United States Department of Agriculture

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

WASTE STORAGE FACILITY

CODE 313

(no)

DEFINITION

An agricultural waste storage impoundment or containment made by constructing an embankment, excavating a pit or dugout, or by fabricating a structure.

PURPOSE

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

- To store manure, agricultural by-products, wastewater, and contaminated runoff to provide the agricultural operation management flexibility for waste utilization

CONDITIONS WHERE PRACTICE APPLIES

Use where regular storage is needed for wastes generated by agricultural production or processing and where soils, geology, and topography are suitable for construction of the facility. For reception pits, use the Virginia Conservation Practice Standard (CPS) Waste Transfer (Code 634).

For liquid waste storage facilities implemented with an embankment, this practice applies only to low hazard structures as defined in the NRCS National Engineering Manual (NEM), Part 520.23.

This practice does not apply to the storage of human waste or animal mortality

CRITERIA

General Criteria Applicable to All Purposes

Laws and Regulations
Plan, design, and construct the waste storage facility to meet all Federal, State, and local laws and regulations.

Location
Locate and design the waste storage facility such that it is outside the 100-year floodplain. Additionally, follow the policy found in the NRCS General Manual (GM) 190, Part 410.25, Flood Plain Management, which may require providing additional protection for storage structures located within the floodplain.

Use Virginia Engineering Design Note 2 (DN 2) – Separation Distances for Facilities used for Waste Storage to determine required separation distances from other features.

Locate waste storage facilities 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 will be 120 days or the storage needed to utilize waste in accordance with a current certified Nutrient Management Plan.

Design Storage Volume
Size the facility to store the following as appropriate:

<u>Operation Volume</u>
- Manure, wastewater, bedding, and other wastes accumulated during the storage period.
- For liquid or slurry storage facilities, include normal precipitation (omit diverted roof runoff) less evaporation during the storage period.
- Normal runoff from the facility's drainage area during the storage period.
- Planned maximum residual solids. Provide a minimum of 6 inches for tanks unless a sump or other device allows for complete emptying.
- Additional storage when required to meet management goals or regulatory requirements.

<u>Emergency Volume (liquid storages only)</u>
- 25-year, 24-hour precipitation on the surface of the liquid or slurry storage facility at the maximum level of the required design storage.
- 25-year, 24-hour runoff from the facility's drainage area.

<u>Freeboard Volume (for liquid or slurry waste storage exposed to precipitation)</u>
Maintain a minimum of 12" freeboard at all times.

Exclude non-polluted runoff from the structure to the fullest extent practical except where including the runoff is advantageous to the operation of the agricultural waste management system.

Inlet
Design inlet to resist corrosion, plugging, freeze damage, and ultraviolet deterioration. Incorporate erosion protection as necessary.

Waste Removal
Provide components for removing waste such as gates, pipes, docks, wet wells, pumping platforms, retaining walls, or ramps. Incorporate features to protect against erosion, tampering, and accidental release of stored waste as necessary. Design ramps to empty liquid waste to be 4 horizontal to 1 vertical or flatter. Design ramps to empty slurry, semi-solid, or solid waste to be 10 horizontal to 1 vertical or flatter unless a special traction surface is provided.

Use Virginia CPS Nutrient Management (Code 590) for land application of stored material or follow other disposal options outlined in a Comprehensive Nutrient Management Plan (CNMP).

Accumulated Solids Removal
To preserve storage volume, make provision for periodic removal of accumulated solids. The anticipated method for solids removal must be accommodated in design, particularly in determining the configuration of impoundments and the type of liner to be used.

Maximum Operating Level
The maximum operating level for liquid storage structures is the level that provides the operational volume.

Staff Gauge
Place a staff gauge or other permanent marker in the liquid storage facility to clearly indicate the following elevations:

- Maximum operating level (top of the operational volume).
- Emergency level (top of the design storage volume).

For storages where the contents are not visible and a staff gauge would not be visible, such as below a slatted floor, identify the method for the operator to measure the depth of accumulated waste in the Operation and Maintenance Plan.

Safety
Include appropriate safety features to minimize the hazards of the facility (refer to American Society of Agricultural and Biological Engineers (ASABE) Standard EP470, Manure Storage Safety for guidance, as needed).

