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Closure of Lagoons and Earthen Manure Storage Structures

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When confined livestock or poultry production facilities cease operations, the earthen manure storage and treatment structures must be closed properly to ensure that surface water and groundwater are protected. These structures include lagoons, settling basins and waste storage ponds.

Earthen manure treatment and storage structures pose little risk to water quality if they are properly designed, installed, operated and maintained. However, those that are poorly designed, installed, operated or maintained are subject to soil erosion, animal burrows, liner damage and weed and tree growth. These conditions can lead to significant spillway discharges and liquid manure seepages that can contaminate surface and groundwater.

The principles and procedures for proper closure explained below include recommendations from *Closure of Earthen Manure Structures*, published by the National Center for Manure and Animal Waste Management, which is supported by the U.S. Department of Agriculture (USDA) Fund for Rural America Program. They also include the criteria in *Conservation Practice Standard 360 — Closure of Waste Impoundments*, from the USDA/Natural Resources Conservation Service (NRCS).

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Federal and state regulations

According to state regulations, owners of concentrated animal feeding operations (CAFOs) with new individual permits must close their animal waste retention structures according to wastewater permitting rules of the Texas Natural Resource Conservation Commission (TNRCC, which will be known as Texas Commission on Environmental Quality [TCEQ] effective September 1, 2002). New permit rules require that a closure plan be developed by a Texas licensed professional engineer and be submitted for approval to the TNRCC within 90 days of discontinuation of use.

At a minimum, all CAFO owners who are temporarily closing or permanently ceasing operations must:

- Remove all waste and wastewater from the structures within 1 year of discontinuing use.
- Submit within 90 days of discontinuation a notarized certification that the structure has been closed according to this provision, place a map depicting the location of the closed structure in the Pollution Prevention Plan and send it to the local TNRCC regional office and to the TNRCC Agriculture Team in Austin.

The U.S. Environmental Protection Agency (EPA) has drafted CAFO regulations that are expected to be enacted in 2003. These regulations would require operators of permitted CAFOs that cease operations to retain their National Pollution Discharge Elimination System permits until all facilities are closed properly. These facilities include waste retention structures that can no longer discharge.

Also, if a facility ceases to be an active CAFO (for example, it ceases to operate or decreases the number of animals below the threshold that defined it as a CAFO), the CAFO must remain permitted until all wastes at the facility no longer have the potential to reach U.S. waters.

The EPA has delegated to the TNRCC the responsibility of protecting Texas water according to the Clean Water Act. As a delegated state, the Texas CAFO regulations must be at least as strict as the regulations and permit requirements set forth by the EPA.

Closure options

Regardless of the intended end use, all pipes and ditches used to convey manure to the structure should be removed and replaced with compacted soil. Remove as much sludge and solid material from the structure as possible without endangering the integrity of the existing liner. Land-apply all liquids and pumpable sludge (slurry) at agronomic rates.

There are three generally acceptable options for completing the closure process; liquid and sludge removal and environmentally safe use are part of each option:

Option A: Permanently eliminate an excavation-type earthen manure structure.

- Divert all surface water away from the storage site.
- Remove from the structure all liquid and solid waste (sludge) and, if needed, some of the nutrient-enriched soil.
- Fill the storage structure with soil to a mounded surface that sheds rainwater.
- Establish sod or a growing crop.

Option B: Permanently eliminate an embankment-type earthen manure structure.

- Divert all surface water away from the storage site.
- Remove from the structure all liquid and solid waste (sludge) and, if needed, some of the nutrient-enriched soil.
- Breach the embankment when the structure is dry and emptied of solids.
- Establish a growing crop or sod on the bottom and on the remaining embankment and pool-area side slopes.

Option C: Permanently convert the structure to a farm pond.

- Establish a maximum water level.
- Remove from the structure all liquid and solid waste (sludge) and, if needed, some of the nutrient-enriched soil.
- Rinse the storage structure several times and use the rinsate to irrigate crop or pasture land.
- Modify the system as needed or desired to ensure that the drainage area is adequate or to enhance the benefits to wildlife, fish, ducks, etc.
- Refill the structure with fresh water.

Special Case - Temporary closure

- If an operation is depopulated temporarily, take steps to minimize runoff of contaminated wastewater into the earthen manure structure and to prevent wastewater discharge from entering it.

