



Natural Resources Conservation Service
CONSERVATION PRACTICE STANDARD
WASTE TREATMENT LAGOON

CODE 359

(no)

DEFINITION

A waste treatment impoundment made by constructing an embankment and/or excavating a pit or dugout.

PURPOSE

This practice is used to accomplish one or more of the following purposes—

- To biologically treat waste, such as manure and wastewater, and thereby reduce pollution potential by serving as a treatment component of a waste management system

CONDITIONS WHERE PRACTICE APPLIES

- Where the lagoon is a component of a planned agricultural waste management system.
- Where treatment is needed for organic wastes generated by agricultural production or processing.
- On any site where the lagoon can be constructed, operated and maintained without polluting air or water resources.
- To lagoons utilizing embankments with an effective height of 35 25 feet or less where damage resulting from failure would be limited to damage of farm buildings, agricultural land, or township and country roads.

CRITERIA

General Criteria for All Lagoons

Laws and Regulations

All Federal, state, and local laws, rules, and regulations governing the construction and use of waste treatment lagoons must be followed.

The owner or operator of the lagoon shall be responsible for securing a no discharge operational permit from the Kentucky Natural Resources And Environmental Protection Cabinet, Department For Natural Resources and Environmental Protection, Division Of Water. Refer to Kentucky Revised Statute; KRS 224.10-100(19) and Kentucky Administrative Regulation 401 KAR 5:009.

Location

To minimize the potential for contamination of streams, lagoons should be located outside of floodplains. However, if site restrictions require location within a floodplain, they shall be protected from inundation or damage from a 25-year flood event, or larger if required by laws, rules, and regulations.

Lagoons shall be located so the potential impacts from breach of embankment, accidental release, and liner failure are minimized; and separation distances are such that prevailing winds and landscape elements such as building arrangement, landforms, and vegetation minimize odors and protect aesthetic values. Lagoons should be located so they have as little drainage area as possible. If a lagoon has a

drainage area, the volume of normal runoff during the treatment period and 25year, 24-hour storm event runoff shall be included in the required volume of the lagoon.

Waste treatment lagoons for new facilities shall be located to meet the minimum distance requirement from public or private facilities as shown in **Table 1**. Existing facilities will require further investigation for proper lagoon locations.

Table 1- Minimum Distance Required for Waste Treatment Lagoons

Public or Private Use Facilities	Min. Distance From Lagoon
Dwellings, churches, schools, businesses, and public use areas	500 feet
Property Lines	300 feet
Potable Wells	300 feet
Natural Water Courses, Drainage Ditches	150 feet
Milking Parlors, Public Roads	100 feet
Area specified by state or local ordinance	Greater of state or local distance shown above

Hazard Classification

The area downstream of the embankment shall be evaluated to determine the impact of damage from a sudden breach of the proposed embankment on both structural and environmental features. This evaluation must consider existing and reasonably anticipated improvements during the life of the structure. Only NRCS hazard class (a) embankments are to be designed under this standard.

Soils and Foundation

The lagoon shall be located in soils with an acceptable permeability that meets all applicable regulations, or the lagoon shall be lined. Information and guidance on controlling seepage from waste impoundments can be found in the Agricultural Waste Management Field Handbook (AWMFH), Appendix 10D.

The lagoon shall have a bottom elevation that is a minimum of 2 feet above the seasonal high water table unless special design features are incorporated that address buoyant forces, lagoon seepage rates, and non-encroachment of the water table by contaminants. The water table may be lowered by use of perimeter drains to meet this requirement.

All lagoons shall be investigated by a geologist and/or soil scientist and a written report prepared that addresses the water table depth, and potential for ground water pollution considering the hydrology, groundwater gradient, soil permeability, etc. Evaluate soils to a depth no less than two feet below the final grade of any excavation. A determination as to whether a liner is needed will be based on the soils or geologic investigation and information on controlling seepage contained in the Agricultural Waste Management Field Handbook (AWMFH), Appendix 10D.

Liners

The subgrade shall be a dense base regardless of liner method. Liners shall be constructed at an elevation above the seasonal high water table unless methods to maintain the liner integrity are considered in the design. The lagoon shall be sealed by one of the liners as described below.