Provide warning signs, fences, ladders, ropes, bars, rails, and other devices, as appropriate, to ensure the safety of humans and livestock. Provide ventilation and warning signs for covered waste holding structures, as necessary, to prevent explosion, poisoning, or asphyxiation.

Design covers and grating over openings such that livestock or humans cannot accidentally displace them and fall into the facility.

Design pipelines with a water-sealed trap and vent, or similar device, if there is a potential for gases from the pipe to accumulate in confined spaces.

Place a fence around impoundments and uncovered tanks which have exposed walls less than 5 feet above ground surface. Use the Virginia CPS Fence (Code 382) for design of a fence that will prevent accidental entry by people or animals likely to be onsite. Post universal warning signs to prevent children and others from entering liquid waste storage structures.

Water Table
Determine the seasonal high water table by either long-term monitoring or by the presence of diagnostic soil redoximorphic features as identified during on-site investigations conducted by an individual trained in soil and water relationships. For the purpose of this standard, “seasonal high water table” refers to the upper limit of soil saturation with water during the wettest season, and can occur at any depth within the entire soil profile observed during an on-site soils investigation. The NRCS Field Handbook for Describing and Sampling Soils recognizes three types of seasonal high water tables: apparent, perched, and artesian.

If feasible, the seasonal high water table may be lowered by the use of an artificial drainage system designed by a qualified individual.

Subsurface Investigations
A subsurface investigation is required for all waste storage facilities. Subsurface investigations will be conducted by individuals trained in soil science, engineering, geology, or a related field and be in accordance with NRCS NEM, Part 531, Geology.

The number and depth of test holes, pits, or borings will vary depending on the planned surface area and depth of the structure and the conditions encountered during the investigation such as the complexity of the soils, the depth to groundwater, and the presence or absence of seeps. At a minimum, there will be one test hole, pit, or boring for each 5,000 ft^2 for the first 20,000 ft^2 of planned storage facility surface area plus at least one test hole, pit, or boring for each additional 10,000 ft^2. Extend each test hole, pit, or boring at least 2 feet below the planned bottom of the structure. The log for each test hole, pit, or boring will indicate the following:

- Existing ground surface elevation;
- A description of the soil material encountered using the Unified Soil Classification System;
- Depth to changes in the soil material encountered;
- Depth to any seeps encountered;

- Depth to high water (note method of determination: mottling, free water encountered, etc.); and
- Depth to bottom of test hole, pit, or boring.

Show the location and log information for all test holes, pits, and/or borings in or near the structure on the construction drawings.

Depending on site conditions, the use of Ground Penetrating Radar, seismographs, or similar equipment may be necessary to complete the site investigation.

Note the presence of sinkholes in karst topography.

Roofs and Covers
Use Virginia CPS Roofs and Covers (Code 367) for design of waste storage facility covers or roofs, as needed.

Treated Wood
Use criteria from NRCS CPS Roof and Covers (Code 367) for treated wood and fasteners.

Additional Criteria for Liquid Waste Storage Impoundments

A liquid waste storage impoundment is a facility where the stored material does not consistently stack and is either a natural topographic depression, manmade excavation, or diked area formed primarily of earthen materials, such as soil (although the unit may be lined with manmade materials).

Foundation
Locate the impoundment in soils with a permeability that meets all applicable regulations or line the impoundment with suitable material. Use liners which meet or exceed Virginia CPS Pond Sealing or Lining (Codes 520, 521, or 522).

For the design of a liner in locations where there is potential for uplift, include an evaluation of all potential buoyant uplift forces on the liner. Limit projected uplift head under clay liners to a gradient of less than 0.5 ft/ft in the clay liner. The gradient is determined as the difference in total head between the top and the bottom of a clay liner when buoyant forces exist divided by the thickness of the clay liner.

Design Bottom Elevation
Locate the impoundment bottom elevation a minimum of 2 feet above the seasonal high water table unless special design features are incorporated that address buoyant forces, impoundment seepage rate and non-encroachment of the water table by contaminants. The water table may be lowered by use of drains to meet this requirement.