Preparing earthen manure structures for closure

Personal safety

The most important consideration in closing a manure storage structure is safety. Because the structure may not have been designed to include the appropriate safety features, take care during closure activities to minimize the contact of vehicles and individuals with solid and liquid waste.

The ramps for emptying liquids should have a slope of 4 horizontal to 1 vertical or flatter. Those that are used to empty slurry, semisolid or solid waste should have a slope of 10 horizontal to 1 vertical, or flatter, unless special traction surfaces are provided.

To ensure the safety of people and livestock, provide warning signs, fences, ladders, ropes, bars, rails and other devices during and after closure, as appropriate. If the ventilation is poor, gases released from agitating and pumping liquid manure in a covered pit can kill people and animals.

If the structure to be closed is covered, post adequate ventilation and warning signs. Erect fences and post warning signs around ponds and uncovered fabricated structures for liquid or slurry waste with walls less than 5 feet above the ground to prevent children and others from using them.

Pathogens (disease-causing agents) associated with animal manure and wastewater are a health concern for those coming in direct contact with them during slurry agitation and removal. Among the pathogens in manure and wastewater of concern to people are viruses; bacteria such as *E. coli*, *Campylobacter* and salmonella; and protozoa (single-celled aquatic animals) such as *Cryptosporidium parvum* and *Giardia*.

After the liquid manure has been agitated and removed, you may opt to treat the remaining solids with disinfectants such as hydrated lime to reduce your exposure to pathogens.

Because lime products are very caustic, handle them carefully to prevent injury. Wear protective clothing — including gloves and shoes — when taking samples of sludge and wastewater.

Protecting the integrity of earthen liners

It is usually less threatening to the environment to maintain an intact liner than to try to remove it. If the liner was poorly designed, built or managed, or if it has been damaged, it may have let nitrogen seep into the soil below. If so, you may wish to remove part of the soil liner.

However, this action should be the exception rather than the rule. A knowledgeable consultant should determine the need for such measures after soil borings and inspection.

Sludge sampling

For most structures, the sludge should be measured and sampled from a boat. To ensure safety, at least three people should be present — two in the boat and one on the lagoon bank. Those in the boat can help each other enter and exit the boat, find sample points and take samples. The person on shore can be an emergency rescuer if needed.

Use flat-bottom boats rather than canoes or V-bottom boats. Everyone in the boat should wear appropriate life preservers.

To measure the sludge depth in a lagoon and estimate its volume, slowly lower a lightweight, rigid, 0.5- to 1-inch-diameter wooden or capped aluminum pole into the lagoon until the liquid seems to become thicker. Record the water level on the pole and continue to push the pole down until you feel it has reached the bottom of the lagoon. Record the water level on the pole again and remove it from the lagoon.

The difference between the readings is the depth of the sludge. Take at least 10 random depth measurements of the entire structure. For a more detailed assessment of sludge volume, establish a formal rectangular grid over the surface of the structure as shown in Figure 1.

The EPA recommends that you use at least four rectangular grid points per cell, with no grid points representing more than 10,000 square feet. Plot the depth measurements at grid points to develop a contour map of sludge deposits on the bottom of the storage. Consult the local Natural Resources Conservation Service office or a land surveyor for recommendations.

It is best to take a sludge sample while you are measuring the liquid and sludge volumes. This allows you to collect samples from several points in the interior of the lagoon. Depending on the density and nutrient concentration of the effluent, the physiochemical contents of the sludge sample may differ by as much as 100 percent from point to point.

To extract a sample, insert a 0.5- to 0.75-inch-diameter PVC pipe into the lagoon sludge until the pipe reaches the bottom. Wearing plastic or latex gloves, cap the end of the pipe to create a vacuum and slowly withdraw it from the lagoon. This will capture a core of lagoon effluent and sludge.

Move the pipe outlet over a clean container, then slowly break the vacuum. Place at least 10 samples in the container and mix them thoroughly. Put the mixed samples in a wide-mouth plastic bottle and follow laboratory instructions for shipping the samples for analysis.

