NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD
POND SEALING OR LINING – CONCRETE
CODE 522
(Ft.^{2})

DEFINITION

A liner for an impoundment constructed using reinforced or non-reinforced concrete.

PURPOSE

This practice is installed to reduce seepage losses from impoundments constructed for water conservation and environmental protection.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies where:

- In-place natural soils have excessive seepage rates.
- Construction of a compacted soil liner is not feasible with available soils.
- Use of impoundment requires concrete both as a liner and a protective subgrade cover.

CRITERIA

General Criteria Applicable to All Concrete Liners

Select the concrete liner design for either 'reduced seepage' or 'liquid tight' criteria, depending on the site conditions and management needs.

Liquid Tight. Where liquid tightness is required to provide an additional level of protection for sensitive environmental settings (SES), geologic concerns, groundwater resources and risk factors as described in the Agricultural Waste Management Field Handbook (AWMFH), Chapter 10, building code requirements must be one of the following:

- Structural Engineering, NRCS National Engineering Manual (NEM) Part 536, Structural Engineering.
- Requirements for Environmental Concrete Structures, Slabs-on-Soil, American Concrete Institute (ACI) 350 Appendix H.

Reduced Seepage. Where liquid tightness is not required, building code requirements must be one of the following:

- ACI 318, Building Code Requirements for Reinforced Concrete
- ACI 330R, Guide for the Design and Construction of Concrete Parking Lots
- ACI 360R, Guide to Design of Slabs-on-Ground
- Concrete Floors on Ground, Chapter 5, Portland Cement Association (PCA)

Include temperature and shrinkage reinforcing steel equal to or greater than shown in Table 1 in floors and slabs.

Table 1. Reinforcing Steel Size (Grade 60) and Spacing for Temperature and Shrinkage Control for Reduced Seepage Concrete with Waterstop

Concrete Thickness	Spacing Between Control Joints			
	< 100 feet	< 125 feet	< 150 feet	< 175 feet
= 5"	#4 @ 18"	#4 @ 15"	#4 @ 15"	#5 @ 18"
≤ 6"	#4 @ 18"	#4 @ 12"	#5 @ 18"	#5 @ 15"
≤ 7"	#4 @ 15"	#5 @ 18"	#5 @ 15"	#5 @ 12"
≤ 8"	#5 @ 18"	#5 @ 15"	#5 @ 15"	#5 @ 12"

Joints. Design construction joints and control joints to meet the appropriate ACI code specified above.

Side Slopes. Design side slopes of the pond or impoundment to be stable during construction. Design liners to withstand all anticipated internal and external loads, and resist agitation scouring, as specified in Table 2 or 3. Proportion the concrete mixture for a sufficiently stiff mix that can be installed on the slope without slumping or bulging.

Foundation and Liner Protection. Design floors and slabs used as a liner for anticipated loads including crack control and joint treatments stated below. Penetrations through the liner, such as pipes, must be properly sealed. Design slabs on ground that will be subject to heavy truck or heavy equipment loads in accordance with ACI 360R, Guide to Design of Slabs-on-Ground, Concrete Floors on Ground, Chapter 5, Portland Cement Association (PCA), or ACI 330R, Guide for the Design and Construction of Concrete Parking Lots.

- Concrete with waterstop – Include distributed reinforcing steel within the concrete, and include embedded waterstop in all joints in accordance with Wisconsin FOTG Construction Specification 004-WS, Waterstop.

  Place steel in the top ½ of the slab thickness with a minimum clear distance from the top of the slab of 1.5 inches.

- Include a waterstop joint plan in the construction plans and include the following: location of joints; cross- section details of joint(s); waterstop materials including factory fabricated corners, intersections, and transitions; and installation specifications.
- Plan additional waterstop control joints where stresses can be predicted to exceed the reinforcing steel's ability to restrain cracking and minimize leakage.
- All waterstop joints in areas subject to equipment traffic shall be designed with a dowel system to transfer the load across the joint. Slab thickness changes at these joints shall be made with a minimum transition ratio of one inch of thickness change over ten inches of run (10:1).
- Concrete used as part of a liner is required to meet WI Construction Specification 4 Concrete.

Additional Criteria for Waste Storage Facilities (WI CPS 313).

