Lesson 24

Operation and Maintenance of Manure Storage Facilities

By Charles Fulhage and John Hoehne, University of Missouri
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Intended Outcomes
The participants will understand the
• Practices and operations necessary to maintain environmentally sound manure storage facilities.
• Significance of a pumpdown marker and maintaining a liner.

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Activities
• Estimate manure-handling requirements (pumpdown/hauling time and frequency).
• Develop a manure storage inspection checklist.
• Develop a record-keeping plan for self assessment or as required by regulation.
Introduction
A well-designed manure storage facility must also be well managed to prevent environmental concerns from developing. Management decisions relative to startup and loading (especially anaerobic lagoons), manure removal, monitoring of structure integrity and other issues, and maintenance of appearance and aesthetics all play critical roles in a well-managed storage. The following lesson provides an overview of these critical issues. In addition, producers can evaluate their own management of an existing storage with the aid of the Environmental Stewardship Assessment of operation and maintenance (Appendix D, Lesson 20).

Regulatory Compliance Considerations
Operation and maintenance of a manure storage facility may involve a number of issues that are affected by regulation. Contact your state regulatory agency, local Natural Resource Conservation Service or University extension office, or other qualified professional for assistance in determining regulations that pertain to operation and maintenance of manure storage facilities. Appendix A outlines some typical regulatory issues that may be present in many states. Other additional issues and considerations may exist in your state.

Annual Manure Removal and Methods
Probably the single most important requirement in operating and maintaining a manure storage facility is to ensure that the facility does not overflow or discharge. Discharges from manure storage facilities may violate local, state, or federal regulations, result in large fines or penalties, and at the

Example 24-1
Using data in Problem 4, Lesson 21, estimate the number of trips required and total time required to haul and spread the broiler litter. Assume two spreader trucks capable of hauling 6-ton loads will have an average round-trip time (including loading and unloading) of 45 minutes.

From Problem 4, Lesson 21, litter volume is 25,872 ft³. Assume a litter density of 33 lb/ft³.

25,872 ft³ x 33 lb/ft³/2,000 lb/ton = 427 tons of litter
427 tons/6 tons/load = 71 loads, so each truck will have to make about 35 trips.

35 trips x 0.75 hrs/trip = 26 hrs, so each truck will have a total hauling time of 26 hours.

If the hauling operation is conducted in 10-hour days, 2.5 to 3 days will be required with two, full-time operators.
very least, represent a potential environmental hazard. Manure removal from storage according to the storage period selected is the most critical activity in preventing discharge. Many discharge problems have occurred because producers were unable to manage the activities necessary to remove manure from storage in a timely manner.

Solid manure
Solid manure is usually removed from storage using front-end loaders, scrapers, or other bulk handling equipment. The size of this equipment influences the time required to load hauling equipment. Hauling equipment includes truck-mounted beater; flail or spinner-type spreader boxes; and pull-type spreaders. The size or volume of the hauling equipment used influences the number of trips required to empty manure storage facilities. The hauling distance determines the time necessary to complete a trip.

Slurry manure
Slurry manure should be agitated before and during pumping of the manure from storage. Agitation equipment should be selected to provide sufficient homogenization of the slurry within an acceptable time. Agitation is usually begun several hours before hauling and continued during the hauling operation. Heavy-duty chopper pumps are usually used to load slurry hauling

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**Example 24-2**

Using data in Problem 5, Lesson 21, estimate the number of trips and total time required to empty the slurry tank. Assume tank wagon volume is 6,000 gallons, and round-trip time (including loading and unloading) is 45 minutes. Compare to the time required to empty the storage with a drag-hose system operating with a flow rate of 600 gal/min.

