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WISCONSIN FIELD OFFICE TECHNICAL GUIDE
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FOTG NOTICE WI-91

April 4, 2018

Purpose. Revisions to Wisconsin Conservation Practice Standards and Specifications.

Effective Date. This notice is effective upon receipt.

Explanation of Changes.

Section IV: Conservation Practice Standards and Specifications:

Aquaculture Ponds (Code 397) – Five year review period. National standard not updated recently. Reviewed with no changes. Date was made current.

Groundwater Testing (Code 355) – Language was added to identify testing parameters for use in microirrigation and livestock consumption.

Saturated Buffer (Code 604) – The national standard was updated to expand the range of applicability of the standard to greater number of field sites, the current 5-percent flow capacity criteria for the saturated buffer is maintained, but designers are now allowed to use an alternate length of the distribution pipe if the 5-percent criteria is found impractical or cost-prohibitive. The required geological investigation for slope stability is also maintained, but designers are allowed an alternate analysis of slope stability based on professional, onsite observations.

Earthfill for Waste Storage Facilities (WCS 204) – The specification was updated to include soil liners. Articulated haul truck was added to the equipment type in Table 1, Embankment and Soil Liner Compaction Requirements.

The following revisions have been posted on the Wisconsin eFOTG website:

Remove the following outdated Standards and Specifications from any printed copies of the WI FOTG:

- Index
- Aquaculture Ponds (Code 397)
- Groundwater Testing (Code 355)
- Saturated Buffer (Code 604)
- Earthfill for Waste Storage Facilities (WCS 204)

Add the following Standards and Specifications to any printed copies of the WI FOTG:

- Index
- Aquaculture Ponds (Code 397)
- Groundwater Testing (Code 355)
- Saturated Buffer (Code 604)
- Earthfill for Waste Storage Facilities (WCS 204)

DIST: Wisconsin Statewide

Natural Resources Conservation Service
8030 Excelsior Drive, Suite 200, Madison, WI 53717
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A link to the Wisconsin FOTG is located on the NRCS website at:
https://www.nrcs.usda.gov/wps/portal/nrcs/main/wi/technical/cp/

ANGELA L. BIGGS
State Conservationist

Attachments

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Natural Resources Conservation Service
CONSERVATION PRACTICE STANDARD
AQUACULTURE PONDS
Code 397
(Acre)

DEFINITION

A water impoundment constructed and managed for farming of freshwater and saltwater organisms including fish, mollusks, crustaceans and aquatic plants.

PURPOSE

Provide a favorable aquatic environment for producing, growing, and harvesting aquaculture crops.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to all impoundments that store water and are managed for aquaculture purposes.

CRITERIA

General Criteria Applicable to all Purposes

Design and install measures according to a site-specific plan in accordance with all local, State, Tribal, and Federal laws and regulations. Apply measures that are compatible with improvements planned or being carried out by others.

Aquaculture ponds may be: (1) embankment ponds that intercept and store surface runoff water, or (2) off-channel impoundments or excavated ponds that are filled by pumping ground water, or diverting spring or stream flows.

The site must be protected from flooding, sedimentation, and non-sediment contamination.

The pond shall be constructed to the recommended size and depth for the species to be grown.

The soils within the pond area, as well as those in the contributing drainage area, must be checked for residues of pesticides and other harmful chemicals if there is any possibility of contamination.

Acid soils shall be limed to achieve a neutral condition or the desired pH level for best production.

The pond shall be located in soils with an acceptable permeability to limit water losses due to seepage or it shall be lined.

When multiple ponds are installed, each pond shall be arranged so that it can be managed independently of the others to facilitate harvesting and the control of parasites and disease.

All ponds shall be designed to prevent the escape of non-native or otherwise harmful species to adjacent surface water bodies especially downstream and upstream of streams and rivers.

A protective cover of vegetation shall be established on all exposed soil surfaces that have been disturbed. If soil or climatic conditions preclude the use of vegetation, other protection methods shall be used.

Any available water source may be used if the quality and quantity are adequate. If water is pumped from rivers and streams or other sources where undesirable fish, pesticide residue, fish disease, and parasites may be introduced, filters must be installed in the pumping system.

