NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD

WASTE STORAGE FACILITY

(no.)
CODE 313

DEFINITION

A waste storage impoundment made by constructing an embankment and/or excavating a pit or dugout, or by fabricating a structure.

PURPOSE

To temporarily store wastes such as manure, wastewater, and contaminated runoff as a storage function component of an agricultural waste management system.

CONDITIONS WHERE PRACTICE APPLIES

Where the storage facility is a component of a planned agricultural waste management system;

Where temporary storage is needed for organic wastes generated by agricultural production or processing

Where the storage facility can be constructed, operated, and maintained without polluting air or water resources;

Where site conditions are suitable for construction of the facility;

To facilities utilizing embankments with an effective height of 35 feet or less where damage resulting from failure would be limited to damage of farm buildings, agricultural land, or township and country roads;

To fabricated structures including tanks, stacking facilities, and pond appurtenances.

CRITERIA

GENERAL CRITERIA APPLYING TO ALL WASTE STORAGE FACILITIES.

Laws and regulations. Waste storage facilities must be planned, designed, and constructed to meet all federal, state, and local laws and regulations.

Laws and regulations of particular concern include those involving county zoning, water rights, land use, land disturbance by construction, pollution control, property easements, wetlands, preservation of cultural resources, and endangered species.

Where South Dakota Department of Environment and Natural Resources (DENR) approval is to be obtained, DENR requirements must be met.

South Dakota dam safety requirements shall be met for construction of facilities utilizing embankments.

Location. Waste storage facilities shall not be located within the 100-year frequency flood plain unless the structure is protected from inundation and damage that may occur during the 100-year frequency flood event.

Waste storage facilities or manure and wastewater disposal sites cannot be located closer than 1,000 feet from an existing public water well or drinking water source nor 250 feet from a well or drinking water source not owned by the producer.

Waste storage facilities or manure and wastewater disposal sites shall not be located closer than 150 feet from a water well or drinking water source that is owned by the producer.

Waste storage facilities 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.

Storage period. The storage period is the maximum length of time anticipated between emptying events. The minimum storage period shall be based on the timing required for environmentally safe waste utilization

considering the climate, crops, soil, equipment, and local, state, and federal regulations.

Storage facilities must store at least 270 days of manure, wastewater, and contaminated runoff produced by a livestock operation. Storage facilities emptied only once per year must store at least one-year production of manure, wastewater, and contaminated runoff.

Design storage volume. Design storage volume shall consist of the total of the following as appropriate:

Residual volume after liquids have been removed. A minimum of 6 inches shall be provided for tanks and 12 inches for all facilities constructed of earthen materials;

Manure, wastewater, and other wastes accumulated during the storage period;

Normal runoff from the facility's drainage area during the storage period less evaporation calculated on the surface of the pond at the average active storage depth (depth midway between the top of the residual and the maximum operating level) during the storage period;

Average annual precipitation falling on the area inside the top of the structure embankment;

25-year, 24-hour runoff from the facility's drainage area;

25-year, 24-hour precipitation on the area inside the top of the structure embankment;

Additional storage as may be required to meet management goals or regulatory requirements (including freeboard).

Note - Uncontaminated storm water runoff shall be diverted away from the facility wherever possible.

Freeboard. Design depth for waste storage facilities constructed of earthen materials must include at least two feet of freeboard, except one foot of freeboard may be used for small ponds that do not have significant contributing drainage areas and that will not need DENR review or approval.

Fabricated structure design depth must include at least six inches of freeboard.

Maximum operating level. The maximum operating level for waste storage facilities shall be the level that provides the volume required by the first four paragraphs under Design Storage Volume.

A permanent marker or recorder shall be installed at this maximum operating level to indicate when drawdown should begin. The marker or recorder shall be referenced and explained in the Operation and Maintenance (O&M) plan.

Active Storage volume is defined as the volume at maximum operating level minus residual volume (first paragraph under Design Storage Volume)**.** Active storage depth is defined as the pond depth at maximum operating level minus the depth required for residual volume.

Evaporation Ponds. Evaporation ponds are waste storage facilities designed to significantly reduce liquid volume through evaporation. Evaporation ponds will only be used to contain contaminated liquid from production facilities where manure or other solid wastes are not stored in the pond.

Evaporation ponds for feedlots shall be installed in combination with a sediment basin to minimize the entry of solid manure into the evaporation pond.