1. Compacted Earth. Earthen liners shall be designed in accordance with NRCS Agricultural Waste Management Field Handbook Appendix 10D, Geotechnical Design and Construction Guidelines to achieve a maximum allowable specific discharge of 0.0028 ft/day (1×10^{-6} cm/sec). A compacted earth liner shall have a minimum thickness of 1 foot on lagoon sides and bottom measured perpendicular to the finished surface. The liner material shall be placed in layers not over 9 inches thick before compaction. A minimum of two compacted layers is required.

Compaction requirements shall be verified in accordance with ASTM D-698 or as determined by the engineer. Compacted earth liners shall have side slopes of 3 horizontal to 1 vertical (3:1) or flatter, except where compacted earth liners are part of (brought up with) an earthfill.

2. Flexible Membrane - A flexible membrane liner designed and constructed in accordance with the NRCS conservation practice standard Pond Sealing and Lining - Flexible Membrane, Code 521-A.
3. Bentonite - A bentonite liner designed and constructed in accordance with the NRCS conservation practice standard Pond Sealing and Lining - Bentonite or Other High Swell Clay Material, Code 521-C.
4. Concrete - A concrete liner designed and constructed in accordance with NRCS Construction Specification 32, Concrete and the following criteria:
 - a. For side slopes and bottoms that will not have any vehicular traffic, use a minimum 4-inch thick concrete slab. No joints are required. Wire mesh or fiber reinforcement is required.
 - b. For concrete lined areas such as approaches, ramps and bottoms that will have vehicular traffic of any kind, use a minimum 4 inch thick concrete slab placed over a minimum 4 inch thick layer of compacted sand. Joints and reinforcement shall be as required by design analysis.
 - c. Concrete lined side slopes shall be 2 horizontal to 1 vertical (2:1) or flatter, except for concrete push-off ramps. Concrete push-off ramp slopes shall be 1 horizontal to 1 vertical (1:1) or flatter on cut slopes and 2 horizontal to 1 vertical (2:1) or flatter on embankment slopes.
5. Natural Clay Base - A natural clay base liner shall have a minimum thickness as defined in NRCS AWMFH Appendix 10D. The soil shall meet the criteria for a unified soil classification of CL, CH, MH, SC, or GC. Subsurface investigations must demonstrate that suitable natural soil material exists for the minimum depth required below the design bottom elevation of the waste treatment lagoon or the lagoon shall be lined.

Natural clay based liners shall have side slopes of 2 horizontal to 1 vertical (2:1) or flatter.

Required Volume

The lagoon shall have the capability of storing the following volumes:

- Volume of accumulated sludge for the period between sludge removal events;
- Minimum treatment volume (anaerobic lagoons only);
- Volume of manure, wastewater, and other wastes accumulated during the treatment period;
- Depth of normal precipitation less evaporation on the surface area (at the required volume level) of the lagoon during the treatment period;
- Depth of the 25-year, 24-hour storm precipitation on the surface area (at the required volume level) of the lagoon.

Treatment Period

The treatment period is the detention time between drawdown events. It shall be the greater of either 60 days; or the time required to provide the storage that allows environmentally safe utilization of waste considering the climate, crops, soil, and equipment requirements; or as required by local, state, and Federal regulations.

Waste Loading

Daily waste loading shall be based on the maximum daily loading considering all waste sources that will be treated by the lagoon. Reliable local information or laboratory test data should be used if available. If local information is not available Chapter 4 of the AWMFH may be used for estimating waste loading.

Embankments

The minimum elevation of the top of the settled embankment shall be 1 foot above the lagoon's required volume. This height shall be increased by the amount needed to ensure that the top elevation will be maintained after settlement. This increase shall be not less than 5 percent. The minimum top widths are

shown in Table 1 2. The combined side slopes of the settled embankment shall not be less than 5 horizontal to 1 vertical, and neither slope shall be steeper than 2 horizontal to 1 vertical unless provisions are made to provide stability.

Table 2 – Minimum Top Widths

Total embankment Height, ft.	Top Width, ft.
15 or less	8
15 – 20	10
20 – 25	12
25 – 30	14
30 – 35	15

Excavations

Unless supported by a soil investigation, excavated side slopes shall be no steeper than 2 horizontal to 1 vertical.