For information on sampling and interpreting test results, see Texas Cooperative Extension publication L-5175, *Managing Crop Nutrients through Soil, Manure and Effluent Testing* (available at *http://tammi.tamu.edu/pubs.html).*

Removal of liquids, pumpable sludge and remaining solids

There are several ways to remove sludge and remaining solids from earthen manure structures:

- Agitate and remove the combined contents (slurry) of the structure and land-apply them.
- Remove and land-apply some of the liquids, saving enough liquid to mix with the sludge. Then agitate, remove and land-apply the sludge using a slurry wagon.
- Dredge and land-apply air-dried sludge, dewater the structure and land-apply the remaining solids after air drying.
- Agitate and remove the combined contents of the structure, use a separator to concentrate and remove the solids. Then use the solids and liquids separately.
- Use a sludge dredge and land-apply the sludge without dewatering it.

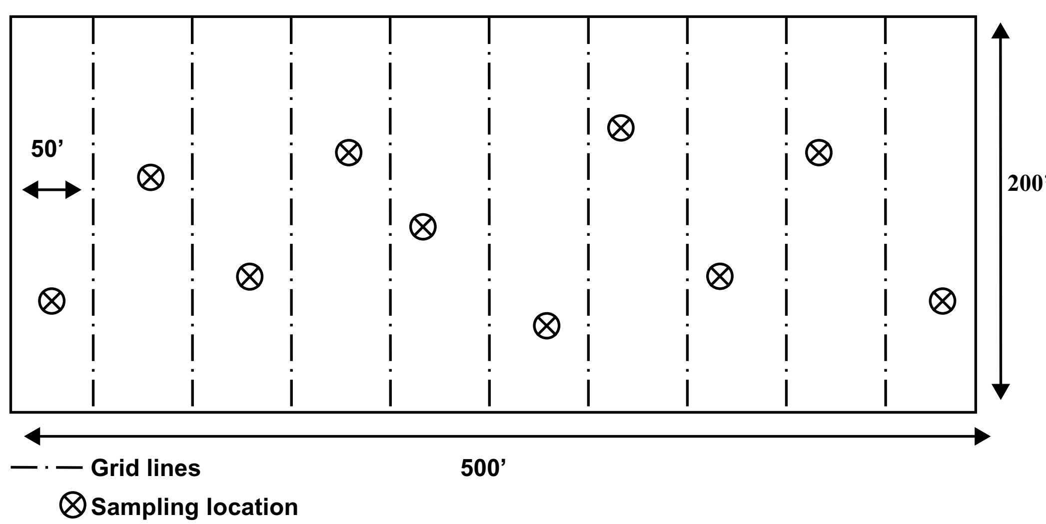

Figure 1. Diagram of a 100,000-square-foot (500 feet by 200 feet) surface area lagoon with grid lines and randomly picked sludge sampling and depth measurement locations.

Agitate the combined contents of the structure and land-apply

To use this method, mix the liquid and sludge with an agitator or a chopper-agitator impeller pump. High-volume pumps (3,000 to 5,000 gallons per minute) specifically designed for agitation will suspend the solids.

However, agitation equipment can effectively suspend solids only within about 50 feet of the agitator. Be careful when using agitation equipment because it can also erode the earthen liner near the agitator.

Ideally, paved pads should have been installed at the agitation points when the lagoon was built. If not, make sure that the agitator directs its flow away from the liner and keep the agitator at least 3 feet from it.

Research on slurry removal from dairy lagoons in Texas has found that steep embankment slopes reduce the traction of wheel-mounted pumping and agitation equipment, posing a safety hazard. Also, on steep slopes, tractor lubrication systems may not operate properly, causing mechanical problems. The universal joints may malfunction if the implement drivelines reach a locking angle. Therefore, use a maximum deflection angle of 15 degrees per universal joint.

The mixed slurry can be pumped through a large-bore sprinkler irrigation system onto nearby cropland. A second pump is often needed to carry and apply the slurry to the field.

At many sites, the slurry should be incorporated into the soil to minimize odor, nitrogen volatilization and runoff.

Remove and land-apply liquids; agitate, remove and land-apply sludge with slurry wagon

Dewater most of the liquid waste in the earthen structure by irrigating it onto nearby cropland or forage land. Then agitate the remaining liquid with the sludge and pump it into a sludge slurry applicator. The sludge can then be spread onto cropland or forage land or incorporated into the soil.