For waste storage facilities, design foundation conditions for concrete liners in accordance with Tables 2 and 3. All waste storage facilities shall also meet the requirements of WI CPS Waste Storage Facility (WI CPS 313). Use WI CPS 313 criteria to determine subsurface saturation and bedrock depth.

Reduced seepage concrete soil composite (Table 2) – Determine the plasticity index (PI) in accordance with ASTM D4318 and the percent fines in accordance with ASTM D1140. Place the concrete in intimate contact with the foundation soil. Design floors and slabs to be a minimum of 5 inches thick with reinforcing consisting of #4 bars spaced at 18 inches on center each way. No control joints are required. Maintain continuous reinforcing steel through all construction joints. Drain tile and/or drain fill material may not be installed within the soil liner component of the composite liner.

Table 2. Concrete Liner System Criteria for Waste Storage Facility Structure Floors and Impoundments Note 1

	Reduced Seepage Concrete with Waterstop	Reduced Seepage Concrete - Soil Composite			
	A	B	C	D	E
Concrete Component	Design Requirement: ACI-318, ACI-330R, or ACI-360R				
Soil Component					
% Fines	N/A Concrete Component Only	≥ 20%	≥ 20%	≥ 40%	Foundry Sand Note 2
Plasticity Index (PI)		≥ 7	—	≥ 12	—
Thickness (bottom and sides)		≥ 1.5 feet	≥ 3 feet	≥ 8 inches	≥ 1.5 feet
Compaction of Placed Material		WI Spec 204	WI Spec 204	WCS-300	WI Spec 204
Sub-Liner Soils (Soil Directly Below Concrete or Soil Component)	See Table 2A for Options				
Separation Distances					
Sinkholes Or Other Karst Features					
Impoundment or Structure below ground	≥ 400 feet	≥ 400 feet	≥ 400 feet	≥ 400 feet	≥ 400 feet
Structure above ground	≥ 200 feet	≥ 200 feet	≥ 200 feet	≥ 200 feet	≥ 200 feet
Well Distance	≥ 100 feet	≥ 100 feet	≥ 100 feet	≥ 100 feet	≥ 100 feet
Subsurface Saturation	≥ 2.5 feet (1.5 feet for sump)	≥ 4.0 feet (3.0 feet for sump)	≥ 5.5 feet (4.5 feet for sump)	≥ 3.5 feet (2.5 feet for sump)	≥ 4.0 feet (3.0 feet for sump)
Bedrock	≥ 2.5 feet (1.5 feet for sump)	≥ 4.0 feet (3.0 feet for sump)	≥ 5.5 feet (4.5 feet for sump)	≥ 3.5 feet (2.5 feet for sump)	≥ 4.0 feet (3.0 feet for sump)
Impoundment					
Inside Side Slopes	2.5:1 or flatter	2:1 or flatter			

Note 1 This liner may be used to meet the requirements of Wisconsin Administrative Code, Chapter NR 213 (NR 213), with additional restrictions (e.g. soils investigations, separation distances, liner properties, maintenance requirements). See NR 213 and WI AWMFH 313 companion document.

Note 2 The foundry sand must be ferrous foundry sand with only minimal concentrations of hazardous constituents, cores and other over-size materials crushed or removed, and at least 5% bentonite content. A site specific WDNR approval is required under NR 538 that may specify greater separation distances and parameters not addressed by this standard. An NR 538 Category I or II ferrous foundry sand may be appropriate.

Sub-Liner Soils. Sub-liner soil requirements are listed in Table 2A. These sub-liner soils can be placed or in situ materials. There is no compaction requirement for in situ materials. Sub-liner soil, if required, must be under the entire footprint of all waste storage facilities. For structures, the sub-liner soil must be wrapped around to the top of the footing to provide continuous protection.

For pre-engineered structures, requirements for sub-liner soil configurations are included in the approval letter for the manufacturer, written by the SCE.

Determine the PI in accordance with ASTM D4318 and the percent fines in accordance with ASTM D1140.

Sand or gravel is allowed between the concrete with waterstop liner or structure and the sub-liner soil. The sub-liner soil thickness must be present below the sand or gravel.

Sub-liner soil thickness is in addition to any concrete or concrete-soil composite thickness requirement.

