NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

WASTE TREATMENT LAGOON

(No.)

CODE 359

DEFINITION

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

PURPOSE

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 feet or less where damage resulting from failure would be limited to 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.

Before construction begins, all required plans and specifications for new and renovated lagoons shall be submitted to the Kansas Department of Health and Environment (KDHE) for review and approval. Construction permits may also be required from the Kansas Department of Agriculture, Division of Water Resources (DWR), for embankment ponds or structures within the 100-year floodplain. The owner or operator of the facility shall be responsible for securing all required permits and approvals from the agency or agencies concerned.

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 that 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 that 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 25-year, 24-hour storm event runoff shall be included in the required volume of the lagoon.

The location of waste treatment lagoons must also conform to the separation distance requirements relating to habitable structures, water resources, and property lines.

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 National Engineering Handbook Part 651 (NEH 651), *Agricultural Waste Management Field Handbook*, Appendix 10D.

The lagoon shall have a bottom elevation that is a minimum of 10 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 seasonal high water table may be lowered by use of perimeter drains to meet this requirement.

Geotechnical investigations. All lagoon sites shall be investigated to determine water table elevations and to identify soil types. Site investigations will consist of borings or equivalent excavations with at least 1 investigation to a minimum depth of 10 feet below the lowest elevation in a waste treatment lagoon or where impenetrable bedrock is encountered—whichever is less. Other investigations are recommended to be a minimum of 2 feet below the lowest elevation of the waste treatment lagoon. The depth to the seasonal high water table (if encountered) shall be documented.

The extent of the investigation shall be commensurate with the complexity of the site geology and the potential hazard posed by the lagoon. It is recommended that at least 1 soil investigation be performed for each acre occupied by a waste treatment lagoon. A minimum of 1 investigation is required—regardless of size. The area occupied by the lagoon is the surface area measured at the design top elevation. Additional information on geologic investigations can be found in Chapter 7 in NEH Part 651.

Information and guidance on soil profile descriptions can be found in Chapter 3 of the Soil Survey Manual (U.S. Department of Agriculture [USDA] Handbook 18, October 1993) or in the Field Book for Describing and Sampling Soils, Version 3.0 (USDA, NRCS, National Soil Survey Center, 2012).

Liners. Liners (if required) shall be used to seal the bottoms and sides of lagoons (at least to the required volume elevation) and shall be accomplished by one of the following methods or materials:

- Compacting native clay soils (on-site or imported).
- Adding bentonite to the soil.
- Adding a soil dispersant to the soil.
- Covering the soil with commercial flexible membranes, geosynthetic clay liner, or concrete.

Liners shall meet or exceed the criteria in Conservation Practice Standard (CPS) 521A, Pond Sealing or Lining, Flexible Membrane; CPS 521B, Pond Sealing or Lining, Soil Dispersant Treatment; CPS 521C, Pond Sealing or Lining, Bentonite Treatment; or CPS 521D, Pond Sealing or Lining, Compacted Clay Treatment, as appropriate.

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 greatest of the following:

- 120 days.
- The time required to provide the storage that allows environmentally safe utilization of waste considering the climate, crops, soil, and equipment requirements.
- 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 in NEH 651 may be used for estimating waste loading.

Embankments. The minimum elevation of the top of the settled embankment shall be 2 feet (for freeboard) above the required volume elevation of the lagoon. This height shall be increased by the amount needed to ensure that the top elevation will be maintained after settlement. This increase shall not be less than 5 percent. The minimum top widths are shown in Table 1.

Table 1–Minimum top widths

Total Embankment Height (feet)	Top Width (feet)
20 or less	10
20.1 - 25	12
25.1 - 30	14
30.1 - 35	15

Side slopes of the settled embankment shall not be steeper than is shown in Table 2. All slopes must be designed to be stable, even if flatter side slopes are required.

Table 2–Minimum side slopes

Total Embankment Height (feet)	Inside Slope	Outside Slope
Less than 12	3:1	2:1
Greater than or equal to 12	3:1	2½:1

Cutoff trenches, wave erosion control measures, and auxiliary spillways shall be provided as needed to ensure safe and proper performance of embankment structures. Refer to CPS 378, Pond, for criteria applicable to these measures.

Excavations. Side slopes of excavated lagoons shall be stable against sloughing. Side slopes of 3 horizontal to 1 vertical (3:1) or flatter are preferred and should be used unless site conditions or machinery limitations require steeper slopes. In no case shall the side slopes be steeper than 2:1.

Inlets. Inlets shall be of any permanent type that is 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.

Conduits shall conform to the criteria indicated in CPS 634, Waste Transfer.

Outlets. 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. Gravity discharge pipes that are used for emptying a waste treatment lagoon shall have a minimum of 2 gates or valves, 1 of which shall be manually operated. Conduits placed through embankments shall conform to the criteria indicated in CPS 378 for seepage protection.

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.

The capacity of pumps used as components of the emptying system shall meet the operational requirements of the producer.

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.

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 shall be 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 Figure 10-27 in NEH 651 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 operation and maintenance (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 BOD_5 (the biochemical oxygen demand of wastewater during decomposition that occurs over a 5-day period) 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 Figure 10-30 in NEH 651 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. The treatment function of the mechanically aerated waste treatment lagoons shall be designed on the basis of daily BOD_5 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 BOD_5 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.

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 the method of sealing.

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

Consider having a sample of the soil to be used for the soil liner sent to a soil mechanics laboratory for tests to determine the density, moisture, and amendment requirements that are needed to meet the required permeability.

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

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

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.

The following should be considered either singly or in combination to minimize the potential of or the consequences of sudden breach of embankment when 1 or more of the potential impact categories listed in Table 3 may be significantly affected:

- An auxiliary spillway.
- Additional freeboard.
- Storage volume for the wet year rather than normal year precipitation.
- Reinforced embankment such as additional top width and/or side slopes that are flattened and/or armored downstream.
- 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 1 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 in Appendix 10D in NEH 651 with a thickness and coefficient of permeability so that specific discharge is less than 1×10^{-6} centimeters per second.
- A flexible membrane liner.
- A geosynthetic clay liner (GCL) flexible membrane liner.
- A concrete liner designed in accordance with slabs-on-grade criteria for CPS 313, Waste Storage Facility, for fabricated structures requiring water-tightness.

Considerations for Improving Air Quality

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

- Reduce the recommended loading rate for anaerobic lagoons to one-half the values given in Figure 10-27 in NEH Part 651.
- Use additional conservation practices such as 366, Anaerobic Digester; 367, Roofs and Covers; and 317, Composting Facilities, in the waste management system.
- Liquid/solid separation prior to discharge to the lagoon will reduce volatile solids (VS) loading, which results 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 CPS 633, Waste Recycling).

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 O&M 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 used 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 the least environmental damage during the normal treatment period to the extent necessary to ensure the safe operation of the lagoon. This strategy shall also include the removal of runoff from large 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.