Outlet
An outlet that can automatically release stored material is not permitted except in septic tanks that feed a treatment system such as a waste treatment strip or leaching field or outlets leading to another storage facility with adequate capacity. Design a permanent outlet that will resist corrosion and plugging. Provide a backflow prevention measure for an outlet that pumps wastewater to secondary storage located at a higher elevations.

Waste Pond Lining
Uncompacted self-sealing linings from native soil are not acceptable for waste containment. **All waste ponds shall be sealed or lined to achieve a permeability of 1 x 10^{-6} cm/sec (0.0028 feet/day) or less on all interior impoundment surfaces**. The liner subgrade will be a dense base regardless of liner method. Protect liners from punctures caused by adjacent fill materials and waste pond filling and pumping operations.

Soil liners should be avoided in karst areas. If soil liners are used in a karst area, perform a geologic site investigation to determine the potential for onsite sinkholes to develop. If a high risk is determined by the geologist or other qualified individual, use a flexible membrane or concrete liner.

The construction of piers, loading ramps, inlets, outlets, and other appurtenances must be accomplished in a manner that does not damage or impair the operation of the liner system. The construction area must be free of water.

Seal the waste pond by one of the following methods:

1. Compacted Soil Liners

Design and construct compacted soil liners (compacted clay, soil dispersant treatment, bentonite treatment) in accordance with Virginia CPS Pond Sealing or Lining, Compacted Soil Treatment (Code 520).

2. Flexible Membrane

Design and construct flexible membrane liners in accordance with Virginia CPS Pond Sealing or Lining, Geomembrane or Geosynthetic Clay Liner (Code 521).

3. Concrete Liner

Design and construct reinforced concrete liners in accordance with Virginia CPS Pond Sealing or Lining, Concrete (Code 522).

Embankments

The minimum elevation of the top of the settled embankment will be one foot above the waste storage pond's required volume. For an impoundment with greater than one acre of surface area and where wave action is a concern, increase the embankment height to account for calculated wave height. In all cases, increase the constructed embankment height by at least 5 percent to allow for settlement. Stabilize all embankments to prevent erosion or deterioration.

Minimum embankment top widths are shown in table 1. Design the combined side slopes of the settled embankment to be equal to or flatter than 5 horizontal to 1 vertical, with neither slope steeper than 2 horizontal to 1 vertical unless provisions are made for stability. The total embankment height (effective height) is the difference in elevation between the auxiliary (emergency) spillway crest or the settled top of the embankment if there is no auxiliary spillway and the lowest point in the cross section taken along the centerline of the embankment.

Table 1. Minimum Top Widths

Total embankment height (ft)	Top width, (ft)
Less than 15	8
15–19.9	10
20–24.9	12
25–30	14
30–35	15

Spillway or Equivalent Protection

For a facility having a total embankment height greater than 20 feet, construct an auxiliary (emergency) spillway or route through the spillway or store below the spillway another volume equivalent to the emergency volume.

Excavations

Design excavated side slopes to meet the requirements of the liner used, see Virginia CPS Pond Sealing or Lining, Compacted Soil Treatment (Code 520), Pond Sealing or Lining, Geomembrane or Geosynthetic Clay Liner (Code 521) or Pond Sealing or Lining, Concrete (Code 522).

Additional Criteria for Fabricated Structures

Foundation

Based on subsurface investigation, provide a foundation for fabricated waste storage structures to safely support all superimposed loads without excessive movement or settlement. Perform subsurface investigations for all fabricated structures sufficient in detail and analysis to support the design in accordance with NRCS NEM, Part 531, Geology.

Where a nonuniform foundation cannot be avoided or where applied loads may create highly variable foundation loads, calculate settlement based upon 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 are available, use presumptive bearing strength values for assessing actual bearing pressures obtained from table 2 or another nationally recognized building code. In using presumptive bearing values, provide adequate detailing and articulation to avoid distressing movements in the structure.

For bedrock foundations with joints, fractures, or solution channels, separate the floor slab and the bedrock by—

- A minimum of 1 foot of soil.
- A liner that meets or exceeds NRCS CPS Pond Sealing or Lining (Codes 520, 521, or 522).
- Other appropriate method or alternative that achieves equal protection.

