed without further liner damage. If the liner is damaged it must be repaired as soon as possible.

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

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

**Crystal Buildup in Recycle Lines**

Struvite (magnesium ammonium phosphate) or similar crystalline material frequently occurs in lagoon liquid recycle pipes. This material develops in pumps and/or at joints of restriction and turbulence in the pipeline. The material starts as a soft scum that adheres to the pipes and pumps. However, once the material solidifies additional crystal growth can be rapid and can completely block even large pipes. There is no proven method of totally preventing these crystals.

To minimize difficulties associated with struvite the following should be considered:

1. Use only smooth-walled plastic pipe.
3. Keep pipe flow velocities well below 5 feet per second.
4. Keep pipes and pumps as free of particulates as possible.
5. Minimize suction lift on the pump.

6. Pump housings should be directly grounded to prevent any stray voltage that could contribute to crystal growth.

Some producers have installed parallel piping systems that can be used to circulate acid. There are several acids (including muriatic or hydrochloric acid) that have been used somewhat successfully to decrease struvite buildup. Extreme caution must be exercised when handling acid. Eye protection and gloves should always be used. Diluted acid solutions should be placed in a plastic reservoir and a pump used to circulate the acid through the piping system until it is free of struvite. After one or more uses, the acid may lose its effectiveness depending on the amount of crystal to dissolve. The acid/salt solution should be disposed of properly by pumping it into the lagoon.

**Maintenance**

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

Maximum storage capacity should be available for periods when the receiving crop is dormant (such as wintertime for bermudagrass and fescue) or when there are extended rainy spells such as the thunderstorm season in the summertime. This means that at the first signs of plant growth in the late winter/early spring, irrigation according to a farm nutrient management plan should be done whenever the land is dry enough to receive animal wastes. This will make storage space available in the structure for future wet periods. In the late summer/early fall lagoons should be pumped down to the low marker (see Figure 2-3) to allow for winter storage. Every effort should be made to maintain lagoons close to the minimum liquid level as long as the weather and waste utilization plan will allow it. Storage ponds and slurry basins should be pumped as low as possible, and only need an upper level marker to show maximum permissible liquid level.

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

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

- Maintenance of a vegetative cover for the dam. Fescue or common bermudagrass are the most common vegetative covers. The vegetation should be fertilized each year, if needed, to maintain a vigorous stand. The amount of fertilizer applied should be based on a soils test, but in the event that it is not practical to obtain a soils test each year, the embankment and surrounding areas should be fertilized with 800 pounds per acre of 10-10-10, or equivalent.

- Brush and trees on the embankment must be controlled. This may be done by mowing, spraying, chopping, or a combination of these practices. This should be done at least once a year and possibly twice in years that weather conditions are favorable for heavy vegetative growth.

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

Maintenance inspections of the entire facility should be made during the initial filling of the structure and at least monthly. Items to be checked should include, as a minimum, the following:

- Waste Inlet Pipes, Recycling Pipes, and Overflow Pipes—look for:
  1. separation of joints
  2. cracks or breaks
  3. accumulation of salts or minerals
  4. overall condition of pipes
- Liquid surface—look for:
  1. undesirable vegetative growth
2. floating or lodged debris

- Embankment—look for:
  1. settlement, cracking, or holes
  2. side slope stability—slumps or bulges
  3. wet or damp areas on the back slope
  4. erosion due to lack of vegetation or a result of wave action
  5. rodent and tree damage

Larger facilities may be subject to liner damage due to wave action caused by strong winds. These waves can erode the earthen sidewalls, thereby weakening the dam. A good stand of vegetation will reduce the potential damage caused by wave action. If wave action causes serious damage to the sidewall, baffles or rip-rap in the lagoon or basin may be used to reduce the wave impacts.

Any of these features could lead to erosion and weakening of the dam. If your facility has any of these features, you should call an appropriate expert familiar with design and construction of waste storage structures. There is a resource list in Appendix A for experts in your area. You may need to provide a temporary fix if there is a threat of a waste discharge. However, a permanent solution should be reviewed by the technical expert. Any digging into an earthen dam with heavy equipment is a serious undertaking with potentially serious consequences and should not be conducted unless recommended by an appropriate technical expert.
Transfer Pumps—check for proper operation of:

1. recycling pumps
2. irrigation pumps

Check for leaks, loose fittings, and overall pump operation. An unusually loud or grinding noise, or a large amount of vibration, may indicate that the pump is in need of repair or replacement.