Inlet

Inlets shall be of any permanent type designed to resist corrosion, plugging, freeze damage, and ultraviolet ray deterioration, while incorporating erosion protection as necessary. Inlets shall be provided with a water-sealed trap and vent, or similar device if there is a potential, based on design configuration, for gases to enter buildings or other confined spaces.

Pipe inlets may be steel, concrete, aluminum, ductile iron or PVC as required in NRCS conservation practice standard for Pond, Code 378. However if corrugated steel is used, it shall be adequately protected with an appropriate coating.

Pipes shall have a minimum diameter of 6 inches. All pipes shall be designed to carry the required flow and shall be installed on a slope of 1 percent or greater and preferably 1.5 percent or greater. Wye or tee fittings shall be placed at a maximum spacing of 150 feet to facilitate cleanout of the pipe in case of blockage. The inlet pipe should terminate a sufficient distance from the shoreline to ensure good distribution. Pipes shall be installed far enough below the ground surface avoid freezing or be provided with other protective measures. Pumped inlets shall be sized to meet the requirements of the pumping equipment. Gravity flow inlet pipes for liquids only may outlet at or above the design volume elevation. The slope of the lagoon at the pipe outlet shall be protected from erosion by paving or by extending the pipe outlet to a point where the discharge will not fall on the slope.

Pipes shall be supported on pilings of pressure treated wood, steel, concrete, or masonry and anchored to prevent dislodging or flotation. Paved slopes shall be no flatter than 4 horizontal to 1 vertical (4:1) and will not be used when appreciable bedding materials are used.

Outlet

Outlets from the required volume shall be designed to resist corrosion and plugging. No outlet shall automatically discharge from the required volume of the lagoon. Manually operated outlets shall be of permanent type.

Emergency Spillway

Lagoons having a maximum design liquid level of 3 feet or more above natural ground (embankment) shall have an emergency spillway (earth or pipe), combination of spillways, or additional storage storage shall be provided to protect the lagoon from over-topping the embankment when a 25-year, 24-hour storm event is exceeded and the design volume is filled. The crest of the emergency spillway shall be located at or above the same elevation as the top of the 25-year, 24-hour storm storage. The emergency spillway shall be designed to pass a 25-year, 24-hour storm without overtopping the embankment. There shall be a minimum of 1 foot of freeboard above the designed depth of flow in the emergency spillway. Emergency

spillway requirements, however, do not apply to lagoons without drainage areas and with less than 3 feet of storage above natural ground.

The emergency spillway shall be placed in undisturbed soil when possible. When it must be placed in fill material, precautions shall be taken to insure the integrity of the structure. Where a lagoon empties into another waste storage pond and the liquid level is positively controlled by an adequately sized overflow pipe, no emergency spillway is required for the primary lagoon. Pipe emergency spillways shall be 6 inch minimum diameter and equipped with trash racks, antivortex devices, and antiseep collars as required in NRCS conservation practice standard for Pond, Code 378. Pipes may be steel, concrete, aluminum, or PVC as required in NRCS conservation practice standard for Pond, Code 378.

Staff Gage

A staff gage or other permanent marker shall be placed in the waste storage pond to clearly indicate the maximum level of storage allowed to accumulate before emptying must be initiated. The marker shall indicate the level at which sufficient storage remains to contain the 25-year, 24-hour runoff and precipitation.

Facility for Drawdown

Measures that facilitate safe drawdown of the liquid level in the lagoon shall be provided. Access areas and ramps used to withdraw waste shall have slopes that facilitate a safe operating environment. Docks, wells, pumping platforms, retaining walls, etc. shall permit drawdown without causing erosion or damage to liners.

Sludge Removal

Provision shall be made for periodic removal of accumulated sludge to preserve the treatment capacity of the lagoon.

Erosion Protection

Embankments and disturbed areas surrounding the lagoon shall be treated to control erosion. This includes the inside slopes of the lagoon as needed to protect the integrity of the liner. Vegetate disturbed areas according to Critical Area Planting, Code 342.

Safety

Design shall include appropriate safety features to minimize the hazards of the lagoon. The lagoon shall be fenced around the perimeter and warning signs posted to prevent children and others from using it for other than its intended purpose.