Table 2. Presumptive Allowable Foundation and Lateral Pressure[1]

Class of materials	Allowable foundation pressure (psf)	Lateral bearing (psf/ft) below natural grade	Coefficient of friction	Cohesion (psf)
Crystalline bedrock	12,000	1,200	0.70	-
Sedimentatry and foliated rock	4,000	400	0.35	-
Sandy gravel or gravel (GW and GP)	3,000	200	0.35	-
Sand, silty sand, clayey sand, silty gravel, clayey gravel (SW, SP, SM, SC, GM and GC)	2,000	150	0.25	-
Clay, sandy clay, silty clay, clayey silt, silt and sandy silty (CL, ML, MH and CH)	1,500	100	-	130
[1] International Building Code (IBC), 2015, International Code Council (ICC)				

Structural Loadings

Design the waste storage structure to withstand all anticipated loads in accordance with the requirements in NRCS NEM, Part 536, Structural Design. Such loads should include internal and external loads, hydrostatic uplift pressure, concentrated surface and impact loads, and water pressure due to seasonal high water table, frost or ice.

Calculate loading from lateral earth pressures using soil strength values determined from the results of appropriate soil tests and procedures described in Technical Release 210-74, Lateral Earth Pressures. Table 3 provides minimum lateral earth pressure values when soil strength tests are not available. If heavy equipment will operate near the wall, use an additional soil surcharge or an additional internal lateral pressure in the wall analysis as appropriate.

For the lateral load from stored waste not protected from precipitation, use a minimum 65 $lb/ft^2/ft$ of depth as the design internal lateral pressure. Use a minimum value of 60 lb/ft2/ft of depth for the lateral load from stored waste protected from precipitation and not likely to become saturated. Use a minimum internal lateral pressure of 72 $lb/ft^2/ft$ of depth for sand-laden manure storage if the percentage of sand exceeds 20%. Designers may use lesser values if supported by measurement of actual pressures of the waste to be stored.

Table 3. Minimum Lateral Earth Pressure Values[1]

Description of backfill material [c]	Unified soil classification	Design lateral soil load ($lb/ft^2/ft$ of depth) [a]	
		Active pressure	At-rest pressure
Well-graded, clean gravels; gravel-sand mixes	GW	30	60
Poorly graded clean gravels; gravel-sand mixes	GP	30	60
Silty gravels, poorly graded gravel-sand mixes	GM	40	60
Clayey gravels, poorly graded gravel-sand mixes	GC	45	60
Well-graded, clean sands; gravely sand mixes	SW	30	60
Sand-silt clay mix with plastic fines	SP	30	60
Silty sands, poorly graded sand-silt mixes	SM	45	60
Sand-silt clay mix with plastic fines	SM-SC	45	100
Clayey sands, poorly graded sand-clay mixes	SC	60	100
Inorganic silts and clayey silts	ML	45	100
Mixture of inorganic silt and clay	CL-ML	60	100
Inorganic clays of low to medium plasticity	CL	60	100
Organic silts and silt clays, low plasticity	OL	Note [b]	Note [b]
Inorganic clayey silts, elastic silts	MH	Note [b]	Note [b]
Inorganic clays of high plasticity	CH	Note [b]	Note [b]
Organic clays and silty clays	OH	Note [b]	Note [b]

Description of backfill material [c]	Unified soil classification	Design lateral soil load (lb/ft^2/ft of depth) [a]	
		Active pressure	At-rest pressure

[1] Table 1610.1, Lateral Soil Load, International Building Code (IBC), 2015, International Code Council (ICC).

[a] Design loads based on moist conditions for the specified soils at optimum density. Include the weight of the buoyant soil plus hydrostatic pressure for submerged or saturated soil.

[b] Unsuitable as backfill material.

[c] Base the definition and classification of soil in accordance with ASTM D 2487.

Structural Design
Design structures with reinforced concrete, steel, wood, or masonry materials in accordance with NRCS-NEM, Part 536, Structural Engineering. Account for all items that will influence the performance of the structure, including loading assumptions, durability, serviceability, material properties and construction quality. Ensure that the material used for a fabricated structure is compatible with the waste product to be stored.