Dimensions of the evaporation pond will be determined by evaluating the expected annual runoff from the contributing area, the annual rainfall on the pond, and the expected annual evaporation calculated on the surface area at the average active storage depth (see the third paragraph under Design Storage Volume). In order to meet the definition of an evaporation pond, the active storage volume must contain the average annual runoff and precipitation minus the mean annual shallow lake evaporation over a minimum period of five years. A minimum of one-foot of depth must be provided above the residual depth and below the maximum operating level. The requirements to handle a 25-year frequency storm event above the maximum operating level and to provide freeboard also apply to evaporation ponds.

Recommended Minimum Liquid Surface Area for Evaporation Ponds.	
Average Annual Precipitation, inches	Ratio, pond bottom area / drainage area
< 18"	0.12
18" - 20"	0.15
20" - 22"	0.18
22" - 24"	0.22
24" - 26"	0.30
> 26"	0.33

The operation and maintenance plan for each evaporation pond shall include specific language to explain that the evaporation pond will require pumping (partial emptying) to maintain required storage capacity during periods of wet climatic conditions.

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.

For inlets carrying solids, the inlet should be designed to deposit waste near the center of the side of the waste storage facility. Minimum pipe diameter shall be 10 inches except as recommended by equipment manufacturers. The preferred pipe slope for gravity flow is one percent. Flatter slopes may be used where provisions are made to clear blockages.

Emptying Component. Some type of component shall be provided for emptying storage facilities. It may be a facility such as a gate, pipe, dock, wet well, pumping platform, retaining wall, or ramp. Features to protect against erosion, tampering, and accidental release shall be incorporated as necessary.

Accumulated solids removal. Provision shall be made for periodic removal of accumulated solids to preserve storage capacity. The anticipated method for doing this must be considered in planning, particularly in determining the configuration of ponds and type of seal, if any.

Safety. Design shall include appropriate safety features to minimize the hazards of the facility. Ramps used to empty liquids shall have a slope of four horizontal to one vertical or flatter. Those used to empty slurry, semi-solid, or solid waste shall have a slope of 10 horizontal to 1 vertical or flatter unless special traction surfaces are provided. Warning signs, fences, ladders, ropes, bars, rails, and other devices shall be provided, as appropriate, to ensure the safety of humans and livestock. Ventilation and warning signs must be provided for covered waste holding structures, as necessary, to prevent explosion, poisoning, or asphyxiation. Pipelines 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. Gravity discharge pipes used for emptying a storage/treatment facility shall have a minimum of two gates or valves, one of which shall be manually operated. Ponds and uncovered fabricated structures for liquid or slurry waste with walls less than five feet above ground surface shall be fenced and warning signs posted to prevent children and others from using them for other than their intended purpose.

Erosion protection. Embankments and disturbed areas surrounding the facility shall be seeded or otherwise treated to control erosion.

Clay liners. Clay liners must be at least 18 inches thick and compacted to at least 95 percent of standard maximum dry unit weight, and at water content within two percent of optimum as determined by ASTM D698. Where DENR approval will be obtained, the compacted clay liner must meet South Dakota regulatory requirements.

Flexible membranes. Flexible membranes shall be designed to be waterproof (including seams) and designed for permanent exposure to ag waste, soils, and sunlight and must have a minimum thickness of 30 mil.

Livestock access. Livestock shall be prohibited access to the interior of waste storage facilities.

Waste stockpiling outside feedlots. Routine waste stockpiling must occur at designated stockpiling sites. These stockpiles must include a liner (see above requirements) to minimize seepage and shall be designed to keep 25-year frequency, 24-hour duration storm runoff away from the stockpile and to contain contaminated 25-year frequency, 24-hour duration runoff.

Groundwater monitoring. Where waste storage facilities are located over shallow aquifers or where discharge to groundwater may occur, regularly sampled groundwater monitoring wells or a Groundwater Discharge Permit may be required. For each affected site, these requirements will be as specified by DENR.

Additional Criteria for Waste Storage Ponds
Soil and foundation. The pond shall be located in soils with an acceptable permeability that meets all applicable regulation, or the pond 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 pond shall have a bottom elevation that is a minimum of two feet above the seasonal high water table unless features of special design are incorporated that address buoyant forces, pond seepage rate and non-encroachment of the water table by contaminants. The water table may be lowered by use of perimeter drains, if feasible, to meet this requirement.

An onsite soils investigation shall be conducted in sufficient detail to determine:

The soil type(s), based on the Unified Soil Classification System:

The need for and extent of seepage control measures required;

Embankment and liner design parameters;

The location of the seasonal high water table, when one is present;

That DENR requirements have been met (where applicable);

Soils information must be obtained to a minimum depth of two feet below the bottom of the proposed storage facility.