This method may not work as well with dairy manure because it is more fibrous, the particles are larger and it contains more solids than do swine and poultry manure.

After removing the liquid and most of the sludge, depending on the condition of the liner, you may need to remove any remaining solids with a small track-type dozer or farm tractor with a bucket.

Dredge and land-apply air-dried sludge, dewater the structure and land-apply remaining solids

Remove the sludge with a dragline or sludge dredge (Fig. 2). If you use a dragline, first dewater the structure by irrigating the water onto nearby cropland or forage land. If you use a sludge dredge, dewater after removing the sludge. Then dewater the existing earthen structure by irrigation onto nearby cropland or forage land.

Air-dry the sludge in the temporary impoundment (if applicable) and/or existing structure, then haul the solids onto cropland or forage land and spread them with a solid manure separator at agronomic rates. Where feasible, incorporate the sludge into the soil to better retain and use the nutrients.

If the manure is more fibrous, it may be practical to establish a sloping temporary impoundment to receive the dredged sludge. If you choose this option, isolate the temporary structure from outside runoff and locate it beside the existing structure.

Once placed in the temporary impoundment, the liquids draining from the dredged sludge should drain back into the existing earthen structure for land application or storage. This procedure helps the sludge dry more quickly and allows more solids to separate. This option is more feasible for cattle manure than for swine or other nonfibrous sludge that does not stack well.

When removing sludge, the operator of

the dredge or dragline must pay close attention to ensure that the soil liner is not accidentally penetrated. Liner damage may not be noticeable until the liquid level drops.

If the soil liner is disturbed, stop the activity immediately and do not continue until operations are modified to prevent further damage. If the structure is being closed or converted to a farm pond, repair the damaged liner with suitable soil as soon as possible.

Agitate the contents of the structure, concentrate and remove solids, and land-apply

Thoroughly agitate and remove all contents from the manure structure. Mechanically separate the solids from the mixture of sludge and liquid and land-apply the liquid. The solids can be land-applied, composted or used for other environmentally safe purposes.

Use a sludge dredge and land-apply without dewatering

Pumping dredges are often used to remove solids from municipal and industrial wastewater lagoons and holding ponds. These dredges typically comprise a floating barge and a variable-depth pumping head to remove sludge from the bottom of the structure (Fig. 2 and 3). The power units can be located on either the barge or the embankment, as with hydraulically operated pumping heads.

Because the sludge is removed without agitation, or dilution, you can remove a higher concentration of solids from the lagoon, thus reducing transportation costs. Aided by guide cables, the pumping dredges work back and forth across a lagoon, working their way down the earthen structure until the solids are removed. Because pumping dredges do not use aggressive agitation or cleaning nozzles, equipment manufacturers and operators claim that they do not damage earthen liners.

Pumping dredges work best where the earthen structures are large or where large amounts of solids must be removed. Because of their size and weight, the dredges may be placed into and removed from an earthen structure with a crane. The dredged solids are land-applied, composted or used for other environmentally safe purposes.

This method is most applicable for a temporary structure closure or for operation and maintenance on an operating storage structure. It could be used on a permanent closure if the structure is also dewatered after dredging.

Figure 2. Pumping dredge operating in a lagoon.

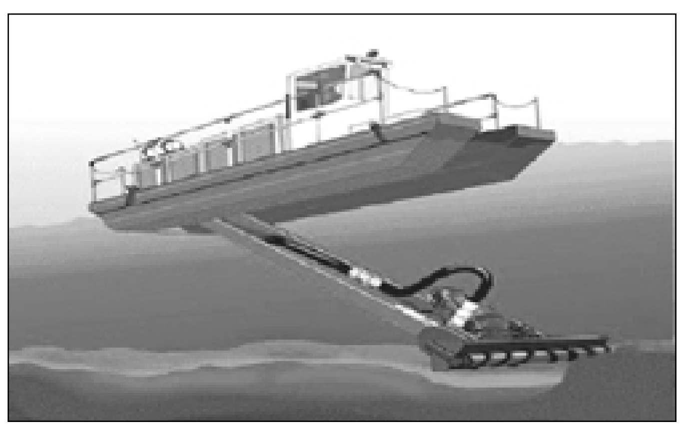

Figure 3. A schematic drawing of the sludge being removed.