Evaporation rates, stocking densities, and cultured species requirements shall be used in establishing specific incoming flow rates.

Water entering the pond shall be aerated to increase dissolved oxygen and dissipate harmful gases, if needed. The minimum dissolved oxygen level in ponds is 3 to 5 parts per million. Supplemental aeration within the aquaculture pond shall be included, as necessary to maintain desired dissolved oxygen.

Water temperature and water chemistry shall be suitable to meet the species requirements and the planned production level.

Incoming water shall be introduced as far away from outlet drain as practicable to prevent the rapid removal of fresh water from the pond.

Provide for the collection, harvest and utilization of wastes from the cultured organisms.

Provisions shall be made for any needed treatment of water released downstream to ensure that the designated use of the receiving waters is not degraded from the aquaculture impoundment structure.

Embankment Ponds. Earthfill dams and embankments that intercept and store runoff water shall meet or exceed the requirements for embankments as specified in Wisconsin Conservation Practice Standard (WI CPS) Pond (Code 378).

The minimum top width of the embankment shall be 14 feet, where it is to be used as a road for harvesting, feeding, and management purposes and is nonpublic.

Excavated Ponds. Ponds established by excavating and constructing an embankment around their outer perimeter that excludes outside runoff shall have either an auxiliary spillway, a principal spillway pipe, or a pumping system installed with sufficient capacity to remove a 10-year/24-hour direct rainfall amount in 48 hours or less. A minimum 8-inch diameter pipe shall be used for a principal spillway.

The minimum design elevation of the top of the embankment shall include 6 inches of freeboard above the highest potential water elevation in the pond. The highest potential water elevation will be the top elevation of the outlet weir or principal spillway, plus the head needed to discharge the maximum pond inflow, plus the depth of the 10-year, 24-hour rainfall.

Perimeter embankment construction shall include the required settlement to maintain freeboard requirements. A minimum width of 10 feet shall be provided between the outside toe of the embankment and the top of the bank of any adjacent stream or ditch.

Pipes and Conduits. Pump discharge through embankments shall be installed above expected high water level, and provisions shall be made to prevent pump and motor vibrations from being transmitted to discharge conduits.

Interior embankments constructed for division of water or to direct water flow for circulation shall have adequate cross section to ensure stability and function for its intended purpose.

Adequate provisions must be made to protect earth surfaces from turbulent water at pipe inlets and outlets.

Drains. All ponds shall have facilities for complete as well as partial drawdown. Turn-down pipes, quick-release valves, bottom-water release sleeves, pumps or other devices for water level control and pond management are to be included in the design and construction of the impoundment. Conduit design and seepage control shall meet or exceed the requirements specified in WI CPS Pond (Code 378).

Pond Bottom. Where organisms are harvested by seining, the pond bottom shall be smooth and free of all stumps, trees, roots, and other debris. Existing channels and depressions in the pond area shall be filled and smoothed. The edges of the pond shall be deepened to provide at least 3 feet of water.

Where crawfish are harvested by trapping, complete clearing and removal of trees, stumps, and other vegetation is not required.

The pond bottom shall be sloped to the outlet at a gradient of at least 0.2 foot per 100 feet.

Access and Safety. Provisions shall be made for access to the site as well as access for operation and maintenance.

Ramps for equipment access shall have a grade of 4 horizontal to 1 vertical or flatter.

Appropriate safety features shall be made available nearby to aid people who may fall into the pond and devices installed to prevent such accidents.

Fences shall be installed as necessary to exclude livestock and unwanted traffic.

CONSIDERATIONS

Considerations include additional design recommendations that are not required criteria, but may be used to enhance or avoid problems with the design and function of this practice.

The state fishery agency or appropriate state university or research institution should be contacted for recommendation on pond size, water depths, and adapted commercial aquatic species.

Consider any adverse impact to cultural resources when planning for aquaculture ponds.

Consider the visual design of ponds should be carefully considered in areas of high public visibility and those associated with recreational fishing.

Consider the effects on the volume of downstream flow or aquifers that might cause undesirable environmental, social, or economic effects and contribute to water table decline from heavy pumping.

Consider measures to avoid depredation by birds and/or other animals.