Outlet. No outlet shall automatically release storage from the required design volume. Manually operated outlets shall be of permanent type designed to resist corrosion and plugging.

Embankments. The minimum elevation of the top of the settled embankment shall be one foot above the waste storage pond's required volume. This height shall be increased by the amount needed to ensure that the top elevation will be maintained after settlement. Where required compaction is less than 95 percent of ASTM D698 standard maximum dry unit weight, the fill height increase for settlement shall not be less than five percent. Minimum freeboard for facilities permitted by DENR must meet state regulations.

Earth embankment slopes must be designed to be stable, and must be three horizontal to one vertical or flatter.

The minimum top widths are shown in Table 1.

Table 1 – Minimum Top Widths

Total Embankment Height at Centerline, ft.	Top Width, ft.
9.9 or less	8
10 – 19.9	10
20 – 24.9	12
25 – 29.9	14
30 – 35	15

Note - SD DENR may require other top widths.

Provide embankment overtopping protection for embankment storage ponds that receive runoff from a contributing drainage area and can impound liquids three feet or more above the natural ground. Overtopping protection may take the form of appropriate vegetation or some other type of embankment armoring, or an auxiliary spillway. The auxiliary spillway may be a channel or an overflow pipe. An earthen channel spillway shall have a minimum bottom width of four feet; an overflow pipe shall have a minimum diameter of six inches.

Excavations. Unless supported by a soil investigation, excavated side slopes shall be no steeper than two horizontal to one vertical.

Wind and wave protection. Erosion protection shall be provided for earthen waste storage facilities having a five-acre or larger liquid surface at maximum operating level.

ADDITIONAL CRITERIA FOR FABRICATED STRUCTURES

Foundation. The foundations of fabricated waste storage structures shall be proportioned to safely support all superimposed loads without excessive movement or settlement.

Where a non-uniform foundation cannot be avoided or applied loads may create highly variable foundation loads; settlement should be calculated from site-specific soil test data. Index tests of site soil may allow correlation with similar soils for which test data is available. If no test data is available, presumptive bearing strength values for assessing actual bearing pressures may be obtained from Table 2 or another nationally recognized building code. In using presumptive bearing values, adequate detailing

and articulation shall be provided to avoid distressing movements in the structure.

Foundations consisting of bedrock with joints, fractures, or solution channels shall be treated or a separation distance provided consisting of a minimum of one foot of impermeable soil between the floor slab and the bedrock or an alternative that will achieve equal protection.

Table 2 - Presumptive Allowable Bearing Stress Values[1]

Foundation Description	Allowable Stress
Crystalline Bedrock	12,000 psf
Sedimentary Rock	6,000 psf
Sandy Gravel or Gravel	5,000 psf
Sand, Silty Sand, Clayey Sand, Silty Gravel, Clayey Gravel	3,000 psf
Clay, Sandy Clay, Silty Clay, Clayey Silt	2,000 psf

[1] Basic Building Code, 12th Edition, 1993, Building Officials and Code Admin. (BOCA)

Liquid tightness. Applications such as tanks, that require liquid tightness shall be designed and constructed in accordance with standard engineering and industry practice appropriate for the construction materials used to achieve this objective.

Structural loadings. Waste storage structures shall be designed to withstand all anticipated loads including internal and external loads, hydrostatic uplift pressure, concentrated surface and impact loads, water pressure due to seasonal high water table, and frost or ice pressure and load combinations in compliance with this standard and applicable local building codes.

The lateral earth pressures should be calculated from soil strength values determined from the results of appropriate soil tests. Lateral earth pressures can be calculated using the procedures in the Natural Resources Conservation Service (NRCS) Technical Release 74, Lateral Earth Pressures, (TR-74). If soil strength tests are not available, the presumptive lateral earth pressure values indicated in Table 3 shall be used.

Lateral earth pressures based upon equivalent fluid assumptions shall be assigned according to the following conditions:

Rigid frame or restrained wall. Use the values shown in Table 3 under the column "Frame tanks," which gives pressures comparable to the at-rest condition.

Flexible or yielding wall. Use the values shown in Table 3 under the column "Free-standing walls," which gives pressures comparable to the active condition. Walls in this category are designed on the basis of gravity for stability or are designed as a cantilever having a base wall thickness to height of backfill ratio not more than 0.085.

Equivalent fluid pressures lower than 60 lbs./ft^2/ft. depth, are appropriate for design only where excellent drainage is provided for backfill.