Estimated cost of liquid and sludge removal

Often a concern in closing an earthen manure structure is the cost. In many cases, the animal feeding operation is closing because of financial difficulties, and limited funds are available to close the waste storage structures properly.

In 2000, the North Carolina Department of Environmental and Natural Resources (DENR) estimated that the cost of closure was $42,000 per acre of surface area. The actual closure costs in North Carolina that year were $5 to $32 per 1,000 gallons of waste removed, according to the Environmental Review Commission of the North Carolina General Assembly.

The pumping cost may be partially offset by the nutrient value of the sludge. Many lagoons accumulate sludge for 10 years or more before their ability to treat the waste declines. Also, the cost of removal equipment is prohibitive for most producers, especially because the sludge is seldom removed.

Often a feasible way to manage the sludge is to hire a custom applicator. This cost is largely based on the amount of sludge to be removed.

A 1999 survey of custom applicators in eastern North Carolina showed that removal prices ranged from 1.5 to 5.0 cents per gallon of sludge. The difference in cost depended on the size and accessibility of the lagoon to be pumped, the distance from the lagoon to available application sites, and the method of sludge application — whether it was to be irrigated, broadcast or injected.

Land application of liquid and sludge at agronomic rates

The material removed from storage structures contains significant amounts of nutrients. Producers should obtain a nutrient analysis, estimate the proper application rate based on soil tests and crop nutrient needs, and monitor the actual application rate.

The accumulation of phosphorus in the sludge requires the largest amount of acreage, based on crop agronomic needs. Research has been conducted on samples of sludge and a mixture of sludge and supernatant (liquid above sludge) from dairy, poultry and swine lagoons in North Carolina and Texas. The studies found much more nitrogen and phosphorus in the samples than in the effluent alone. Therefore, nutrient management plans should include estimates for life cycle land area requirements for the future closing of waste impoundments.

It is recommended that USDA/NRCS Conservation Practice Standards for Nutrient Management (590) and Waste Utilization (633) be followed when planning and applying animal waste materials.

The amount of land area needed for applying sludge during closure depends on:

- Nutrient content of the sludge
- Nutrient content of the supernatant
- Crop to be grown
- Soil type
- Existing soil fertility level in planned land application area
- A surplus of phosphorus in the planned land application area
- Local/state regulations
- Application method

Do not apply nutrients at a higher rate than the annual nitrogen requirements. Check the soil phosphorus levels at the application area annually until test results indicate that a commercial phosphorus application is needed.

Evaluate the application sites for their current soil phosphorous levels and for the risk of runoff or erosion that could contaminate surface water. When selecting suitable land application sites, follow state regulations and best management practices.

Specific earthen manure storage closure procedures

Option A. Permanent elimination of pit-type earthen storage structures

1. *Divert all surface water runoff away from the structure.* This includes runoff from building roofs, abandoned feedlots and cropland.
2. *Remove pipes and structures that add runoff or manure to the structure.*
3. *Remove all liquid and pumpable sludge and solids.* For details, refer to the dewatering procedures discussed earlier.
4. *Fill the structure with soil.* Push in existing dams or embankments and bring in additional fill as needed. To allow for settlement, make sure that the backfill height is 5 to 10 percent higher than the design finished grade.

   The degree of compaction required for backfill material depends on the future use of the site. For example, a higher compaction is needed for building construction than for animal pasture or cropland. The soil must be compacted enough to prevent the development of a depression that collects rainwater. If a depression occurs because of unexpected settlement, additional earth fill may be required after a year or two.
5. *Establish a crop cover or sod.* To minimize erosion, till the final surface and establish a vegetative cover. A crop with a deep root zone is preferred because it can harvest the remaining nutrients. For additional guidance, see the USDA/NRCS Conservation Practice Standard, Critical Area Planting (342).

Option B. Permanent elimination of embankment-type earthen storage structures

1. *Divert all surface water runoff away from the structure.* This includes runoff from building roofs, abandoned feedlots and cropland.
2. *Remove pipes, pipe inlets and structures that previously added contaminated runoff or wastewater to the structure.*
3. *Remove all liquid and pumpable sludge and solids.* For details, see the dewatering procedures discussed earlier.
4. *Breach the embankment (dam).* After removing as much liquid and sludge as possible, allow the remaining solids to dry and use earth-moving equipment to remove them. If more than about 12 inches of solids remain after pumping, remove the solids, making every effort to maintain the liner integrity.