Note: Pumping systems should be inspected and operated frequently enough so that you are not completely “surprised” by equipment failure. You should perform your pumping system maintenance at a time when your holding pond, slurry basin, or lagoon is at its low level. This will allow some safety time should major repairs be required. Having a nearly full facility is not the time to think about switching, repairing, or borrowing pumps. Probably, if your basin is full, your neighbor’s is full also. You should maintain an inventory of spare parts or pumps.

Surface water diversion features are designed to carry all surface drainage waters (such as rainfall runoff, roof drainage, gutter outlets, and parking lot runoff) away from your basin and other waste treatment or storage structures. The only water that should be going in your facility is that which comes from your flushing (washing) system pipes and the rainfall that hits the water surface directly. You should inspect your diversion system for the following:

1. adequate vegetation
2. diversion capacity
3. ridge berm height

The only exception to this is if you maintain animals or waste piles outside in such a manner that runoff from the concentrated animal area or waste area may enter surface waters. You should consult with a technical specialist to see what best management practices are needed for these situations. One possible practice is to catch the runoff water in a lagoon or slurry storage basin.
Identified problems should be corrected promptly. It is advisable to inspect your system during or immediately following a heavy rain. If technical assistance is needed to determine proper solutions, consult with appropriate experts.

You should record the level of the storage basin or lagoon just prior to when rain is predicted, and then record the level again 4 to 6 hours after the rain (assumes there is no pumping). This will give you an idea of how much your liquid level will rise with a certain rainfall amount (you must also record the rainfall for this to work). Knowing this should help in planning irrigation applications and storage. If your facility rises excessively, you may have an inflow problem from a surface water diversion or there may be seepage into the structure from the surrounding land.

**Possible Causes of Storage Structure Failure**

Failures in animal waste storage structures result in the unplanned discharge of wastewater into surface or ground waters of the state. Types of failure include leakage through the bottom or sides, overtopping, and breach of the dam. Assuming proper design and construction, the owner has the responsibility for ensuring structure safety. Items which may lead to structure failures include:

- Modification of the design structure—an example is the placement of a pipe in the dam without proper design and construction. (Consult an expert in storage system design before placing any pipes in dams.)

- Waste liquid levels—high levels are a safety risk.

- Rodent and tree damage to embankments.

- Failure to inspect and maintain the dam.

- Excess surface water flowing into the structure.
Liner integrity—protect from inlet pipe scouring, damage during sludge removal, or rupture from lowering waste liquid level below groundwater table.

Note: When wastes overtop the dam, the moving water soon causes gullies to form in the dam. Once this damage starts, it can quickly cause a large discharge of wastewater and possible dam failure. Repairs to embankments should be made according to specifications of a technical specialist.

There are several methods of improving or enhancing the handling and treatment of animal wastes. Many of these methods involve the separation of solids and liquids within the animal waste system. The producer may benefit through decreased costs in sludge and solids removal from lagoons, decreased nitrogen concentrations in wastewaters and the increased flexibility in the land application of wastes depending on the enhancement method used.

**Solids Separation**

Removal of fresh solids from manure slurries will reduce the pollutant content of manure, prolong the life of storage structures, improve the effectiveness of biological treatment, and minimize odors. Beneficial uses of the recovered solids include bedding materials, animal feed supplements, composts, and soil amendments.

**Mechanical Separation**

Mechanical separators of animal waste include: inclined screens, vibrating-screens, belt presses, and screw presses. Manure is collected in a sump sized to store the largest combination of flush tank capacities or pit storage accumulations. A submersible or stationary bottom-impeller lift pump mixes the manure and liquids into a slurry and pumps it across the separator where the liquid drains off. These devices are effective in removing at least 30 percent of all solids and produces a product with a moisture content between 30 and 35 percent. Separators with few moving parts, such as inclined screens and vibrating-screens, are more effective when large amounts of water are moved through the devices, such as in flushing systems. Most mechanical separators require daily cleaning and
flow adjustments. Screens will need to be replaced periodically when the solids removal is decreased.

**Gravity Separation**

A gravity settling basin may be less costly while removing 50 percent or more of the solids from liquid manure. Solids can be settled and filtered by a shallow basin (2 to 3 feet deep) with concrete floors and walls and a porous dam or perforated pipe outlet. Basins should allow access by a front-end loader to remove solids every 1 to 2 months.