Additional Criteria for Anaerobic Lagoons

Loading Rate

Anaerobic lagoons shall be designed to have a minimum treatment volume based on Volatile Solids (VS) loading per unit of volume. The maximum loading rate shall be as indicated in AWMFH Figure 10-22 or according to state regulatory requirements, whichever is more stringent.

Operating Levels

The maximum operating level shall be the lagoon level that provides the required volume less the 25-year, 24-hour storm event precipitation on the surface of the lagoon. The maximum drawdown level shall be the lagoon level that provides volume for the required minimum treatment volume plus the volume of accumulated sludge between sludge removal events. Permanent markers shall be installed at these elevations. The proper operating range of the lagoon is above the maximum drawdown level and below the maximum operating level. These markers shall be referenced and described in the O&M plan.

Depth Requirements

The minimum depth at maximum drawdown shall be 6 feet. If subsurface conditions prevent practicable construction to accommodate the minimum depth at maximum drawdown, a lesser depth may be used, if the volume requirements are met.

Additional Criteria for Naturally Aerobic Lagoons

Loading Rate

Naturally aerobic lagoons shall be designed to have a minimum treatment surface area as determined on the basis of daily BOD₅ loading per unit of lagoon surface. The required minimum treatment surface area shall be the surface area at maximum drawdown. The maximum loading rate shall be as indicated by AWMFH Figure 10-25 or according to state regulatory requirements, whichever is more stringent.

Operating Levels

The maximum operating level shall be the lagoon level that provides the required volume less the 25-year, 24-hour storm event on the lagoon surface. The maximum drawdown level shall be the lagoon level that provides volume for the volume of manure, wastewater, and clean water accumulated during the treatment period plus the volume of accumulated sludge between sludge removal events. Permanent markers shall be installed at these elevations. The proper operating range of the lagoon is above the maximum drawdown level and below the maximum operating level. These markers shall be referenced and described in the O&M plan.

Depth Requirements

The minimum depth at maximum drawdown shall be 2 feet. The maximum liquid level shall be 5 feet.

Additional Criteria for Mechanically Aerated Lagoons

Loading Rate

Mechanically aerated waste treatment lagoons' treatment function shall be designed on the basis of daily BOD₅ loading and aeration equipment manufacturer's performance data for oxygen transfer and mixing. Aeration equipment shall provide a minimum of 1 pound of oxygen for each pound of daily BOD₅ loading.

Operating Levels

The maximum operating level shall be the lagoon level that provides the required lagoon volume less the 25-year, 24-hour storm event precipitation and shall not exceed the site and aeration equipment limitations. A permanent marker or recorder shall be installed at this elevation. The proper operating range of the lagoon is below this elevation and above the minimum treatment elevation established by the manufacturer of the aeration equipment. This marker shall be referenced and described in the O&M plan.

Table 3- Potential Impact Categories from Breach of Embankment or Accidental Release	
1.	Surface water bodies — perennial streams, lakes, wetlands, and estuaries
2.	Critical habitat for threatened and endangered species
3.	Riparian areas
4.	Farmstead, or other areas of habitation
5.	Off-farm property
6.	Historical and/or archaeological sites or structures that meet the eligibility criteria for listing in the National Register of Historical Places

CONSIDERATIONS

General

Lagoons should be located as close to the source of waste as possible.

Solid/liquid separation treatment should be considered between the waste source and the lagoon to reduce loading.

The configuration of the lagoon should be based on the method of sludge removal and method of sealing.

Due consideration should be given to economics, the overall waste management system plan, and safety and health factors.

Considerations for Minimizing the Potential for and Impacts of Sudden Breach of Embankment or Accidental Release from the Required Volume

Features, safeguards, and/or management measures to minimize the risk of embankment failure or accidental release, or to minimize or mitigate impact of this type of failure should be considered when any of the categories listed in Table 3 might be significantly affected.