Internal lateral pressure used for design shall be 65 lb/ft^2 where the stored waste is not protected from precipitation. A value of 60 lb/ft^2 may be used where the stored waste is protected from precipitation and will not become saturated. Lesser values may be used if supported by measurement of actual pressures of the waste to be stored. If heavy equipment will be operated near the wall, an additional two feet of soil surcharge shall be considered in the wall analysis.

Tank covers shall be designed to withstand both dead and live loads. The live load values for covers contained in ASAE EP378.3, Floor and Suspended Loads on Agricultural Structures Due to Use, and in ASAE EP 393.2, Manure Storages, shall be the minimum used. The actual axle load for tank wagons having more than a 2,000-gallon capacity shall be used.

If the facility is to have a roof, snow and wind loads shall be as specified in ASAE EP288.5, Agricultural Building Snow and Wind Loads. If the facility is to serve as part of a foundation or support for a building, the total load shall be considered in the structural design.

Structural design. The structural design shall consider all items that will influence the performance of the structure, including loading assumptions, material properties and construction quality. Design assumptions and construction requirements shall be indicated on standard plans.

Tanks may be designed with or without covers. Covers, beams, or braces that are integral to structural performance must be indicated on the construction drawings. The openings in covered tanks shall be designed to accommodate equipment for loading, agitating, and emptying. These openings shall be equipped with grills or secure covers for safety and for odor and vector control.

All structures shall be underlain by free draining material or shall have a footing located below the anticipated frost depth.

A single layer of steel placed near the center of the slab or wall may be used for members that are not more than eight inches thick.

Fabricated structures shall be designed according to the criteria in the following references as appropriate:

Steel: "Manual of Steel Construction," American Institute of Steel Construction.

Timber: "National Design Specifications for Wood Construction," American Forest and Paper Association.

Concrete: "Building Code Requirements for Reinforced Concrete, ACI 318," American Concrete Institute.

Masonry: "Building Code Requirements for Masonry Structures, ACI 530," American Concrete Institute.

Midwest Plan Service (MWPS-36) Concrete Manure Storage Handbook available from the Extension Service.

Slabs on grade. Slab design shall consider the required performance and the critical applied loads along with both the subgrade material and material resistance of the concrete slab. Where applied point loads are minimal and liquid-tightness is not required, such as barnyard and feedlot slabs subject only to precipitation, and the subgrade is uniform and dense, the minimum slab thickness shall be 4 inches with a maximum joint spacing of 10 feet. Joint spacing can be increased if steel reinforcing is added based on subgrade drag theory.

For applications where liquid-tightness is required such as floor slabs of storage tanks, the minimum thickness for uniform foundations shall be five inches and shall contain distributed reinforcing steel. The required area of such reinforcing steel shall be based on subgrade drag theory as discussed in industry guidelines such as American Concrete Institute, ACI 360, "Design of Slabs-on-Grade."

When heavy equipment loads are to be resisted and/or where a non-uniform foundation cannot be avoided, an appropriate design procedure incorporating a subgrade resistance parameter(s) such as ACI 360 shall be used.

CONSIDERATIONS

Waste storage facilities should be located as close to the source of waste and polluted runoff as practicable.

Non-polluted runoff should be excluded from the structure to the fullest extent possible except where its storage is advantageous to the operation of the agricultural waste management system.

Solid/liquid separation of runoff or wastewater entering pond facilities should be considered to minimize the frequency of accumulated solids removal and to facilitate pumping and application of the stored waste.

TABLE 3 - LATERAL EARTH PRESSURE VALUES[1]

Soil		Equivalent fluid pressure (lb/ft^2/ft of depth)			
		Above seasonal high water table[2]		Below seasonal high water table[3]	
Description[4]	Unified Classification[4]	Free-standing walls	Frame tanks	Free-standing walls	Frame tanks
Clean gravel, sand or sand-gravel mixtures (maximum 5% fines)[5]	GP, GW, SP, SW	30	50	80	90
Gravel, sand, silt and clay mixtures (less than 50% fines) Coarse sands with silt and and/or clay (less than 50% fines)	All gravel sand dual symbol classifications and GM, GC, SC, SM, SC-SM	35	60	80	100
Low-plasticity silts and clays with some sand and/or gravel (50% or more fines) Fine sands with silt and/or clay (less than 50% fines)	CL, ML, CL-ML SC, SM, SC-SM	45	75	90	105
Low to medium plasticity silts and clays with little sand and/or gravel (50% or more fines)	CL, ML, CL-ML	65	85	95	110
High plasticity silts and clays (liquid limit more than 50)[6]	CH, MH	-	-	-	-

[1] For lightly compacted soils (85% to 90% maximum standard density.) Includes compaction by use of typical farm equipment.
[2] Also below seasonal high water table if adequate drainage is provided.
[3] Includes hydrostatic pressure.
[4] All definitions and procedures in accordance with ASTM D 2488 and D 653.
[5] Generally, only washed materials are in this category
[6] Not recommended. Requires special design if used.