PLANS AND SPECIFICATIONS

Plans and specifications for constructing aquaculture ponds shall be in keeping with this standard and shall describe the site-specific requirements for applying the practice to achieve its intended purpose.

As a minimum the plans shall include:

- A site location map with topographic information,
- Typical cross sections of the pond(s) showing the elevations and dimensions,
- Structure size, location, material type, and elevations,
- Disposal of any excess excavated material,
- Location and type of fence, if required, and
- Areas to be vegetated and vegetative specification.

OPERATION AND MAINTENANCE

A written site specific operation and maintenance plan shall be prepared and provided for use by those responsible for the system. The O&M plan shall provide for inspection, operation, and maintenance of vegetation, pipes, valves, spillways, roads, and other parts of the system

REFERENCES

USDA, NRCS Wisconsin Field Office Technical Guide (FOTG), Section IV, Practice Standards and Specifications.

Natural Resources Conservation Service
CONSERVATION PRACTICE STANDARD
GROUNDWATER TESTING
Code 355
(No.)

DEFINITION

Testing the physical, biological, and chemical quality of groundwater from a water well or spring.

PURPOSE

This practice is applied to determine the quality of a groundwater supply with respect to its intended use.

CONDITIONS WHERE PRACTICE APPLIES

This standard applies to groundwater from a production well or spring used for agricultural or wildlife purposes.

This practice does not apply to monitoring wells installed to sample, monitor, or test groundwater quality parameters related to contamination associated with waste management systems.

CRITERIA

Select the parameters for testing consistent with the intended use or concerns identified with the well or spring.

For livestock consumption, select the parameters for testing as specified in the **Specialty Water Test** under **Water Testing for Microirrigation Systems**.

Use sampling and testing procedures that comply with Environmental Protection Agency's "Manual of Methods for Chemical Analysis of Water and Wastes."

Water Testing for Microirrigation Systems

Obtain a **Basic Water Test** to determine water suitability regarding clogging of the microirrigation system emitters. Use water test results to determine irrigation suitability and any treatment requirements.

A **Basic Water Test** will include analysis of the following substances:

- pH
- Total Hardness
- Alkalinity
- Conductivity
- Iron
- Suspended Solids

Obtain a **Specialty Water Test** to determine if water quality standards are met for micro-irrigation when neighboring wells have known water quality issues due to specialized substances. Use water test results to determine suitability and any treatment requirements.

A **Specialty Water Test** will include analysis of all of the substances listed for a **Basic Water Test** in addition to analysis of the following substances:

- Total Coliform Bacteria
- Nitrates & Nitrites
- Atrazine
- Arsenic
- Copper
- Lead
- Manganese
- Zinc
- Other identified substances of concern (e.g. pesticides, heavy metals, volatile organic compounds, etc.)

CONSIDERATIONS

Consider using a computerized total farm record keeping system for ease of data input, analysis, and retrieval of testing results.

PLANS AND SPECIFICATIONS

Prepare plans and specifications for groundwater testing that describe the requirements for applying the practice to achieve the intended purpose. Include the following:

- Document the location and depth of supply.
- Document aquifer characteristics, geology, and history of site relative to sources of potential contamination, such as surface water, septic systems, chemical storage facilities, landfills, roads, animal waste storage or treatment facilities, or naturally occurring sources of contamination.
- Document the construction method used to install the well or spring development.
- Include a description of the collection process, storing, transporting, and testing samples; and the reporting of test results.

OPERATION AND MAINTENANCE

Maintain the water test records for the design life of the well or spring. Include the following items as part of the water test records:

- Sample site location by ground coordinates, such as by Global Positioning System (GPS), or other suitable method
- Name and title of person who collected sample(s)
- Planned use of the water
- Depth interval where sample was taken
- Date and time of water sampling

- Type of sampler and volume of sample
- Standard collection procedure used
- Date of water quality analyses
- Name and address of laboratory that performed analyses
- Parameters tested
- Schedule of additional testing, if required by the applicable water quality standard
- Records to evaluate trends and the effects of any remedial actions to produce water of quality suitable for the intended purpose
- Observations of well or spring condition at time of sampling
- Installation date of well or spring development
- Other records as required by regulations

REFERENCES

U.S. Environmental Protection Agency, Mar. 1983. "Manual of Methods for Chemical Analysis of Water and Wastes", EPA/600/479/020, Office of Research and Development, Washington, DC 20460, 552 p.