An alternative is an earthen settling basin for 6 to 12 months storage of solids. The basin top width should be no more than 100 feet with a length-to-width ratio near 3:1 and a liquid depth of 8 to 10 feet. The basin contents should be thoroughly agitated and removed for land spreading either by liquid manure spreader or slurry irrigation. If an earthen basin is used, the operator must make the necessary inspections discussed earlier in this chapter for anaerobic lagoons. The dam structure and waste level must be constantly monitored, and the dam structure maintained to allow visual inspection for structural deterioration.

A third alternative consists of a large rectangular metallic or concrete settling tank with a 3:1 length-to-width ratio with an 8-foot depth. Tank volume depends on a peak-flow wastewater detention time of 10 to 30 minutes. Most solids in livestock manure settle in about 10 minutes although some additional settling occurs for hours. Tank inlets and outlets are baffled and solids are removed by automated skimmers and scrapers. Unless substantial solids storage is added to the settling tank volume, tank cleaning will need to occur frequently.

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

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

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

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

COMPOSTING

Composting biologically stabilizes organics like manure into a humus-like material. The opportunity exists for livestock producers to compost farm manures, separated manure solids, vegetative matter or by-products from other agricultural or nonagricultural sources. In some cases, composting may be a less expensive waste reduction process than alternative storage and treatment methods. The final composted product has less odor and breeds fewer flies than raw manure. The volume and weight is less than raw manure, thus requiring less cost to haul and spread the compost. Also, the heat generated by the composting process destroys pathogenic organisms and weed seeds in the manure.

**Explain the benefits of composting separated manure solids.**
Factors such as particle size, aeration, moisture content, carbon-to-nitrogen (C:N) ratio, and temperature are critical to efficient composting. The raw material particle size determines the porosity of the pile, which affects aeration. Optimum moisture contents range from 50 to 60 percent. C:N ratios should range from 20:1 to 30:1. Temperatures generated by microbial activity should reach 130° to 160°F. Temperature can be most affected by aeration and moisture content. Composting can occur in windrows, with aeration provided by mechanical turning, or in static piles or bins with forced aeration.

The drier the collected manure or material is, the more compatible composting will be. Farmers considering investing in manure storage should find that composting is a competitive option. The equipment, methods, and handling practices are similar to those used for other farm operations. Care should be taken at composting sites to protect groundwater and surface water. Before initiating a composting operation, the supply of raw materials and demand for the finished product must be reliably established.

**AEROBIC TREATMENT**

The main advantages of aerobic (with oxygen) lagoons are that bacterial treatment tends to be more complete than anaerobic treatment and the end products are relatively odorless. In naturally aerobic lagoons or oxidation ponds, oxygen needed for treatment diffuses across the water surface. Mechanically aerated lagoons combine the odor control advantages of aerobic digestion with relatively small surface area requirements. Aerators are used mainly to control odors in sensitive areas and nitrogen removal where land available for manure application is limited. A major limitation for mechanically aerated lagoons is the expense of continually operating electrically powered aerators. Aerobic lagoons also produce more sludge than anaerobic lagoons because more of the manure is converted to microbial biomass. Suitable land must be available to accept the sludge with its associated nutrients. However, it may be possible to dewater this sludge (see above) and move the solids off the farm for application at other farms, or for treatment such as composting.

**MULTISTAGE LAGOONS**
Two-stage lagoons have certain advantages over the typical, single, primary lagoon. A two-stage anaerobic lagoon system has the same total liquid volume as a single primary lagoon. The first lagoon contains the design treatment volume and the sludge storage volume, while the second lagoon provides temporary storage prior to land application. A two-stage lagoon allows a maximum liquid level to be maintained in the primary lagoon for the most efficient stabilization of incoming wastes. The result is a more stable operation, which helps to minimize odors. More than two lagoons in series are rarely beneficial.

Pumping from a second stage lagoon also reduces the solids pickup common to primary lagoons due to seasonal water turnovers, floating debris, and biological mixing. Because of the reduced solids, the second stage of a two-stage anaerobic lagoon system appears to have up to 25 percent less nitrogen in the lagoon liquid and up to 50 percent less phosphorus than a single primary lagoon with the same total volume. A second-stage lagoon, since it functions only as storage, may be pumped down completely. There only needs to be an upper level marker in this lagoon.

Disadvantages of multistage lagoons include:

- increased surface area to meet storage volume requirements, and
- increased construction cost.