Due consideration should be given to environmental concerns, 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 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 "Potential Impact Categories from Breach of Embankment or Accidental Release" 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 under "Potential Impact Categories from Breach of Embankment or Accidental Release" may be significantly affected:

An auxiliary (emergency) spillway;

Additional freeboard;

Storage for wet year rather than normal year precipitation;

Reinforced embankment -- such as, additional top width, flattened and/or armored downstream side slopes;

Secondary containment.

POTENTIAL IMPACT CATEGORIES FROM BREACH OF EMBANKMENT OR ACCIDENTAL RELEASE

Surface water bodies - perennial streams, lakes, wetlands, and estuaries.

Critical habitat for threatened and endangered species.

Riparian areas.

Farmstead, or other areas of habitation.

Off-farm property.

Historical and/or archaeological sites or structures that meet the eligibility criteria for listing in the National Register of Historical Places.

The following options 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 the "Potential Impact Categories from Breach of Embankment or Accidental Release" may be significantly affected:

Outlet gate locks or locked gate housing;

Secondary containment;

Alarm system;

Another means to empty the required volume.

CONSIDERATIONS FOR MINIMIZING THE POTENTIAL OF WASTE STORAGE POND LINER FAILURE.

Sites with categories listed under "Potential Impact Categories for Liner Failure" should be avoided if possible. If avoidance is not possible, give consideration to providing an additional measure of safety from seepage.

POTENTIAL IMPACT CATEGORIES FOR LINER FAILURE

Any underlying aquifer is at a shallow depth and not confined;

The vadose zone is rock;

The aquifer is a domestic water supply or ecologically vital water supply;

The site is located in an area of solutionized bedrock such as limestone or gypsum.

Should any of the potential impact categories listed in the above "Potential Impact Categories For Linear Failure" 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 over a clay liner;

A geosynthetic clay liner (GCL) flexible membrane liner;

A concrete liner designed in accordance with slabs on grade criteria for fabricated structures requiring water tightness.

CONSIDERATIONS FOR MINIMIZING THE IMPACT OF ODORS.

An anaerobic lagoon with loading rates reduced to less than half the values in AWMFH Figure 10-22 instead of waste storage ponds should be considered for sites where odors are a concern.

Practices such as the following should be considered to reduce odor emissions:

Covering the storage facility with a suitable cover.

Using naturally aerated or mechanically aerated lagoons.

Using composting in conjunction with a solid waste system rather than a liquid or slurry system.

Using a methane digester and capture system.

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 its design.

The plan shall contain the operational requirements for emptying the storage facility. This shall include the requirement that waste shall be removed from storage and utilized at locations, times, rates, and volume in accordance with the overall waste management system plan. In addition, for ponds, the plan shall include an explanation of the permanent marker or recorder installed to indicate the maximum operating level. The plan shall include a strategy for removal and disposition of waste with least environmental damage during the normal storage period to the extent necessary to insure the pond's safe operation. This strategy is for the removal of the contribution of unusual storm events that may cause the pond to fill to capacity prematurely with subsequent design inflow and usual precipitation prior to the end of the normal storage period. Development of an emergency action plan should be considered for waste storage facilities 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.

REFERENCES

ASAE. 1991. EP 393.2 - Manure Storages. ASAE. St. Joseph, MI

ASAE. 1992. EP470 - Manure Storage Safety. ASAE. St. Joseph, MI

Midwest Plan Service. 1993. Livestock Waste Facilities Handbook, 3rd Ed. (MWPS-18), Department of Agricultural and Biosystems Engineering, Iowa State University, Ames, IA.

Midwest Plan Service. 1994. Concrete Manure Storages Handbook. (MWPS-36), Department of Agricultural and Biosystems Engineering, Iowa State University, Ames, IA.

USDA Natural Resources Conservation Service, 1992. Agricultural Waste Management Field Handbook, USDA NRCS, Washington, D.C.

South Dakota Department of Environment and Natural Resources (SD DENR) references.

Animal Waste Management to Protect Water Quality (EC-895), South Dakota Cooperative Extension Service.

Technical Reports 33 and 34, National Oceanic and Atmospheric Administration (NOAA)