Natural Resources Conservation Service
CONSERVATION PRACTICE STANDARD
SATURATED BUFFER
Code 604
(Ft.)

DEFINITION

A subsurface, perforated distribution pipe used to divert and spread drainage system discharge to a vegetated area to increase soil saturation.

PURPOSE

Install the practice to achieve one or more of the following purposes:

- To reduce nitrate loading from subsurface drain outlets.
- To enhance or restore saturated soil conditions in riverine, lacustrine fringe, slope, or depression hydrogeomorphic landscape classes.

CONDITIONS WHERE PRACTICE APPLIES

This practice is applicable to lands with a subsurface drainage system adaptable to discharge in a vegetated area.

Apply this practice where the soils and topography of the vegetated discharge area are capable of maintaining a raised water table without adverse effects to crops, channel banks, shorelines, or adjacent land.

This practice does not apply to drainage systems or underground outlet systems that have surface inlets which allow entry of soil and debris capable of plugging the distribution pipe(s).

Do not use this practice to discharge septic system effluent or animal waste.

CRITERIA

General Criteria Applicable to All Purposes

Design and install measures according to a site-specific plan in accordance with all local, State, Tribal, and Federal laws and regulations. Apply measures that are compatible with improvements planned or being carried out by others.

Conduct geologic and soil investigations to confirm:

- Conditions, such as a restrictive layer, are present to create saturated conditions when water is diverted from a subsurface drainage system.
- The absence of pockets or layers of high conductivity soil that could provide preferential flow paths.
- A minimum of 0.75 percent organic carbon (1.2 percent organic matter) in the top 2.5 feet of soil.
- The absence of abandoned drain pipes or clay tile in the buffer area that could continue to drain the buffer.

The minimum width of the vegetated buffer zone is 30 feet.

Locate and design the system to maximize the amount of subsurface drainage water distributed to the potentially saturated soil zone. Ensure there are no adverse impacts to adjacent lands.

Avoid placing the distribution pipe along any channels incised deeper than 8 feet, unless a slope stability analysis shows an acceptable level of safety against saturated streambank failure.

Provide a minimum cover of 2 feet over the top of the distribution pipe.

Flow. DRAINMOD or other appropriate model simulations, drainage mainline capacity, or drainage system drainage coefficient with area drained can be used to determine drainage system capacity.

Minimum saturated buffer design flow is five percent of drainage system capacity.

Use soil profile saturated hydraulic conductivity, saturated buffer design flow rate, and hydraulic heads available at a particular site to compute minimum buffer dimensions and length of distribution pipe required to meet selected saturated buffer design flow.

Water control structure. Design the water control structure using the criteria found in Wisconsin NRCS Conservation Practice Standard (WI NRCS CPS), Structure for Water Control (Code 587). Locate the water control structure where it is accessible for water table observation and for operation and maintenance.

Design the water control structure to maintain the target water table elevation(s) over the distribution pipe during the management period. Convey drainage water in excess of the design capacity of the saturated buffer through an overflow pipe to a suitable, stable outlet. Use nonperforated pipe for the overflow pipe for a minimum of 20 feet from the water control structure to avoid draining the saturated soil zone around the water control structure.

The water control structure must not cause water to back up into a main or lateral beyond a property line unless the upstream landowner has given written permission.

Distribution pipe. Design the distribution pipe and overflow pipe according to the criteria found in WI NRCS CPS, Subsurface Drain (Code 606). Ensure capacity of the distribution pipe is greater than the saturated buffer design flow to ensure that the soil lateral flow capacity rather than distribution pipe capacity limits saturated buffer flow.

Situate the distribution pipes on a topographic contour or grade to facilitate uniform groundwater inflow to the saturated zone. Add additional water control structures as needed for flow uniformity. The maximum elevation difference between structures is three feet.

Vegetation. Vegetate the soil saturation area and any other disturbed areas to prevent erosion and to utilize nitrogen from the drain water.

Protect all disturbed areas from erosion by seeding or mulching. Refer to WI NRCS CPS, Conservation Cover (Code 327) or Critical Area Planting (Code 342) for criteria on seed selection, seedbed preparation, fertilizing, and seeding.