**BIOGAS (METHANE) RECOVERY AND USE**

Anaerobic digestors are designed and managed to optimize the breakdown of organic matter by bacteria, which produces certain gases. When organic matter is stabilized (broken down), gaseous by-products, primarily methane (CH\(_4\)) and carbon dioxide (CO\(_2\)), are formed. Biogas energy is usually used either for on-farm heating using a boiler or furnace, or for electrical cogeneration. To evaluate the site-specific economics and for on-site energy use, management, and marketing, you should know the expected methane yield from a digestor system. Estimates of methane productivity of 36 cubic feet per 1,000 pounds live animal weight per day have been established for dairy manure.
Describe the methods that can be used to minimize odors.

**Odor Control Products**

A number of commercial products have been marketed that advertise the ability to either reduce or control odors. These materials include: (1) masking agents, (2) chemicals that can temporarily bind ammonia, (3) chemicals that inhibit urease production and, therefore, ammonia production, (4) chemicals that neutralize odor, (5) chemicals that stimulate bacterial growth and (6) bacterial preparations that contain “special” strains of bacteria. However, most of these products have not been scientifically evaluated and proven to be effective. Nonetheless, there are numerous reports from producers attesting to the partial effectiveness of some of these products. A livestock producer should be very wary of any unsupported claims by vendors of “odor control” products. Chemicals that may have positive results in one situation may not be effective in seemingly similar situations.

Describe the advantages and disadvantages of land application using manure spreaders.

**Transport and Utilization**

Liquid applicators and spreaders are an alternative to irrigation systems for transporting and applying liquid waste slurries, lagoon sludges and semi-solid manures. Compared to irrigation, tank and box spreaders have several advantages and disadvantages:

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
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</thead>
<tbody>
<tr>
<td>provides more transport mobility</td>
<td>requires more time and labor</td>
</tr>
<tr>
<td>allows direct soil injection</td>
<td>higher operating costs</td>
</tr>
<tr>
<td></td>
<td>requires improved travel roads and proper soil trafficability</td>
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</table>

Proper location and design of pumping and loading areas are necessary to protect equipment and operators and to avoid damaging the lagoon dike or embankment. Care should be taken to minimize spills during loading and transport.
Liquid tank and box spreaders must be accurately calibrated to apply wastes at proper rates. Calibration is the combination of settings and travel speed needed to apply wastes at a desired rate. Proper calibration of spreader equipment is essential for applying animal wastes at established rates according to a farm’s waste utilization plan. Calibration will be covered in Chapter 5.

**Hose-Drag Injection**

This method combines the advantages of direct injection with the faster application times of irrigation. Slurry can be applied to fields located within one mile of the storage facility. A moderate-pressure centrifugal pump delivers slurry through portable irrigation pipe to the field edge. A segment of collapsible hose connects the irrigation pipe to a distribution header located over a tractor-mounted tool bar chisel plow. The plow has several shanks, each with a wide sweep chisel point attached and an injection tube from the header. The tractor drags the hose behind the injectors through the field in an S-shaped pattern, always turning away from the hose.

**Irrigation Systems**

**Design**

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

Systems installed after September 1, 1996 need to include detailed design specifications for the irrigation system as part of the certified waste management plan. As a result, systems installed previously may not have been provided specifications and management guidelines needed to ensure proper system operation. A brief description of system components and general operational procedures for common types of wastewater irrigation...
systems follows. Contact the irrigation designer or technical specialist who certified your waste management plan to obtain details and manufacturer’s specifications for your system. This information will be required when you apply for your General Permit (see Chapter 8).

There are two primary types of wastewater and lagoon irrigation systems: stationary and traveling sprinklers.

Stationary Sprinkler Systems

Stationary systems for land application of lagoon and wastewater liquids are usually permanent installations (lateral lines are PVC pipes permanently installed below ground). One of the main advantages of stationary sprinkler systems is that these systems are well suited to irregularly shaped fields. Thus, it is difficult to give a standard layout, but there are some common features between systems. Sprinkler spacing is based on nozzle flow rate and desired application rate. To provide proper overlap, sprinkler spacings are normally 50 to 65 percent of the sprinkler wetted diameter. Sprinkler spacing is typically in the range of 80 feet by 80 feet using single-nozzle sprinklers. Other spacings can be used and some systems are designed to use gun sprinklers (higher volume) on wider spacing. A typical layout for a permanent irrigation system is shown in Figure 2-4.