The following should be considered either singly or in combination to minimize the potential of or the consequences of sudden breach of embankments when one or more of the potential impact categories listed in Table 2 may be significantly affected:

- An auxiliary (emergency) spillway
- Additional freeboard
- Storage volume for the wet year rather than normal year precipitation
- Reinforced embankment — such as, additional top width, flattened and/or armored downstream side slopes
- Secondary containment
- Water level indicators or recorders

The following should be considered to minimize the potential for accidental release from the required volume through gravity outlets when one or more of the potential impact categories listed in Table 3 may be significantly affected:

- Outlet gate locks or locked gate housing
- Secondary containment
- Alarm system
- Another means of emptying the required volume

Considerations for Minimizing the Potential of Lagoon Liner Seepage

Consideration should be given to providing an additional measure of safety from lagoon seepage when any of the potential impact categories listed in Table 4 may be affected.

Table 4- Potential Impact Categories for Liner Seepage	
1.	Any underlying aquifer is at a shallow depth and not confined
2.	The vadose zone is rock
3.	The aquifer is a domestic water supply or ecologically vital water supply
4.	The site is located in an area of carbonate rock (limestone or dolomite)

Should any of the potential impact categories listed in Table 4 be affected, consideration should be given to the following:

- A clay liner designed in accordance with procedures of AWMFH, Appendix 10D with a thickness and coefficient of permeability so that specific discharge is less than 1×10^{-6} cm/sec.
- A flexible membrane liner
- A geosynthetic clay liner (GCL) flexible membrane liner
- A concrete liner designed in accordance with slabs on grade criteria, Waste Storage Facility (313), for fabricated structures requiring water tightness.

Considerations for Improving Air Quality

To reduce emissions of greenhouse gases, ammonia, volatile organic compounds, and odor:

- Reduce the recommended loading rate for anaerobic lagoons to one-half the values given in AWMFH Figure 10-22.
- Use additional practices such as Anaerobic Digester – Ambient Temperature (365), Anaerobic Digester – Controlled Temperature (366), Waste Facility Cover (367) and Composting Facilities (code 317) in the waste management system.
- Liquid/solid separation prior to discharge to lagoon will reduce volatile solids (VS) loading resulting in reduced gaseous emissions and odors. Composting of solids will further reduce emissions.
- Design lagoons to be naturally aerobic or to allow mechanical aeration.

Adjusting pH below 7 may reduce ammonia emissions from the lagoon but may increase odor when waste is surface applied (See Waste Utilization, code 633).

PLANS AND SPECIFICATIONS

Plans and specifications shall be prepared in accordance with the criteria of this standard and shall describe the requirements for applying the practice to achieve its intended use.

OPERATION AND MAINTENANCE

An operation and maintenance plan shall be developed that is consistent with the purposes of the practice, its intended life, safety requirements, and the criteria for design. The plan shall contain the operational requirements for drawdown and the role of permanent markers. This shall include the requirement that waste be removed from the lagoon and utilized at locations, times, rates, and volume in accordance with the overall waste management system plan. In addition, the plan shall include a strategy for removal and disposition of waste with least environmental damage during the normal treatment period to the extent necessary to insure the lagoon's safe operation. This strategy shall also include the removal of unusual storm events.

Development of an emergency action plan should be considered for lagoons where there is a potential for significant impact from breach or accidental release. The plan shall include site-specific provisions for emergency actions that will minimize these impacts.

Recommendations for inspection and maintenance of the embankment, vegetation, and other structures shall be included. Include the statement that waste be removed from the lagoon and utilized at locations, times, rates, and volumes in accordance with the overall waste management system plan. The lagoon shall be operated to maintain the maximum liquid level below the storage required for the 25- year 24-hour storm.

After 5 years of operation, the waste treatment lagoon shall be checked for sludge accumulation annually. If sludge has encroached into the treatment volume, the sludge will be removed and applied at agronomic rates based on analysis of the sludge.

Include plans for the removal of unusual storm events. Develop an emergency action plan including site-specific provisions for emergency actions that will reduce impacts from accidental release or embankment reach.

REFERENCES

- NRCS National Engineering Handbook Part 650, Engineering Field Handbook.
- NRCS National Engineering Handbook Part 651, Agricultural Waste Management Field Handbook
- NRCS Conservation Practice Standards:
 - Critical Area Planting, Code 342
 - Pond, Code 378
 - Pond Sealing or Lining, Code 521

- Nutrient Management, Code 590
- NRCS National Engineering Manual, Part 520