Storage volume = 192,168 ft³ x 7.48 gal/ft³ = 1,437,417 gallons
1,437,417 gallons/6,000 gallons/trip = 240 trips
240 trips x 0.75 hrs/trip = 180 hours

Thus, about 18, ten-hour days would be required to haul manure from the slurry tank with the tankwagon. Pumping time with the drag-hose system is calculated as follows:

1,437,417 gallons/(600 gal/min x 60 min/hr) = 40 hours

About 40 hours of pumping time would be required to empty the storage at a flow rate of 600 gal/min with the drag-hose system. Additional time would be required to lay out mainline and drag hoses and to move this equipment from field to field.
equipment. Hauling equipment includes conventional tank wagons and some box-type spreaders designed to haul slurry. The flow rate capability of the loading pump determines the time required to load, and the size or volume of the hauling equipment determines the number of trips that must be made. Hauling distance is an important factor in total trip time.

Umbilical or “drag-hose” systems are also used in spreading slurry manure. This method offers the advantage of continuous flow, and the slurry manure is injected or incorporated into the soil during spreading. Emptying time with this method depends primarily on the pumping rate through the drag hose. The use of a flow meter is recommended with these systems to ensure that manure is applied at the proper rate.

**Lagoon**

Lagoons may or may not be agitated. If they are not agitated, considerable nutrient buildup in the sludge will occur and will be a factor when sludge is agitated and removed. Lagoon effluent is usually removed by pumping equipment that may be similar to irrigation equipment. Hand carry, solid set, stationary big gun, traveling gun, and center pivot equipment have all been used to land apply lagoon effluent. Drag-hose systems are also sometimes used to apply lagoon effluent. The pumping flow rate of the system is the primary determining factor in the time required to pump down a lagoon.

**EXAMPLE 24-3**

Estimate the time required to pump down the lagoon in Problem 6, Lesson 21. Assume a pumping flow rate of 500 gal/min. Assume the lagoon will not be agitated (sludge volume will not be removed). Volume to be pumped includes manure/bedding; lot runoff; runoff from the 25-yr, 24-hr storm; wash water; and the added depth on the lagoon for rainfall/evaporation and the 25-yr, 24-hr storm.

Summing the appropriate volumes:
199,290 + 59,284 + 27,780 + 146,390 = 432,744 ft³

Estimate the volume of the added 0.5-foot depth of the 25-yr, 24-hr storm by multiplying by the area of the lagoon.
500 ft x 250 ft x 0.5 ft = 62,500 ft³

Total volume to pump = 432,744 + 62,500 = 495,244 ft³
495,244 ft³ x 7.48 gal/ft³/(500 gal/min x 60 min/hr) = 123 hours

About 12, ten-hour days (actual pumping time) would be required to pump the lagoon. Additional time would be required to lay pipe and set up travel lanes, depending on the equipment used.

**For management, large effluent volumes associated with lagoon systems require pumping rather than hauling equipment.**
The Importance of Agitation

Agitation is the most critical operation in maintaining available storage in liquid manure systems. Failure to properly agitate will likely result in a continuing buildup of settled solids that are not removed. The result is less and less available storage as time goes by. Agitation of manure re-suspends settled solids and ensures that most or all of the manure will flow to the inlet of the pump or removal device. Additionally, agitation homogenizes the manure mixture and provides a more consistent nutrient analysis as the manure is being removed. The need for agitation may complicate nutrient analysis. Manure samples for nutrient analysis should be obtained after a pit is well agitated. In most cases, the results of such an analysis will not be available before land-applying the manure. In these cases, analysis results from prior pumping events can be used to anticipate the present analysis (and estimate proper application rate), and the present analysis, when available, can be used to calculate the nutrients actually applied.

Agitation of manure storage facilities releases gases that may increase odor levels and present a health hazard. Considerations should be given to weather and wind conditions, time of day, and day of the week to minimize the possibility of odor conflicts while agitating.

Slurry systems

Many types of agitators are available for agitating slurry systems. These include hydraulically or mechanically driven propellers or choppers, bypass devices on manure loading pumps, and others. Careful thought should be given to the design and configuration of slurry manure storage facilities so that they can be adequately agitated. Placement of the agitator (ports, annexes) and the volume to be agitated are important considerations.

Effective agitation at distances greater than 40 to 50 ft from the agitation device may be difficult to achieve in slurry storage facilities. Hence, consideration should be given to limiting “compartment size” to these dimensions, and providing adequate access for pumping and agitating each compartment. A slurry storage may require several hours of agitation before it is sufficiently mixed for pumpout.