Table 2A. Sub-Liner Soil Requirements for Waste Storage Facility Impoundments

	Minimum Soil Requirements			
	A	B	C	D
% Fines	≥ 20%	≥ 20%	≥ 40%	Foundry Sand Note 1
Plasticity Index (PI)	≥ 7	—	≥ 12	—
Thickness (bottom and sides)	≥ 1.5 feet	≥ 2 feet	≥ 8 inches	≥ 1.5 feet
Compaction of Placed Material	WI Spec 204	WI Spec 204	WI Spec 300	WI Spec 204

Note 1 The foundry sand must be ferrous foundry sand with only minimal concentrations of hazardous constituents, cores and other over-size materials crushed or removed, and at least 5% bentonite content. A site specific WDNR approval is required under NR 538 that may specify greater separation distances and parameters not addressed by this standard. An NR 538 Category I or II ferrous foundry sand may be appropriate.

Sensitive Environmental Settings. Table 3 contains the criteria for constructing liquid waste storage facilities in Wisconsin's sensitive environmental settings, as defined in WI CPS 313. Determine the PI in accordance with ASTM D4318 and the percent fines in accordance with ASTM D1140.

Design the storage facility as a reinforced concrete hydraulic or environmental structure according to NRCS NEM, Part 536, Structural Design with liquid tight concrete. (Concrete with waterstop ACI 350 or 350 Appendix H)

Alternatively, construct a facility with reduced seepage concrete and secondary liquid containment. Three components must be present for this system, a concrete liner, a drainage layer, and a secondary liquid containment liner. Design the concrete liner to meet the reduced seepage liner requirements contained within this standard. The drainage layer will consist of a minimum of twelve (12) inches of clean stone, with a drainage system that enters into an observation and pumping port. This port must be monitored for discharge and pollutants. If pollutants are identified, the port must be pumped until the source is identified and repairs can be completed. If discharging to the surface, evaluate the effects of out-letting to perennial or intermittent waterways.

Pre-engineered structures may contain specific additional requirements which are included in the approval letters for the manufacturer, written by the SCE.

Table 3. Structural Concrete and Concrete Liners with Secondary Liquid Containment System for Waste Storage Facilities in Sensitive Environmental Settings

	Liquid Tight Concrete with Waterstop	Reduced Seepage Concrete with waterstop PLUS Secondary Liquid Containment-Soil Liner	Reduced Seepage Concrete with waterstop PLUS Secondary Liquid Containment-Geomembrane Liner [Note 2]	Reduced Seepage Concrete with waterstop PLUS Secondary Liquid Containment-Foundry Sand Liner
	A	B	C	D
Concrete Component	ACI-350	Design Requirement: ACI-318, ACI-330R, or ACI-360R		
Drainage Layer	—	Drainage layer with a minimum of twelve (12) inches of clean stone between the concrete liner and the secondary liquid containment liner.		
Soils of the Secondary Liquid Containment				
Fines	—	≥ 40%	**No Soil Component or Sub-liner is required for secondary containment system**	Foundry sand
Plasticity Index (PI)	—	≥ 12		—
Thickness (bottom and sides)	—	1.5 feet		1.5 feet
Compaction of Placed Material	—	WI Spec 204		WI Spec 204
Separation Distances				
Sinkhole or other Karst Features	250 feet	250 feet	250 feet	250 feet
Well	100 feet	100 feet	100 feet	100 feet
Subsurface Saturation	2 feet	4 feet	3 feet	4 feet
Bedrock	1.5 feet	3 feet	2 feet	3 feet
Impoundment				
Inside Side Slopes	2.5:1 or flatter	2.5:1 or flatter	2.5:1 or flatter	2.5:1 or flatter

[Note 1] Separation distance assumes a concrete thickness of 6 inches. Increase separation distance when slab thickness is greater than 6 inches by an equal amount.

[Note 2] Design geomembrane secondary containment with the Design, Materials, Subgrade Preparation, Penetrations, and Cover Soil sections of WI NRCS CPS 521- Pond Sealing or Lining- Geomembrane or Geosynthetic Clay Liner (Additional Criteria for Waste Storage Facilities of CPS-521 does not apply)

Additional Criteria for Clean Water Applications

Liners for clean water applications shall be according to Table 2, Reduced Seepage Concrete with waterstop or Reduced Seepage Concrete - soil composite. No sub-liner soil is required.