Additional Criteria to Reduce Nitrate Loading

Ensure saturated conditions are within the high soil organic carbon region of the soil profile when adequate drain flows exist. Design the system to maintain a water table within 12 inches of the ground surface at the location of the distribution pipe during the management period. Maintain the water control

structure at the design level except when the water table must be lowered for providing an adequate root zone for the crop, trafficability for field work, adverse weather conditions, or system maintenance.

Additional Criteria to Enhance or Restore Saturated Soil Conditions

Design the system to replicate groundwater levels shown in the "Water Features" section of the USDA Web Soil Survey reports.

CONSIDERATIONS

Consider using other practices and management systems in conjunction with this practice to achieve a reduction of nitrate-nitrogen levels. Examples include WI NRCS CPSs, Nutrient Management (Code 590), Cover Crop (Code 340), Drainage Water Management (Code 554), Denitrifying Bioreactor (Code 605), and Constructed Wetland (Code 656).

Consider adding an envelope around the drain to improve exit flow. Refer to criteria in WI NRCS CPS, Subsurface Drain (Code 606).

For cost-effectiveness, consider locating the saturated buffer where it will intercept a subsurface drain outlet draining at least 15 acres.

Consider installing observation wells in the buffer midway between the distribution pipe and the stream bank or shoreline to facilitate water table documentation and sampling.

A saturated buffer may infiltrate less overland flow than a nonsaturated buffer.

Where possible to maintain a water table at or near the buffer soil surface, planting the buffer to a mix of hydrophytic species suitable for wet soil conditions will enhance nitrate removal and increase soil carbon replacement at and near the soil surface.

Installation of this practice may enhance wildlife and pollinator habitats.

Install an anti-seep collar if piping of trench earth fill along the bypass pipe is a concern.

Consider measures to reduce the potential for root plugging of distribution lines by woody species. Set planted trees back far enough that distribution lines will not be under the drip line of mature tree canopies. Plant herbaceous species in areas over distribution lines. If the riparian area is currently in trees, either clear the trees or establish an herbaceous zone outside the tree line for the water distribution area.

PLANS AND SPECIFICATIONS

At a minimum, include the following in the plans:

- A plan view of the layout of the water distribution system.
- Profile(s) of the existing drain, distribution pipe, and outlet channel.
- Details of required structure(s) for water level control.
- Vegetation establishment requirements.
- Construction specifications that describe site-specific installation requirements.

OPERATION AND MAINTENANCE

Develop an operation and maintenance plan. Review this plan with the land manager. Specified actions include normal repetitive activities in the application and use of the practice (operation), and repair and upkeep of the practice (maintenance). At a minimum, include a description of:

- Planned water level management and timing.
- Inspection and maintenance requirements of the water control structure(s), distribution pipe(s), and contributing drainage system, especially upstream surface inlets.
- Periodic removal of invasive trees or shrubs to reduce distribution line plugging.
- If the site is to be monitored, include the monitoring and reporting requirements designed to demonstrate system performance and provide information to improve the design and management of this practice. At a minimum, record water levels (elevations) at the control structure, observation ports, and if used, observation wells. Record water levels biweekly when a water table is present and following precipitation events that result in high flows.

REFERENCES

- Jaynes, D.B. and T. Isenhart. 2011. Re-saturating Riparian Buffers in Tile Drained Landscapes. A Presentation of the 2011 IA-MN-SD Drainage Research Forum. November 22, 2011. Okoboji, IA.
- Jaynes, D.B. and T. Isenhart. 2012. Re-saturating Riparian Buffers using Tile Drainage. Unpublished.
- Jaynes, D.B. and T.M. Isenhart, 2014. Reconnecting Tile Drainage to Riparian Buffer Hydrology. Journal of Environmental Quality 43:631-638. doi: 10.2314/jeq2013.08.0331. Advances in Agronomy 92:75-162.

WISCONSIN CONSTRUCTION SPECIFICATION

204. EARTHFILL FOR WASTE STORAGE FACILITIES

A. SCOPE

The work shall consist of all operations necessary to place the earthfill or soil liner required by the drawings or directed by the Technician.