Underfloor pits in confinement buildings are particularly susceptible to solids buildup if not properly agitated. Many underfloor pits were not designed for convenient, effective agitation. To minimize solids accumulation and maintain the design storage period, an underfloor pit must be adequately agitated at each pumping event. The type of agitator to be used should be considered in pit design. Some pumps are designed to operate in both agitation and pumping modes. These pumps can provide effective agitation if access to the pit is available as noted above. Experience has shown that underfloor pits with pipes through the pit wall angled to the surface outside the building are difficult to agitate and empty. The practice of removing a load of manure from the pit by vacuum and then “blowing” it back into the pit usually does not provide sufficient agitation to suspend solids.

The agitation and manure pumping system should allow agitation while manure is being loaded or pumped (as with a drag-hose system), as well as prior to pumping.
Most pumping equipment will not remove the “last” few inches of manure from the pit floor. This factor should be considered in designing pit depth and the associated storage period. If the pump intake is located in a sump in the pit floor, more complete emptying is possible. However, sumps can collect rocks and other debris that can cause pump damage.

**Lagoon systems**

In the past, it was not a common practice to agitate lagoons for pumpdown. The relatively large volume of lagoons and relatively “clean” water on the lagoon surface did not indicate a compelling need to agitate lagoons. However, as many years of experience was gained, the effects of sludge buildup and nutrient accumulation became more obvious and pronounced. Lagoons receiving significant amounts of bedding experienced high rates of sludge buildup. Sludge buildup will eventually displace needed treatment and storage volume if not periodically removed. Additionally, nutrients, particularly phosphorus, tend to concentrate in sludge and may represent a difficult management problem if sludge is allowed to build up over a number of years before it is removed. Sludge buildup in lagoons should be monitored, and sludge should be periodically removed if significant volumes accumulate in the bottom of the lagoon.

Since lagoons are relatively large, agitation can be an imposing problem. Power takeoff (PTO)-driven propeller agitators are the best choice for agitating lagoons. These units are available in lengths up to 40 ft or longer and provide the greatest flow rate of any type of agitator. They also require relatively large power units (100-150 hp) to operate at full capacity. Large lagoons may require two or more of these agitators operating simultaneously at different locations around the lagoon to provide adequate mixing. Extremely large lagoons may require dredging equipment similar to that used in the municipal sector.

**Lagoon Monitoring and Condition Parameters**

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

**Startup and loading procedures**

Lagoon startup is a very important factor in developing a mature lagoon that has an acceptable odor level and will perform in the expected manner over the long term. Lagoons are designed with a “treatment volume” that provides an environment for development and maintenance of a bacterial population that degrades and stabilizes manure. The size of the treatment volume is based on a volatile solids (VS) loading rate, which depends primarily upon temperature. Volatile solids are the “non-mineral” or organic solids in manure that are subject to bacterial degradation. At warmer temperatures, bacteria are more active and VS loading rates are higher. The converse is true for cooler temperatures. For the bacteria to develop and function properly, the actual VS loading rate should be as designed. The proper VS loading rate is achieved only if the lagoon contains a volume of

Lagoon agitation reduces long-term accumulation of nutrients that could present management problems when the facility is taken out of service.
water equal to the treatment volume at startup. A lagoon with only one-tenth of the treatment volume filled at startup will experience an “overload” by a factor of 10 (VS loading rate is ten times greater than designed). Therefore, it is very important to plan a procedure to have sufficient water in a lagoon at startup. The treatment volume should be used as a target. Achieving this goal may require identifying a water source (pond, lake) and implementing the needed pumping procedures to transfer the desired volume of water to the lagoon. Since bacteria are more active at warmer temperatures, consideration should be given to starting a lagoon in the spring or early summer. In this way, bacteria will have a warm season to establish themselves before activity slows during the winter. Spring startup of lagoons often requires special planning of construction schedules and animal procurement.