Most permanent systems use Class 160 PVC plastic pipe for mains, submains, and laterals and either 1-inch galvanized steel or Schedule 40 or 80 PVC risers near the ground surface where an aluminum quick coupling riser valve is installed. In grazing conditions, all risers must be protected (stabilized) if left in the field with animals.

The minimum recommended nozzle size for wastewater is 1/4 inch. Typical operating pressure at the sprinkler is 50 to 60 PSI. Sprinklers can operate full or part circle. The system should be zoned (any sprinklers operated at one time constitutes one zone) so that all sprinklers are operating on about the same amount of rotation to achieve uniform application. Gun sprinklers typically have higher application rates; therefore, adjacent guns should not be operated at the same time (referred to as “head to head”).
Traveling Sprinklers

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

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

The hose-drag traveler consists of a hose drum, a medium-density polyethylene (PE) hose, and a gun-type sprinkler. The hose drum is mounted on a multiwheel trailer or wagon. The gun sprinkler is mounted on a wheel or sled type cart referred to as the gun cart. Normally, only one gun is mounted on the gun cart. The hose supplies wastewater to the gun sprinkler and also pulls the gun cart toward the drum. The distance between adjacent pulls is referred to as the lane spacing. To provide proper overlap, the lane spacing is normally 70 to 80 percent of the gun wetted diameter. A typical layout for a hard-hose traveler irrigation system is shown in Figure 2-5.
Figure 2-5. Schematic layout of a hose-drag traveler. Travel lanes are 100 to 300 feet apart, depending on sprinkler capacity and diameter coverage.

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

Nozzle sizes on gun-type travelers are 1/2 to 2 inches in diameter and require operating pressures of 75 to 100 PSI at the gun for uniform distribution. The gun sprinkler has either a taper bore nozzle or a ring nozzle. The ring nozzle provides better break-up of the wastewater stream which results in smaller droplets with less impact energy (less soil compaction) and also provides better application uniformity throughout the wetted radius. But, for the same operating pressure and flow rate, the taper bore nozzle throws water about 5 percent further than the ring nozzle, i.e. the wetted diameter of a taper bore nozzle is 5 percent wider than the wetted diameter of a ring nozzle. This results in about a 10 percent larger wetted area such that the precipitation rate of a taper bore nozzle is approximately 10 percent less than that of a ring nozzle.

A gun sprinkler with a taper bore nozzle is normally sold with only one size nozzle, whereas a ring nozzle is often provided with a set of rings ranging in size from 1/2 to 2 inches in diameter. This allows the operator flexibility to adjust flow rate and diameter of throw without sacrificing application uniformity. However, there is confusion that using a smaller
ring with a lower flow rate will reduce the precipitation rate. This is not normally the case. Rather, the precipitation rate remains about the same because while a smaller nozzle results in a lower flow, it also results in a smaller wetted radius or diameter. The net effect is little or no change in the precipitation rate. Furthermore, on water drive systems, the speed compensation mechanism is affected by flow rate. There is a minimum threshold flow required for proper operation of the speed compensation mechanism. If the flow drops below the threshold, the travel speed becomes disproportionately slower, resulting in excessive application even though a smaller nozzle is being used. System operators should be knowledgeable of the relationships between ring nozzle size, flow rate, wetted diameter, and travel speed before interchanging different nozzle sizes. As a general rule, operators should consult with a technical specialist before changing nozzle size to a size different than that specified in the certified waste management plan.
In summary, below are several advantages and disadvantages for stationary and traveling irrigation systems:

<table>
<thead>
<tr>
<th>STATIONARY SYSTEMS</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>• good for small or irregular fields</td>
<td>• higher initial costs</td>
<td></td>
</tr>
<tr>
<td>• do not have to move equipment</td>
<td>• must protect from animals in fields</td>
<td></td>
</tr>
<tr>
<td>• must protect from animals in fields</td>
<td>• small bore sprinklers more likely to get plugged or broken</td>
<td></td>
</tr>
<tr>
<td>• small bore sprinklers more likely to get plugged or broken</td>
<td>• no flexibility to move to other (new) fields</td>
<td></td>
</tr>
<tr>
<td>• no flexibility to move to other (new) fields</td>
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<thead>
<tr>
<th>TRAVELING SYSTEMS</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>• system is transportable</td>
<td>• more difficult to calibrate</td>
<td></td>
</tr>
<tr>
<td>• application rate can be adjusted (speed and nozzle settings)</td>
<td>• does not maximize the use of area for irregularly shaped fields</td>
<td></td>
</tr>
<tr>
<td>• easily used for new fields</td>
<td>• impractical for small areas</td>
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### Pumps

