I hereby certify that this engineering document was prepared by me or under my direct personal supervision and that I am a duly licensed Professional Engineer under the Laws of the State of Wisconsin

Date: 7/22/2025

Dennis J. Johnson, P.E.
Reg.No.E-29100

JEG File #0169-01

Prepared for:

GRUBER LIVESTOCK SOUTH LLC
236 LINCOLNSHIRE LANE
BOLINGBROOK, IL 60440

Prepared by:

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DESIGN REPORT

GRUBER LIVESTOCK SOUTH LLC

MARIETTA TOWNSHIP

CRAWFORD COUNTY

NE 1/4 OF NW 1/4
SECTION 23
T-8-N R-4-W

JULY 2025

JOHNSON ENGINEERING GROUP

GRUBER LIVESTOCK SOUTH LLC

CRAWFORD COUNTY, MARIETTA TOWNSHIP, WISCONSIN

SECTION 23 – NE1/4 OF NW1/4

T-8-N R-4-W

TABLE OF CONTENTS

1. PROJECT PARTICIPANTS

Owner Contact

Gruber Livestock South LLC
236 Lincolnshire Lane
Bolingbrook, IL 60440
Contact: Mary Hrycyk
Phone: (630)-673-3245
Email: mhrycyk1@yahoo.com

Project Site Location

Crawford County, Wisconsin
Marietta TWP (T8N R4W)
NE1/4 NW1/4, Section 23

County Animal Waste Contact

David Troester
LCD County Conservationist
Crawford County Land Conservation Department
225 N. Beaumont, Suite 230
Prairie du Chien, WI 53821
Phone: (608) 326-0272
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Johnson Engineering Group, LLC Contacts

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2. PURPOSE

The purpose of this project manual is to provide information on the design of the proposed manure storage structure and conformance with WI NRCS conversation practice standards and specifications.

Reviewable structures include:

- Waste Storage Facility

Wisconsin agencies with permit approval/design review include:

- Crawford County Animal Waste Storage
- WDNR WRAAP Permit

It is our understanding that Crawford County has adopted Wisconsin's livestock facility siting law (Wis. Stat. § 93.90 and Wis. Admin. Code ch. ATCP 51), so a siting permit is required for the proposed project.

3. BACKGROUND

Gruber Livestock South LLC ("GLS") is proposing to construct a new feedlot consisting of one total confinement barn at the project site. The fully constructed facility will consist of 2,499 gilts[1] (0.4 animal units) for a total of 999.6 Animal Units[2], below-ground concrete liquid manure storage, office, high/low loadout, and access road/truck turnaround area. Gilts will be brought to the site as feeder pigs.

[1] A gilt is a female pig that has not yet farrowed.

[2] An "animal unit" or "AU" is a unit of measure developed to compare the differences in the amount of manure produced by livestock species. The "AU" is standardized to the amount of manure produced on a regular basis by a slaughter steer or heifer, which also correlates to 1,000 pounds of body weight. The "AU" is used for administrative purposes by various governmental entities for permitting and record keeping.

4. MANAGEMENT ASSESSMENT

The management assessment was performed with the owner/operator to explore options and to determine the purpose of storage components, available resources, manure disposal schemes, and waste characteristics.

Waste Characterization

Waste Storage Facility

A new barn is being proposed at the project site. The new barn will be 101' x 208' with an 8' deep concrete pit. The new barn will hold, and manure calculations are based on, animal waste from 2,499 gilts with an average weight of 150 lbs.

Manure generation rates are estimated respectively as 0.15 cubic feet (C.F.) per pig per day. The manure generation rates exclude bedding or wastewater because no bedding will be used and there are no sources of wastewater that will be stored in the manure storage.

The gilts will produce an estimated 136,875 C.F. of manure per year or 1,023,896 gallons. The gross volume of the proposed manure storage is approximately 143,568 C.F or 1,073,885 gallons using 1.2 feet of the facility for freeboard. The net volume of the proposed manure storage is approximately 139,853 C.F. or 1,046,173 gallons using 1.2 feet of the facility for freeboard, deducting the divide walls and columns, and adding capacity for the pumpouts. A copy of the manure generation calculations is attached in **Appendix C**. Manure generation and storage calculations can also be found on **sheet C-105** of the plan set.

The manure will be like finishing hog manure. We are anticipating 28 #/1000 gallons of N, 14 #/1000 gallons of P2O5, and 22 #/1000 gallons of K2O in the manure.

Land Base

There are approximately 222.6 acres of land available for manure within 5 miles of the project site. The land is used for row crops and forage and will benefit from manure applications. A 590 Nutrient Plan detailing the specific fields that will be used for land application of the manure and compost will be prepared by others.

Planned Storage Period

Waste Storage Facility

The designed manure storage period is approximately 372 days when the gross volume is adjusted in accordance with the manure generation and storage calculations shown on **sheet C-105** of the plan set.