Problems associated with insufficient volume at startup include excessive odor and high rates of sludge buildup. A lagoon that is started with insufficient volume may take years to recover and may never attain an operating state equal to a lagoon that is started properly.

In addition to startup, long-term loading procedures are critical to lagoon performance. A somewhat common and unfortunate practice in the livestock industry is to expand animal numbers without expanding lagoon size. This results in a proportionate increase in VS loading, and the associated problems can be expected to develop. Volatile solids loading should not be increased beyond the design loading. Alternatives to reduce VS loading (or expand animal numbers) include solids separation, construction of additional lagoon volume, or pretreatment of manure. Lagoons should also receive manure in a consistent manner (no “slug” loading). This is usually accomplished in modern production systems utilizing hydraulic transport of the manure to the lagoon.

Salt levels in a lagoon should be monitored because high levels can reduce lagoon performance.

Many manure releases and spills occur during pumping activities. Extra care should be taken during these operations.

Salt and nutrient levels, testing

Bacterial activity is somewhat sensitive to salt levels in the lagoon. Salts are a natural byproduct of the biological degradation of manure. The removal of some salts as the lagoon is pumped and the addition of fresh water via rainfall, runoff, and wash water combine to generally keep salt levels within an acceptable range. However, some conditions can occur that may lead to elevated salt levels. These include extended periods of dry weather, high rates of evaporation, little or no dilution with lot runoff and wash water, and perhaps overloading of the lagoon. Elevated salt levels inhibit bacterial activity, and lagoon performance is characterized by increased odors or “sour” smells and increased sludge buildup rates. A simple field test called “electrical conductivity” (EC) is effective in monitoring salt levels. A University of Missouri study found that EC values in the range of 8,000 to 12,000 umho/cm were associated with greatest bacterial activity. If salt levels rise too high in a lagoon, the most effective remediation is to pump the lagoon and add water from a freshwater source (pond or lake). The availability of such a freshwater source is an enhancement to long-term lagoon operation, and consideration should be given to such a source when planning a lagoon.

While overall salt levels are the primary concern in lagoon health, occasionally other more specific compounds may affect lagoon performance. These might include copper, arsenic, (dietary inputs), certain medications, and perhaps excessive use of harsh cleaning agents. If reduced lagoon performance is suspected due to factors such as these, specific testing may be required to isolate the source.
Overall Monitoring Activities

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

Monitoring during pumping activities

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

Periodic inspections and checklists

A manure storage facility should be inspected periodically to ensure that any potential problems are detected before environmental impacts occur. The frequency of inspections may vary, but a regular inspection schedule should be developed and followed for each system. Inspection frequency might depend on such factors as system size, system complexity, mechanical devices (recycle pumps, float switches in reception pits), flow rate of recycle system, proximity to a sensitive water source, and type of storage facility. Checklists offer a means of ensuring that all items are inspected and noting when they were inspected. They also are evidence of environmental stewardship and may be useful in the event of litigation.

An example checklist for manure storage facilities is included in Appendix B at the end of this lesson.

Liners

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

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

When a lagoon is pumped or other manure storage structure is emptied, the date of the activity should be recorded along with the volume or amount of manure removed, locations where the manure is spread, and the nutrient content (lab analysis) of the manure. This information may be required by the regulatory agency for interim or year-end reports, or may be useful in the event of litigation.

Pumpdown or manure-level markers

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

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

- When pumping operations should begin and end
- Level at which overflow will occur
- Fraction of total storage that is currently filled

A common practice is to install steel fence posts at the upper and lower pumpdown levels for earthen impoundments. While this approach provides basic information on beginning and ending pumpdown, experience has shown that more knowledge is needed. Also, fence posts installed in this manner are subject to damage and displacement. A good pumpdown marker will indicate the level, or elevation, of manure throughout the possible range (from lower pumpdown level to overflow, or spillway) in the storage facility. Experience has shown that a 6 inch by 6 inch treated wood pole properly imbedded makes a good pumpdown marker. Notches or other indicators can be carved into the pole to show pertinent elevations. Painted numbers or colors on the pole are not durable enough to maintain readability over a number of years. Figure 24-1 shows a type of pumpdown marker that provides the information needed.