Pumps used for land application of wastewater are generally straight centrifugal pumps when solids content is less than 4 percent. A centrifugal pump consists of an impeller rotating in a casing. Open impeller-type pumps are normally used for wastewater applications. A gate valve, discharge check valve, and totaling propeller-type flow meter should be
installed on the discharge side of the pump. The suction line and strainer should be floated in the lagoon such that the intake is about 18 inches below the water level and able to draw the most solids-free liquid. The pump should be located as far from the inlet pipe to the lagoon as possible. If the lagoon is located in an area where a prevailing wind direction exists, the suction line should be located on the upwind side of the lagoon, because solids tend to migrate to the downwind side.

Pumps are rated to deliver a set number of gallons at a given operating head (pressure) at a specified efficiency. Pump manufacturers provide pump curves for each of their pumps. These curves show the relationship between head, horsepower, capacity, and efficiency. Pump curves can be used in case you need to modify your operating conditions from the original irrigation design. As pump models are discontinued it becomes more difficult to obtain this information for older pumps. Keep equipment specification information in a safe place, such as with your other records.

**Slurry Irrigation**

Direct irrigation of manure slurry through a large-diameter sprinkler nozzle is an alternative for farms that produce larger quantities of manure and have nearby pasture or cropland. Irrigation of liquid manure requires less labor, time, and operating expense than hauling and does not have the soil compaction problems.

Centrifugal pumps that can deliver at least 30 PSI pressure at the sprinkler nozzle are needed for irrigation. In addition, due to the high solids content of the slurry, a lift pump similar to the chopper-agitator pump already described is needed to help the centrifugal pump maintain its prime. Internal pump chopper mechanisms can help avoid clogging.

Slurries with more than 4 percent solids cause higher friction losses in the pipes, requiring more pump pressure and horsepower. It is essential that the irrigation lines be flushed with clean water after slurry pumping. With proper management, slurry manure up to 7 percent total solids can be irrigated.

Over application of nutrients is a concern with slurry irrigation systems. Moving sprinklers frequently helps to avoid this. Thus, traveling irrigators are recommended. Hose-drag travelers are less labor intensive and apply manure more uniformly than other traveling systems. The hose reel should
be driven by an auxiliary engine, because the high solids content will clog other types of drives. Gun sprinklers operate at higher pressures resulting in greater potential for misting and wind drift.

**OPERATION**

A thorough knowledge of the irrigation system is needed to apply wastewater in accordance with the waste utilization plan. The operator must be familiar with correct pressure settings, sprinkler spacing, and time of operation needed to ensure the appropriate amount is uniformly applied. Irrigation equipment calibration will be discussed in detail in Chapter 5.

**HEAVY-USE AREAS**

A number of open, unpaved, bare areas tend to develop around dairy/cattle farms. Examples are working corrals, exercise areas or drylots, feeding or watering areas, shaded animal lounging areas, and transition areas from pavement to dirt. These areas may be interpreted as feedlots subject to strict runoff controls or vegetated areas contributing to nonpoint sources of pollution. In most cases, improvements to these areas will be needed to minimize the impacts of runoff into streams.

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

Current regulations require that dirt lots be located at least 100 feet away from perennial streams, 25 feet away from intermittent streams and drainageways, and have a permanently vegetated buffer. Under no circumstances should these lots have an unfenced stream or wet area within their boundary. All surface water from above these lots should be diverted around them. Sloping lots should have cross terraces to reduce...
erosion and collect eroded sediment and manure solids. At the lowest point of the lot edge, earthen or concrete settling basins help trap solids that may otherwise leave in rainfall runoff. Where possible, these lots should be rotated and the surface manure pack scraped from the unused lot before reseeding with grass. Waterers located within these areas should be kept in good repair to minimize leakage and spillage.

**ROTATIONAL GRASSED LOAFING LOTS**

Instead of bare loafing areas, Type B systems may consider using rotational grassed loafing lots. These grassed paddocks are located near the milking parlor/confinement area (within 1/4 mile) and are managed in order to protect water quality. A dedicated area is divided into three grassed paddocks using an electric fence system. For each paddock, a density of 15 to 20 cows per acre is recommended. The system is usually established in moderately sloping land (4 to 10 percent) of a well-drained soil capable of maintaining a heavy sod such as tall fescue.