   When climatic conditions are unfavorable for drying, refill the structure with water, agitate it and empty it repeatedly until the desired amounts of solids are removed. Then remove a section of the existing waste storage pond embankment.

   The breach should be low enough on the slope of the dam to allow any water that enters the structure to drain quickly. If the pool area of the breached structure is lower than the breach elevation, additional fill and shaping may be needed to ensure that any water entering the former pool area can drain adequately.

Option C. Permanent conversion to a freshwater pond

1. *Set the maximum water level.* Add an emergency overflow spillway if one does not currently exist, or install a standpipe to set a maximum water level. Set the overflow spillway at least 2 feet below the lowest point in the embankment or dam (or the top of the dam should be at least 12 inches above the design depth of flow in the emergency spillway). Consult an engineer to design an adequate emergency spillway.
2. *Divert all surface water runoff away from the storage until the pond is flushed adequately.* This includes runoff from building roofs, abandoned feedlots and cropland. Then divert back into the pond any clean surface water not coming from old abandoned feedlots or other

animal concentration areas. If there is little drainage area to provide clean surface runoff, it may take longer to fill the pond with clean water. Diversion structures built to exclude surface runoff from embankment ponds may be fairly large and therefore require careful hydraulic design. Inlet and/or outlet grade control structures may be required in conjunction with the diversion structures to protect the installation from erosion.

3. *Remove any pipes and structures that add contaminated runoff or manure to the storage.*
4. *Remove all liquid and pumpable sludge and solids.* For details, refer to the dewatering procedures discussed earlier.
5. *Rinse the structure with water.* After pumping out all sludge and liquid, fill the lagoon with water and allow it to sit for several months. Although nutrient concentrations should be low during the next growing season, have the liquid nutrients analyzed to assess the effects of the anticipated nutrient application.

   Then agitate the structure and empty it completely. Apply the contents according to the water needs of the crop, unless the previously mentioned assessment indicates a problem that could cause long-term resource or water quality problems.
6. *Refill the structure with water.* Check the dissolved oxygen (DO) concentration after the second refill. If levels are less than 3 mg/liter (for catfish, a minimum of 3 mg/liter is adequate, but 5 mg/liter or more is desirable; for trout, the minimum concentration is 5 mg/liter, but 8 mg/liter or more is desirable), continue the rinsing (fill and dewater) cycles. Once the DO levels are 3 mg/liter or higher, the earthen structure can be managed as a farm pond.

   Another option is to check the nitrogen levels and continue rinsing until the available levels, as measured by a laboratory or a nitrogen meter, are less than 10 mg/liter Nitrate-N. Add clean runoff or other fresh water to the lagoon to keep the pond near capacity. A high water level helps protect the liner from being damaged by drying out or by burrowing animals or plant growth.

   Do not use water from the unit for livestock consumption without first testing it for pathogens and nitrate levels and consulting with a veterinarian. For more information, see Texas Cooperative Extension publication E-8, *Water Quality Guide for Livestock and Poultry* (*http://tammi.tamu.edu/pubs.html*).
7. *Establish a growing crop or sod.* To minimize soil erosion, till the final structure's surface and plant it with vegetation.

Special Case: Temporary closure — managing manure storages at temporarily depopulated operations

Producers sometimes depopulate livestock facilities temporarily, intending to restart production later. State regulations may define the length of inactivity allowed before the facilities are declared "abandoned" and closure is required.

1. *If possible, divert any uncontaminated surface water away from the earthen structure.* This includes runoff from building roofs and cropland. Do not divert runoff from abandoned feedlots. Runoff from these sites is wastewater that must be captured and stored, then land-applied at agronomic rates.
2. *Remove all liquid, pumpable sludge and solids.* For details, refer to the dewatering procedures discussed earlier.
3. *Refill the storage with water.* Keep liquid levels at least 2 feet below the top of the structure or at or below the 25-year, 24-hour storm storage marker as required by state regulations. The added water will limit the damage to the side slopes from erosion, weed growth and burrowing animals.
4. *Manage the structure to prevent liquid overflow.* Land-apply the excess water from the structure in accordance with appropriate agricultural practices. It must not be discharged into surface waters.