Tanks may be designed with or without a cover. Design openings in a covered tank to accommodate equipment for loading, agitating, and emptying. Equip these openings with fencing, grills or secure covers for safety, and for odor and vector control as necessary.

Additional Criteria - Stacking Facilities

A stacking facility may be open, covered, or roofed and is used for wastes which behave primarily as solid. Determine the wall height using the anticipated stacking angle of the waste material. Construct a stacking facility of durable materials such as reinforced concrete, reinforced concrete block, or treated lumber. Design the stacking facility with adequate safety factors to prevent failure due to internal or external pressures, including hydrostatic uplift pressure and imposed surface loads such as equipment which may be used within, on, or adjacent to the structure.

Seepage
Prevent leachate in amounts that would pollute surface or groundwater with collection and disposal of liquids in a safe manner as necessary. Prevent influent seepage in amounts that would infringe on designed storage capacity. Seepage control may not be necessary on sites that have a roof, waste material with little seepage potential or in certain climates.

Internal Drainage
Make provisions for drainage of leachate, including rainfall from the stacking area (especially those without a roof). Collect leachate in a tank or waste storage impoundment, or properly treat in a lagoon or vegetated treatment area.

Poultry Litter Stacking Facility
To reduce the potential for spontaneous combustion damage to wood walled facilities, design the height of the litter stack not to exceed 7 feet, with litter to wood contact limited to 5 feet.

CONSIDERATIONS

For exposed liners utilizing HDPE or similar materials that are slippery when wet, consider the use of textured liners or addition of features such as tire ladders that would allow for escape from the waste storage structure.

Consider solid/liquid separation of runoff or wastewater entering impoundments to minimize the frequency of accumulated solids removal and to facilitate pumping and application of the stored waste.

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

Since the economics and risks associated with waste storage facilities are quite high, consider providing the operator with the cost to close the facility. Cost should include removal of the planned sludge accumulation volume and the waste stored at the maximum operating volume.

Considerations for Siting

Consider the following factors in selecting a site for waste storage facilities:

- Proximity of the waste storage facility to the source of waste.
- Access to other facilities.
- Ease of loading and unloading waste.
- Compatibility with the existing landforms and vegetation, including building arrangement, to minimize odors and adverse impacts on visual resources.
- Adequate maneuvering space for operating, loading, and unloading equipment.

Considerations for Minimizing the Potential for and Impacts of Sudden Breach of Embankment or Accidental Release from the Waste Storage Facility

Consider 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 when any of the categories listed below might be significantly affected.

Potential impact categories from breach of embankment or accidental release include—

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

Consider the following either singly or in combination to minimize the potential of or the consequences of sudden breach of embankments:

- 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.
- Double liners.

Options to consider to minimize the potential for accidental release from the waste storage facility through gravity outlets include—

- Outlet gate locks or locked gate housing.
- Secondary containment.
- Alarm system.
- Another nongravity means of emptying the waste storage facility.

Considerations for Minimizing the Potential of Waste Storage Pond Liner Failure

Avoid sites with categories listed below unless no reasonable alternative exists.

Potential impact categories for liner failure are—

- 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 water soluble bedrock such as limestone or gypsum.

For a site with one or more of these site conditions, consider providing a leak detection system in conjunction with the planned liner to provide an additional measure of safety.

Considerations for Stacking Facilities

For any facility that is an organic producer or that sells manure to organic producers, consider using rot-resistant or treated lumber that meets the requirements for organic production. The producer should consult with the organic certifier as to the use and acceptability of treated lumber for waste storage.

Considerations for Improving Air Quality

Liquid manure storage may result in emissions of volatile organic compounds, ammonia, hydrogen sulfide, methane, nitrous oxide, and carbon dioxide. Solid manure storage may result in emissions of particulate matter, volatile organic compounds, ammonia, carbon dioxide, and nitrous oxide.

To reduce emissions of greenhouse gases, ammonia, volatile organic compounds, particulate matter and odor, other Virginia CPSs such as Anaerobic Digester (Code 366), Roofs and Covers (Code 367), Waste Treatment (Code 629), Amendments for Treatment of Agricultural Waste (Code 591), and Composting Facility (Code 317) can be added to the waste management system.