Weather stations

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

**Aesthetics and Appearance**

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

**General cleanliness and sanitation**

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

**Mowing**
Few activities undertaken by the producer are as effective as frequent mowing in conveying a positive image of livestock production. Producers who maintain “front yard quality” around the production and manure storage facilities provide a powerful first impression of pride and responsibility. Conversely, the presence of tall grass, weeds, shrubs, and trees in undesirable locations creates an impression of laxity and disrespect for environmental responsibility. Regulatory personnel inspect most livestock production and manure storage facilities at some interval. If tall grass, weeds, brush, and trees hamper the inspector, a positive report is an unlikely outcome. Routine inspections for seepage, rodent burrowing, erosion, or other damage are much more effective if the areas have been mowed at regular intervals.

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

**Closure of Earthen Impoundments**
Earthen manure storage impoundments may be abandoned for a number of reasons. These reasons may include termination of the livestock production enterprise, financial hardship or bankruptcy, or a change in the way manure is handled in the manure management system. Regardless of the reason, abandoned earthen manure storage facilities represent a potential environmental concern.

**Regulations**
Some states may have specific regulations regarding earthen impoundments no longer used for manure storage and treatment. Regulations may include some or all of the following primary elements:
- Management of impoundment before closure
- Removal of impoundment contents
- Land application of impoundment contents
- Impoundment closure
- Conversion to farm pond
Management of impoundment before closure. There is often an interim period when animals are no longer produced and manure is not being introduced into the lagoon. During this period, the lagoon should be managed and maintained in accordance with normal recommended practices. Overflow or discharge must not be allowed, and the contents should be land applied in accordance with good agronomic practice.

Removal of impoundment contents. An earthen impoundment closure plan (if required) will include partial or complete removal of the impoundment contents. This operation can be quite challenging due to the materials to be removed. The contents usually include some relatively dilute liquid, some slurry, and some sludge accumulation. The dilute liquid and slurry portions can usually be agitated and removed with pumping equipment. Complete sludge removal may be difficult due to the highly viscous nature of the sludge and difficulty in maneuvering within the impoundment with the necessary equipment. Preservation of the existing impoundment seal may be more important than complete sludge removal.

Land application of impoundment contents. A closure plan should include land application of the nutrients according to an accepted nutrient management plan. Lagoon sludges are especially rich in accumulated phosphorus, and land area requirements may be based on phosphorus rather than nitrogen. An attempt should be made to estimate nutrients to be removed during closure. This requires probing the impoundment to determine sludge levels, analyzing sludge and liquid samples, and calculating nutrients based on relative volumes of sludge and liquid. This information may be required by the regulatory agency for approval of a closure plan.

Impoundment closure. After emptying, the impoundment should be filled with soil and landscaped in accordance with the original land contours. Fill material and compaction should be sufficient so settling and ponding do not occur. Surface water should be diverted from the site, and a growing crop or sod should be established on the fill’s surface.

Conversion to farm pond. Regulations may allow conversion of the impoundment to a farm pond. Water quality characteristic of a farm pond may be difficult to achieve if some solids remain in the impoundment. “Rinsing” the impoundment by filling with fresh water and pumping as with lagoon effluent (several times may be required) may be necessary to achieve water quality sufficient to support aquatic life and be suitable for discharge. Structural and operational features may need to be added, such as a principal and/or emergency spillway. Since most earthen manure impoundments are located on a site that minimizes surface water, sufficient watershed may not be available for optimum pond performance.