Management of the system involves rotating the animals between the three paddocks or confinement area, with consideration for the level of vegetation and soil moisture in each paddock. A confinement area or designated sacrifice paddock is used when the three grassed paddocks are too wet or when the grass is too short and likely to be damaged or destroyed by cow traffic. If a sacrifice area is used it should be located far from streams or established drainageways in order to prevent the runoff of sediment and animal manures.

Rotational grassed loafing lots provide numerous benefits such as vegetated exercise and rest areas which have been shown to reduce stress from concrete floors. These lots reduce handling time and mastitis in milking cows through greater cleanliness, all of which appear to result in cows that produce more milk. Proper management of rotational grassed loafing lots will improve water quality through the reduction of soil erosion and the amount of sediment and nutrients delivered to streams and lakes.
Chapter 2: System Components and Operation—Type B

Grazing and Cattle Watering Systems

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

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

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

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

Stock Trails and Stream Crossings

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

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

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

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

**STREAM FENCING**

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

**SETTLING BASIN-VEGETATIVE FILTER**

A vegetative filter can be a pasture, grassed waterway, or even cropland where wastewater is treated by settling, dilution, soil infiltration, and crop uptake of nutrients. Vegetative filters can be very effective at filtering pollutants. However, they are not allowed as the only means of waste
treatment in a confined animal operation. Waste collection devices as described earlier in this chapter are required to handle feedlot and barn wastes. Vegetative filters can be a best management practice (BMP) to further enhance waste treatment, and to minimize the potential of other discharges of pollutants.

A settling basin placed before the vegetative filter to separate manure solids from the wastewater is essential to prevent the upper side of the vegetative filter from clogging with solids and reducing soil infiltration. The most common type of settling basin is a shallow, reinforced concrete structure with a sloping entrance ramp to permit equipment access for solids cleanout. The basin should have a drain in one sidewall so that liquids can be removed. It is helpful to have two settling basins, so one can be used while the other is drying out for cleaning. Solids should be removed from the basin monthly or after each heavy rainfall.

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

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

Vegetative filter areas should be prepared and seeded at least one growing season before use. A combination of seasonal forage species that can tolerate wet conditions is suggested. Foliage should be clipped periodically and removed from the filter area. Do not remove late-fall foliage—foliage growth will help filter winter and spring runoff. Vegetative filters can provide low-cost, low-management control of barnyard runoff and milking center wastewater for many small- and medium-sized dairies. Studies indicate that vegetative filters can remove more than 95 percent of the nutrients, solids, and oxygen demanding material from wastewater. They are not effective, however, on farms where large areas of paved feedlot drain into the filter or where large amounts of water are used in the milking center.
1. What practices could be done on your farm to improve waste handling or treatment? ............................. see pages 2B-1 to 2B-40

2. Describe how different dairy wastes may be handled by either a liquid or solid/semisolid waste handling treatment system. ................................................................. see page 2B-1

3. Describe some common types of lagoon and storage pond liners. ........................................................................................................ see page 2B-8

4. What is the difference between a lagoon and a slurry storage system? How are they managed differently? ........ see page 2B-10

5. Describe the six storage volumes for an anaerobic lagoon. ........................................................................................................ see page 2B-11

6. Explain why you should manage liquid storage levels year around. ................................................................. see page 2B-18

7. Name some maintenance procedures that should be performed periodically to ensure your waste application equipment is functioning properly. ......................... see pages 2B-19 to 2B-21

8. Name some maintenance procedures that should be performed periodically to ensure the animal waste structure does not leak or develop a dam break. ............................. see pages 2B-19 to 2B-20

9. List several ways in which you may be able to reduce the amount of solids entering a lagoon or waste storage pond. ................................................................. see pages 2B-23 to 2B-25

10. Name some advantages and disadvantages of the following types of waste application equipment:
    • manure spreaders ............................................. see page 2B-28
    • hose-drag injection ............................................. see page 2B-29
    • stationary sprinklers........................................ see page 2B-34
    • traveling guns .................................................. see page 2B-34
11. What procedures need to be taken following the operation of a slurry irrigation system? ...........................................see page 2B-35

12. What practices are used or are needed on your farm in order to protect water quality? ............................ see pages 2B-36 to 2B-40