Adjusting pH below 7 may reduce ammonia emissions from the waste storage facility but may increase odor when waste is surface applied—see NRCS CPS Nutrient Management (Code 590).

Some fabric and organic covers have been shown to be effective in reducing odors.

Maintain appropriate manure moisture content for solid manure storage facilities. Excessive moisture will increase the potential for air emissions of volatile organic compounds, ammonia, and nitrous oxide, and may lead to anaerobic conditions, which will increase the potential for emissions of methane and hydrogen sulfide. Too little moisture will increase the potential for particulate matter emissions.

PLANS AND SPECIFICATIONS

Prepare plans and specifications that describe the requirements for applying the practice to achieve its intended use. As a minimum, include the following in the engineering plans and specifications:

Record all required information in an engineer field book, on a plan sheet or design computation sheet, or in another appropriate location.

DESIGN DATA

- Completed Environmental Evaluation and subsequent requirements.
- Soils investigation.
- Survey and plot data: profile, cross-sections, topography, as needed.
- Design computations, including purpose of practice and references used.
  - Waste volume and sizing calculations.
  - Structural Calculations for all components, including reinforcing steel, type of materials,

  - thickness, anchorage requirements, and lift thickness.
  - Drainage Calculations (as necessary).
- Plan view of site with existing and planned features, including dimensions, distances, etc. Include locations, sizes and type of pipelines and appurtenances. Also include approximate location of utilities.
- Requirements for foundation preparation and treatment.
- Standard Cover Sheet (VA-SO-100A).
- Materials and quantities needed. Identify borrow material and/or spoil area, as needed.
- Vegetation and/or ground cover requirements.
- Identification of needed Erosion & Sediment Control measures.
- Supplemental practices required.
- Virginia Conservation Practice Specifications (700 Series).
- Operation and Maintenance Plan.
- A completed Agricultural Waste Management System Plan for the owner's total livestock operation that addresses types and numbers of animals and includes an Emergency Action Plan.

CHECK DATA

1. As-built survey.
2. As-built plans including dimensions, types and quantities of materials installed, and variations from design. Include justification for variations.
3. Locations of appurtenant practices.
4. Adequacy of vegetation and/or ground cover.
5. Complete as-built section of Cover Sheet.

OPERATION AND MAINTENANCE

Develop an operation and maintenance plan that is consistent with the purposes of the practice, its intended life, safety requirements, and the criteria for its design. At a minimum, the plan will:

- Include the operational requirements for emptying the storage facility including the expected storage period. Begin removal of the liquid storage facility as soon as practical after the maximum operating level has been reached. Also include the requirement that waste be removed from storage and utilized at locations, times, rates, and volume in accordance with the overall waste management system plan.
- For impoundments and other liquid storages include an explanation of the staff gauge or other permanent marker to indicate the maximum operating level. For storages where the contents are not visible and a staff gauge would not be visible, such as below a slatted floor, identify the method for the operator to measure the depth of accumulated waste.
- Include a provision for emergency removal and disposition of liquid waste in the event of an unusual storm event that may cause the waste storage structure to fill to capacity prematurely.
- Include instructions as needed for ventilating confined spaces according to ASABE standard S607, Venting Manure Storages to Reduce Entry Risk.
- Develop an emergency action plan for waste storage facilities where there is a potential for significant impact from breach or accidental release. Include site-specific provisions for emergency actions that will minimize these impacts.
- Include a description of the routine maintenance needed for each component of the facility. Also include provisions for maintenance that may be needed as a result of waste removal or material deterioration.

REFERENCES

American Society for Testing and Materials. Annual Book of ASTM Standards. Standards D 653, D 698, D 1760, D 2488. ASTM, Philadelphia, PA.

USDA Natural Resources Conservation Service. 1992. Agricultural Waste Management Field Handbook. USDA-NRCS, Washington, DC.

USDA Natural Resources Conservation Service. General Manual. USDA-NRCS, Washington, DC.

USDA Natural Resources Conservation Service. National Engineering Manual. USDA-NRCS, Washington, DC.

USDA Soil Conservation Service. 1989. Technical Release Number 74, Lateral Earth Pressures, USDA-SCS, Washington, DC.