Some states may require that a management plan for closure of a manure impoundment be developed and submitted for approval by the regulatory agency before closure activities are begun.
## APPENDIX A

**Regulatory Compliance Assessment: Operating and Maintaining Manure Storage Facilities**

<table>
<thead>
<tr>
<th>Regulatory Issue</th>
<th>Is this issue addressed by regulations?</th>
<th>Is my livestock/poultry operation in compliance?</th>
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<tbody>
<tr>
<td></td>
<td>If “Yes,” summarize those regulations.</td>
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<tr>
<td><strong>Written Management Plan Requirements</strong></td>
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<tr>
<td>Is a plan required for . . .</td>
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<td></td>
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<tr>
<td>Operation and maintenance of the storage and associated equipment?</td>
<td>__Yes __ No If Yes, summarize:</td>
<td>__Yes __ No Don't Know</td>
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<td></td>
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<tr>
<td>Emergency response to storage-related spills or failures?</td>
<td>__Yes __ No If Yes, summarize:</td>
<td>__Yes __ No Don't Know</td>
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<tr>
<td>Groundwater monitoring in vicinity of manure storage facilities?</td>
<td>__Yes __ No If Yes, summarize:</td>
<td>__Yes __ No Don't Know</td>
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<tr>
<td><strong>Record-Keeping Requirements</strong></td>
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<td>Are there requirements for keeping records of manure storage facility . . .</td>
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<td>Inspections?</td>
<td>__Yes __ No If Yes, summarize:</td>
<td>__Yes __ No Don't Know</td>
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<tr>
<td>Manure levels?</td>
<td>__Yes __ No If Yes, summarize:</td>
<td>__Yes __ No Don't Know</td>
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<tr>
<td>Date and amount of manure removals?</td>
<td>__Yes __ No If Yes, summarize:</td>
<td>__Yes __ No Don't Know</td>
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<tr>
<td>Maintenance?</td>
<td>__Yes __ No If Yes, summarize:</td>
<td>__Yes __ No Don't Know</td>
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<td>Other operation and maintenance requirements?</td>
<td>__Yes __ No If Yes, summarize:</td>
<td>__Yes __ No Don't Know</td>
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<td>Manure nutrients and other characteristics?</td>
<td>__Yes __ No If Yes, summarize:</td>
<td>__Yes __ No Don't Know</td>
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<tr>
<td><strong>Regulatory Access to Records</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do records need to be . . .</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Submitted to regulatory agency?</td>
<td>__Yes __ No If Yes, to whom and how frequently?</td>
<td>__Yes __ No Don't Know</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kept on file for regulatory agency review?</td>
<td>__Yes __ No If Yes, for how long?</td>
<td>__Yes __ No Don't Know</td>
</tr>
</tbody>
</table>
## APPENDIX B

### Monthly Manure Storage/Lagoon Checklist

<table>
<thead>
<tr>
<th>Farm:</th>
<th>Pit/Storage/Lagoon ID:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspected by:</td>
<td>Date:</td>
</tr>
</tbody>
</table>

### Manure/Effluent Level and Other Observations

<table>
<thead>
<tr>
<th>今日</th>
<th>Last Observation: [日期]</th>
</tr>
</thead>
<tbody>
<tr>
<td>液体高度:</td>
<td>[英尺]  [英尺]</td>
</tr>
<tr>
<td>剩余深度:</td>
<td>[英尺]  [英尺]</td>
</tr>
</tbody>
</table>

| 是否有液位标记器可用且可见? | 是/否 | 补救行动已采取/计划?
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>储存/池塘: 是否存在18英寸的自由间隙?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>汇流池: 是否有足够的体积可防止25年，24小时的径流?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>粪肥泵/传输管道是否正常工作？</td>
<td></td>
<td></td>
</tr>
<tr>
<td>再循环泵/传输管道是否正常工作？</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 土结构

| 内部衬里侵蚀观察 . . . | 是/否 | 补救行动已采取/计划?
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>由于波浪作用?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>由于在入口处?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>由于在出口处?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>由于降雨侵蚀?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>由于搅拌设备访问点?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 存在波堤/大坝损害的迹象 . . .

| 埋葬动物? | | |
| 存在树木? | | |
| 存在大型杂草? | | |
| 液位或沟壑? | | |
| 稀疏而坚实的草皮? | | |

### 补救行动已采取/计划?

| 是/否 | 补救行动已采取/计划?
|------|------------------|
| 从最低点在坝，波堤或溢流液位。

---

1. Measured from lowest point in dam, berm, or spillway to liquid level.
**APPENDIX B**
Monthly Manure Storage/Lagoon Checklist (continued)