Determine the plasticity index (PI) in accordance with ASTM D4318 and the percent fines in accordance with ASTM D1140. Place the concrete in intimate contact with the foundation soil. Design floors and slabs to be a minimum of 5 inches thick with reinforcing consisting of #4 bars spaced at 18 inches on center each way. No control or expansion joints are required. Maintain continuous reinforcing steel through all construction joints.

CONSIDERATIONS

Consider texturing concrete surfaces to provide traction for rubber-tired equipment. Texturing may not compromise the integrity of the liner.

PLANS AND SPECIFICATIONS

Prepare plans and specifications for a concrete liner for a pond or a waste storage impoundment that describe the requirements for applying the practice to achieve its intended purpose. This should include:

- Soils investigation, including subgrade.
- Concrete and reinforcing requirements.
- Quantities of concrete and reinforcement as specified.
- Subgrade preparation, materials and compaction.
- Construction and material specifications.
- Safety requirements.
- Applicable Wisconsin Construction Specifications

OPERATION AND MAINTENANCE

Maintenance activities required for this practice consist of those operations necessary to prevent and/or repair damage to the concrete liner. This includes, but is not limited to:

- Visually inspecting liner annually.
- Excluding animals.
- Repairing damage to concrete liner, as necessary. Repairing liner to its original condition.
- Preventing damage from roots of tree and large shrubs by removing such vegetation at first appearance.
- Preventing and/or repairing rodent damage to concrete subgrade.

REFERENCES

American Concrete Institute (ACI), Farmington Hills, MI

ACI 318, Building Code Requirements for Reinforced Concrete

ACI 330R, Guide for the Design and Construction of Concrete Parking Lots

ACI 350, Appendix H, Requirements for Environmental Concrete Structures, Slab-on-Soil

ACI 360, Design of Slabs on Grade

DEFINITIONS

Bedrock – The solid or consolidated rock formation typically underlying loose surficial material such as soil, alluvium or glacial drift. Bedrock includes but is not limited to limestone, dolomite, sandstone, shale and igneous and metamorphic rock. Although solid or consolidated bedrock can sometimes be removed with typical excavation equipment, these materials are included in this definition of bedrock.

Construction Joints – These joints are used where a fresh pour of concrete abuts an existing recent pour. Construction joints where the steel is continuous through the joint are considered to be monolithic if constructed properly.

Control Joints – Control joints are used to control the location of cracks caused by concrete shrinkage during setting and thermal changes. Steel reinforcement is interrupted in control joints with embedded waterstop. (Includes expansion, contraction, and isolation joints).

Environmental Structure – Any structure intended for conveying, storing, or treating water, wastewater, or other liquids and nonhazardous materials, such as solid waste, and for secondary containment of hazardous liquids or solid waste and designed to be liquid-tight, with minimal leakage under normal service conditions.

Expansion Joints (Expansion or contraction joints) – These joints are used to prevent crushing of abutting concrete or other structural units due to compressive forces developed during expansion caused by high temperature.

Hydraulic structure – Any structure subjected to hydrostatic or hydrodynamic pressures, either externally or internally.

Impoundment – A waste storage facility constructed of earthen embankments and/or excavations for the purpose of storing waste. An impoundment may be lined or unlined.

Intimate Contact – Direct contact between liner materials (concrete, GCL, and geomembrane) and soil.

Isolation Joint – Joint installed to separate one section of concrete from another. Isolation joints prevent transfer of loading from one section to another, and allow movement to occur between a concrete slab and adjoining columns or walls. They also separate new concrete from existing or adjacent construction which might expand, contract, or settle at different rates.

Karst features – Refers to areas of land underlain by carbonate bedrock (limestone or dolomite). Typical land features in karst areas include sinkholes, network of interconnected fissures, fractures, disappearing streams, closed depressions, blind valleys, caves, and springs. See the companion document in Chapter 10 of the AWMFH for additional discussion of karst features.

Sinkholes – Closed, usually circular depressions which form in karst areas. Sinkholes are formed by the downward migration of unconsolidated deposits into solutionally enlarged openings in the top of bedrock.

Structure – A waste storage facility consisting of constructed surfaces, tanks, or walls for the purpose of storing waste above or below the ground surface. Structures may be constructed of concrete, steel, wood or other construction materials.

Sub-Liner Soil – The soil directly below the bottom of the liner. This may be placed or in situ material.