B. MATERIALS

All fill materials shall be obtained from required excavations and designated borrow areas. The selection, blending, routing, and disposition of materials shall be subject to approval by the Technician.

Fill materials shall contain no sod, brush, roots, frozen soil, or other perishable materials. Stones larger than two-thirds of the uncompacted layer thickness shall be removed from the materials prior to compaction. Additional soil properties are shown on the drawings.

C. GENERAL

Construction operations shall be carried out in such a manner and sequence that erosion and air and water pollution will be minimized. The completed job shall present a professional appearance and shall conform to the lines, grades, and elevations as shown on the drawings or as staked in the field. All operations shall be carried out in a safe and skillful manner. Safety and health regulations shall be observed and appropriate safety measures used by the contractor.

D. FOUNDATION PREPARATION

The foundation area shall be cleared of trees, stumps, roots, brush, rubbish, frozen soil, and stones having a maximum dimension greater than 6 inches. Foundations shall be stripped to remove vegetation and other unsuitable materials to a minimum depth of 6 inches or to a greater depth if so shown on the drawings. Topsoil shall be stripped from the foundation area and stockpiled for use as a top dressing for vegetation establishment unless otherwise shown on the drawings.

The moisture content of the scarified foundation materials shall be maintained as specified for the earthfill in Section 7. The surface materials of the foundation shall be compacted and bonded with the first layer of earthfill as specified for subsequent layers of earthfill.

E. EXCAVATION

The required excavations shall conform to the lines, grades, and elevations as shown on the drawings. Excavation beyond specified limits shall be corrected by filling with approved compacted materials.

The required dimensions and side slopes of all structure and trench excavations shall be as shown on the drawings. Trenches deeper than 4 feet shall have side slopes above the 4-foot depth excavated at 0.5:1 or flatter depending on the materials being excavated or the trench shall be braced to safeguard the work and workers. When backfilling pipe trenches in the waste storage facility embankment, the trench slopes shall be cut back to 1:1 from 12 inches above the top of the pipe. The backfill material and compaction shall be equivalent to the surrounding embankment.

To the extent that they are needed, all suitable materials removed from the specified excavations shall be used in the construction of the required earthfill or soil liner. The suitability of materials for specific purposes will be determined by the Technician.

All surplus or unsuitable excavated materials shall be disposed of at the locations shown on the drawings or as approved by the Technician. Surplus materials shall not be placed in wetlands.

F. BORROW AREAS

When the quantities of suitable materials obtained from specified excavations are insufficient to construct the specified fill portions of the permanent works, additional materials shall be obtained from the designated borrow areas. The borrow area shall be stripped to remove vegetation or other unsuitable materials to a minimum depth of 6 inches or to the depth shown on the drawings. This stripping shall be performed immediately prior to use of the borrow material to reduce the time the area is exposed to erosion. For large borrow areas, only a portion of the area should be stripped at a time.

G. FILL MOISTURE CONTENT

Fill materials shall have a moisture content sufficient to insure the required compaction. When kneaded in the hand, the soil will form a ball which does not readily separate and will not extrude out of the hand when squeezed tightly. The adequacy of the moisture content will be determined by the Technician.

If the top surface of compacted fill is too dry to permit suitable bond, it shall either be removed or scarified and wetted by sprinkling to an acceptable moisture content prior to placement of the next layer of fill. The applied water must be allowed time to be absorbed by the fill or disked into the dry layer.

Fill material that is too wet shall be allowed to dry to an acceptable moisture content before placement. If the top surface of compacted fill is too wet, it shall be either removed or allowed to dry to an acceptable moisture content before compaction or placing additional layers of fill.

H. FILL PLACEMENT

Fill shall not be placed until the required excavation and preparation of the underlying foundation is completed and approved by the Technician. Fill shall be placed beginning at the lowest elevation of the foundation. No fill shall be placed on a frozen surface.

If the surface of any layer becomes too hard and smooth for proper bond with the succeeding layer, it shall be scarified parallel to the axis of the fill to a depth of not less than 2 inches before the next layer is placed.

Available topsoil shall be placed on the top and the exposed outside slopes of the waste storage facility embankment, the borrow areas, and any other area where the topsoil was removed during construction and where vegetation will be established.