<table>
<thead>
<tr>
<th>Concrete/Steel Tanks</th>
<th>Yes</th>
<th>No</th>
<th>Corrective Action Taken/Planned?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Signs of ...</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cracks or structural damage?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leakage?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wet spots around base of tank?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Clean water diversion</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are perimeter drains plugged or blocked?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is roof water entering storage?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is field runoff entering storage?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are diversions/waterways maintained?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Visual appearance and safety</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is site neat and recently mowed?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is storage visually hidden from public?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are mortality or afterbirth observed?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are medical consumables observed?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is area fenced and properly marked?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is escape ladder available?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Odor</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anaerobic lagoon is ...</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Purple?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At least 1/3 full?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actively bubbling?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Manure storage or holding pond is ...</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Covered or crusted over?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>All structures</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are all inlet pipes submerged?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate downwind odor from facility:</td>
<td>None</td>
<td>Faint</td>
<td>Distinct</td>
</tr>
</tbody>
</table>
About the Authors

This lesson was prepared by Charles Fulhage, Extension Agricultural Engineer, and John Hoehne, Extension Agricultural Engineer–Commercial Agriculture Program, both at the University of Missouri, Columbia, when the lesson was developed. The first author can be reached at the following e-mail address:
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Glossary

25-year, 24-hour storm. Specific storm event required by federal regulation to be accumulated and stored in a manure management system.

Drag-hose system. Land application method in which manure is continuously pumped to a field applicator. The applicator moves while dragging a flexible hose.

Earthen impoundment. Impoundment made by excavation or earthfill for temporary storage of animal or other agricultural waste.

Effluent. The liquid discharge of a waste treatment process.

Electrical conductivity (EC) test. Measure of a solution’s ability to carry an electrical current, which in turn is an indication of salt levels in a lagoon.

Loading. Quantity of substance entering the receiving body, primarily indicates amount of manure entering a lagoon.

Pumpdown. Periodic removal of manure or effluent from a manure storage facility.

Sludge. Settled, partially decomposed solids that accumulate at the bottom of a manure storage facility.

Slurry. Manure that has had sufficient water added so that it can be pumped.

Treatment volume. The permanent volume in a lagoon, which provides an environment for biological degradation of manure solids.

Volatile solids (VS). The organic fraction of manure solids that is subject to bacterial degradation.
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Livestock and Poultry Environmental Stewardship Curriculum: Lesson Organization
This curriculum consists of 27 lessons arranged into six modules. Please note that the current lesson is highlighted.

Module A. Introduction
1. Principles of Environmental Stewardship
2. Whole Farm Nutrient Planning

Module B. Animal Dietary Strategies
10. Reducing the Nutrient Excretion and Odor of Pigs Through Nutritional Means
11. Using Dietary and Management Strategies to Reduce the Nutrient Excretion of Poultry
12. Feeding Dairy Cows to Reduce Nutrient Excretion
13. Using Dietary Strategies to Reduce the Nutrient Excretion of Feedlot Cattle

Module C. Manure Storage and Treatment
20. Planning and Evaluation of Manure Storage
21. Sizing Manure Storage, Typical Nutrient Characteristics
22. Open Lot Runoff Management Options
23. Manure Storage Construction and Safety, New Facility Considerations
24. Operation and Maintenance of Manure Storage Facilities
25. Manure Treatment Options

Module D. Land Application and Nutrient Management
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31. Manure Utilization Plans
32. Land Application Best Management Practices
33. Selecting Land Application Sites
34. Phosphorus Management for Agriculture and the Environment
35. Land Application Records and Sampling
36. Land Application Equipment

Module E. Outdoor Air Quality
40. Emission from Animal Production Systems
41. Emission Control Strategies for Building Sources
42. Controlling Dust and Odor from Open Lot Livestock Facilities
43. Emission Control Strategies for Manure Storage Facilities
44. Emission Control Strategies for Land Application

Module F. Related Issues
50. Emergency Action Plans
51. Mortality Management
52. Environmental Risk and Regulatory Assessment Workbook