Incremental closure procedures

Incremental closure is a modification of Option A listed above. It has been used to close abandoned lagoons in the southeastern United States. It is well suited for the permanent elimination of lagoons in several situations:

- Lagoons with large surface areas (more than 2 acres)
- Earthen manure structures with narrow embankments that cannot support tractors and agitators to suspend settled solids and sludge
- Earthen manure structures with degraded embankments or slopes
- Earthen manure structures with bottoms below the groundwater table
- Lagoons with large length-to-width ratios that are difficult to properly mix or access with an agitator
- Earthen manure structures with physical conditions that make it impossible or impractical to completely remove accumulated sludge and silt to a stable foundation
- In areas where soil or fill material is unavailable to completely fill the existing structure
- Earthen manure structures that will ultimately have their sidewalls removed and be filled in with soil or reshaped to match the existing contour

Incremental closure of an earthen manure structure is generally accomplished using these steps (Fig. 4):

1. Place the agitation equipment at one end or corner of the structure. Agitate the sludge, remove it from the structure and land-apply.
2. Once the depth of settled/accumulated material is reduced to less than 1 foot, use bulldozers or other earth-moving equipment to slowly move the sidewall at a rate of about 10 to 15 feet at a time toward the center of the structure.

   One way to accomplish this procedure is to use a construction technique called "header banking." Header banking involves pushing fill material into the pond area with a bulldozer to displace pond solids while building a new sidewall and working pad for the dozer.

   The depth of fill material should be 1.5 to 2.5 feet. It should be able to support operating earth-moving equipment. Fill material used in this operation should be at or near optimum moisture. The moisture content of fill material should be adjusted before it is taken to the placement site. The existing embankment material can be used as borrow, brought to optimum moisture and used as prepared fill.
3. As the embankment is pushed inward, make sure that the agitated sludge displaced by the fill is pushed toward the center of the structure rather than being covered with soil.
4. Take soil cores to monitor the process and ensure that the embankment fill during movement incorporates only a minimal amount of sludge. Make borings with a soil auger and estimate the depth of sludge remaining in the structure after the previous movement of the lagoon embankment.

   No chemical analysis is required. Rather, the soil cores serve as a quality control practice to ensure that the sludge is being moved toward the "open" portion of the lagoon, rather than being buried. Take cores along the "filled-in area" to depths corresponding to the previous bottom elevation of the structure. Each core should represent about 750 square feet of area. Keep records on where the cores are taken as well on the depth of sludge, if any, still buried under the fill.
5. Move the agitation equipment across the surface as the earthen structure is filled in. Continue agitating the sludge, removing the solids, moving the embankment and taking soil core samples until the structure is reduced to a size manageable by agitation equipment alone or until all contents of the lagoon are removed.

The goal of incremental closure is to remove most of the sludge material while avoiding damaging the liner or handling