The pre-compacted thickness of each layer of fill and compaction requirements shall be as stated below unless otherwise specified in the construction plans. Materials placed by dumping in piles or windrows shall be spread uniformly to not more than the specified layer thickness prior to compaction. The Technician shall determine if adequate compaction is being achieved and may require more than the minimum specified passes of the compaction equipment.

(1) Embankments. The fill shall be placed in horizontal layers extending the entire length and width of the embankment. Unless otherwise specified in the construction plans, compaction requirements shall be as shown in Table 1. Each layer shall be compacted by a minimum of one pass over the entire surface of the fill by the compaction equipment.

(2) Adjacent to Structures and Pipes. Adjacent to structures or pipes, earthfill shall be placed in 4-inch lifts (prior to compaction) in a manner adequate to prevent damage to the structure and to allow the structure or pipe to gradually and uniformly assume the backfill loads. Compaction shall be accomplished by means of manually directed power tampers or plate vibrators or hand tamping unless otherwise specified. Heavy equipment shall not be operated within 2 feet of any structure or pipe. Compaction by means of drop weights operating from a crane or hoist of any type will not be permitted.

All intrusions into or penetrations of a clay or other soil liner will be backfilled with equivalent material and compacted to maintain its integrity. Pipe trenches into a storage facility will be backfilled with the same soils and compaction required for the storage facility for the distance shown on the drawings.

(3) Soil Liners. A soil liner shall be installed as designated on the drawings. This work shall consist of constructing a low permeability earthliner for the inside slopes and the bottom of the earthen basin to the thickness shown on the drawings. It also includes the soil liner material placed in conjunction with other liner materials to form a composite liner as shown on the drawings. Only soils approved by the Technician will be used.

The soil liner fill shall be placed in layers with a maximum thickness of 6 inches prior to compaction. The liner material shall be disked or worked in such a manner as to obtain a maximum clod size of 4 inches prior to compaction. Each layer of liners that do not require a specified density shall be compacted by a minimum of one pass over the entire surface of the fill by a:

- Rubber-tired front end loader (fully-loaded); or
- Scraper (fully-loaded); or
- Articulated haul truck (fully-loaded); or
- Sheepsfoot; or
- Tamping roller

Smooth drum rollers are not suitable for compaction of fine-grained liners.

Operation of the compaction equipment will be continuous over the entire area during fill operations. Any liner area disturbed by subsequent construction operations will be scarified and recompacted as specified.

(4) Small Areas of Unsuitable Materials. Lenses or pockets of soil not meeting the criteria requirements in the applicable NRCS Standard or shown on the drawings, shall be removed and replaced with specified materials. The extent of removal and the quality of replacement materials will be as shown on the drawings or approved by the Technician. Excavated slopes shall be 1:1 or flatter. Replacement soil material placement, layer thickness, and compaction will be as stated for soil liners. Manually directed power tampers may be used for compaction and the soil shall be placed in 4-inch lifts prior to compaction.

Table 1 - Embankment and Soil Liner Compaction Requirements

Equipment Type	Applicable Soils[1]	Maximum Fill Height[2] (feet)	Layer Thickness[3] (inches)
Sheepsfoot or tamping roller 10,000 lb. min. operating weight	ML, MH, CL, CH, SM, SC, GM, GC	None	9
Vibratory tamping roller 9,000 lb. min. operating weight	SM, SC, GM, GC	None	6
Smooth drum vibratory roller 10,000 lb. min.	SP, SW, GP GW	20	6
Rubber-tired scraper or articulated haul truck (fully loaded)	ML, MH, CL, CH SM, SC, GM, GC	None	9
Rubber-tired front end loader or articulated haul truck (fully loaded)	ML, MH, CL, CH SM, SC, GM, GC	20	6
Track-type crawler standard tracks 30,000 lb. min.	SM, SC, GM, GC, ML, CL, SP, SW, GP, GW	10	6
Farm tractor 2,400 lb. min.	ML, MH, CL, CH, SM, SC, GM, GC	15	6

[1]Unified Soil Classification System.

[2]Measured from the top of the fill to the lowest point along the centerline of the fill.

[3]Prior to compaction.