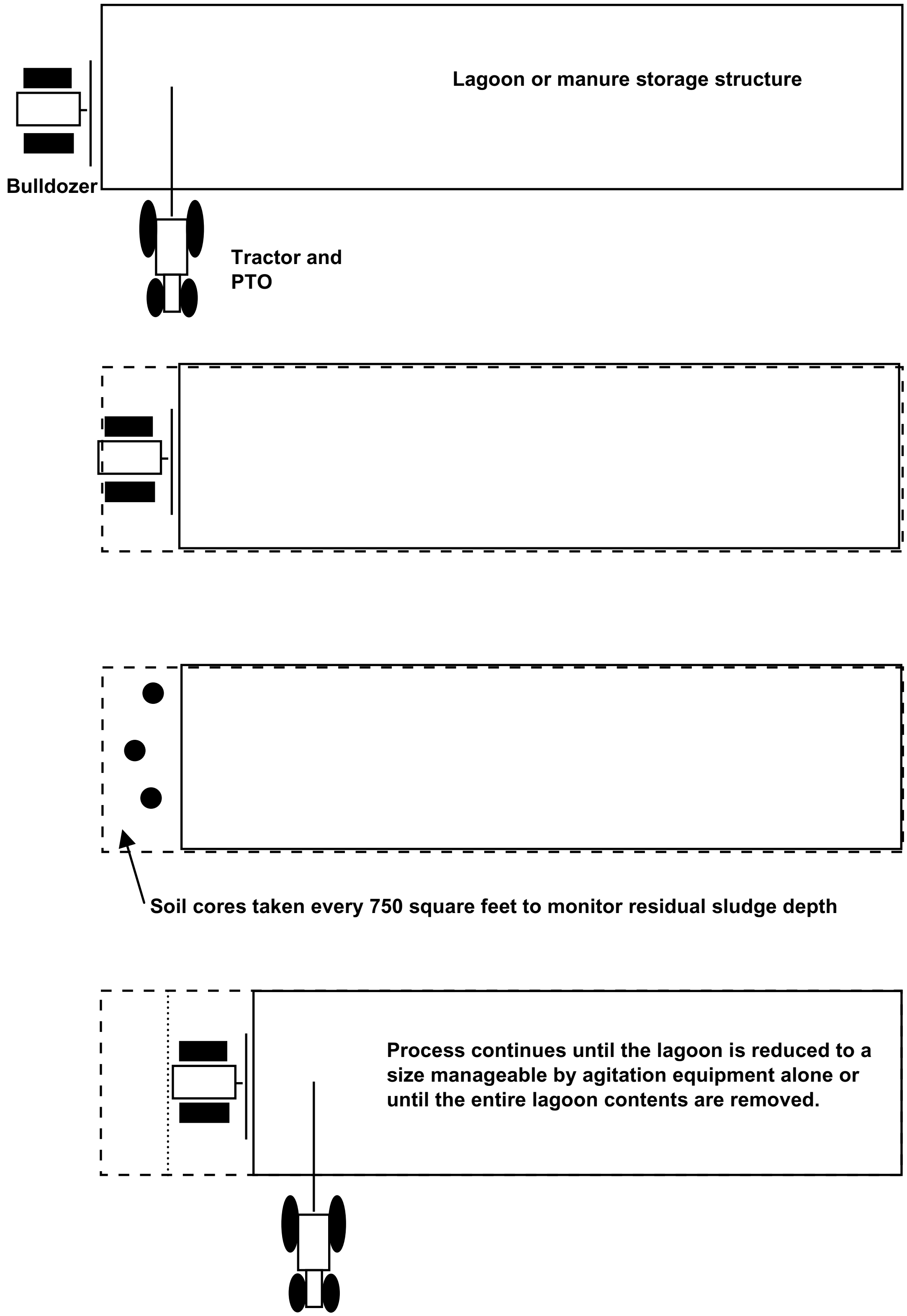

Figure 4. Incremental closure of lagoons and storage basins.

layers of sludge more than 5 inches thick. To minimize the sludge layer thickness while closing the unit:

- Agitate the sludge or solid material within a smaller area,
- Move embankment a shorter distance, or
- Place the bulldozer blade lower in the existing soil to push sludge material over from beneath.

Timing of Closure

One question that is often debated concerns when to close an earthen lagoon or manure storage structure. Should it be closed immediately when operations cease, or would it be better to wait 3 to 5 years?

Although environmental concerns remain after a facility ceases to be used, the level of risk tends to decrease over time if the structure is properly maintained. Both options offer several advantages and disadvantages, both economic and environmental.

Certainly, allowing more time for closure permits more flexibility in applying the sludge. It may be very difficult to apply it all quickly at agronomic rates, given the high concentration of nutrients in the sludge layer; applying the sludge over a period of years instead of all at once may be more environmentally friendly.

The structure must be maintained during this time of no use just as it was during operation, including conducting regular inspections, maintaining proper vegetation on embankments and pumping when necessary to maintain safe water levels. This maintenance, and the additional cost of setting up equipment to pump sludge several times rather than all at once, may represent a significant cost to the operation.

The advantages of immediate closure include

- The expense of maintaining embankments and the pumping lagoon ends quickly.
- The possibility of overtopping spillway discharges, or leakage, ends quickly.
- Closing structures at one time should minimize the expense of pumping and hauling sludge.

The advantages of slower closure include:

- The pathogens in the sludge are more likely to die or be reduced to insignificant levels.
- The nutrients in the sludge can usually be more easily applied at agronomic rates if used over a longer period.

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