Waste Handling and Transfer

Manure from the proposed barn is planned to fall through slatted floors into the cast-in-place waste storage facility below.

Mortalities will be removed from the barn and composted.

Facility Waste Removal Methods

Manure from the proposed waste storage facility will be mixed and pumped as a liquid and will be land applied. The manure and compost removed from storage will be land applied at agronomic rates in accordance with the farm's 590 Nutrient Management Plan.

Access Needs

There is not an existing driveway into the project site. A driveway is proposed from Plainview Ridge Road. Construction of the driveway is part of GLS's scope. A gravel turnaround area will be provided on the southeast side of the barn that will connect to the driveway. Grading of the site will provide access around the waste storage facility. Pump outs are located on the north and south sides of the barn.

Safety Needs

The waste storage facility is a confined space and should be operated in compliance with the provisions contained in ASABE EP-470, Manure Storage Safety. ASABE standard EP-470 states:

> *"Do not enter an under-floor (underground) covered storage or pumping station without using the proper respirator equipment. In addition, these safety practices are needed: (a) Shut off any manure pumps, (b) ventilate storage or pumping stations at the maximum rate, (c) test the storage or station for air or O_2 level and toxic gas levels, (d) attach a safety harness and rope to the working person with at least one person standing by to help with a mechanical retrieval device, and (e) have on hand an extra set of proper respirator equipment for the person standing by."*

Confined space warning signs shall be placed where access to the waste storage facility is possible. Pump outs should remain covered unless in use.

The proposed barn will be ventilated with fans to remove manure gases. There will be an emergency generator if power is shut off for any reason.

Labor and Equipment Needs

One full-time employee will be needed for animal welfare. Maintenance personnel will be onsite as needed for barn upkeep. Manure will be pumped by outside contractors.

Potential Odor Concerns

There are two existing houses within 2,500 feet of the proposed facility. Due to the proximity of these houses to the proposed facility, an odor management plan has been developed and will be included in the permit submission to Crawford County.

Facility Expansion

GLS is not planning to expand the facility.

5. SITE ASSESSMENT

The site assessment was performed to determine physical site characteristics that will influence the placement, construction, maintenance, and environmental integrity of proposed structures.

Topography

A site topographic survey was conducted to determine locations and elevations of buildings, roads, lanes, soil test excavations, setbacks, wells, surface waters, surface drains, and drain tile.

The site topographic survey was completed on July 1, 2025, by Johnson Engineering Group, LLC personnel. The survey was done in Wisconsin State Plane Coordinates South District 4802, NAD1983. The vertical coordinate system was NAVD1988 using a geoid model G12A USA.

The site topographic survey can be found on **sheet C-102** and **sheet C-103** of the plan set.

Soils Investigation

A soils investigation was completed on July 1, 2025, by Johnson Engineering Group, LLC personnel. The soils investigation was completed using a backhoe.

Johnson Engineering Group, LLC Soils Investigation

Four soil test excavations were advanced with a backhoe inside or near the footprint of the proposed waste storage facility. A handheld penetrometer was used to estimate the bearing capacity of the in-place soils. The borings were filled with native material taken from the borings.

Boring 1 was advanced approximately 9 feet below site grade. Boring 2 was advanced approximately 12 feet below site grade. Boring 3 was advanced approximately 12 feet below site grade. Boring 4 was advanced approximately 9 feet below site grade.

Boring 1 consisted of sandy and silty soils. Boring 2 consisted of sandy and silty soils. Boring 3 consisted of sandy and silty soils. Boring 4 consisted of sandy and silty soils.

The Johnson Engineering Group, LLC soils logs can be found in **Appendix B**. In addition, Borings 1 through 4 are shown on **sheet C-104** of the plan set.

Bedrock

Bedrock was not encountered during soil test excavations. Consequently, bedrock is not expected to be encountered during excavation of the proposed waste storage facility or animal mortality facility (See **sheets C-109** and **C-110** of the plan set). Soil test excavations extended from approximately 1 to 10 feet below the planned top of the waste storage facility floor.

Saturation

Slight mottling was encountered during soil test excavations Boring 1, Boring 2, and Boring 4. A tile system is proposed to be installed to lower the perched water table.

Borrow Areas

Soils excavated for the proposed waste storage facility are planned to be used for constructing the proposed access roads around the barn and the pad for the animal mortality facility.

Wells

There are no potable wells on the project site. A setback of 100 feet from a waste storage facility is required by NRCS 313. A well will be established by GLS and will be installed further than 100 feet from the waste storage facility.

Wetlands

Based on a review of the Wisconsin Department of Natural Resources Wetland Map in the Surface Water Data Viewer, neither the proposed waste storage facility nor the animal mortality facility is believed to be in a mapped wetland. Mapped wetlands are located more than 1.8 miles northwest and potential wetland indicator soils are more than 4,000 feet southwest of the proposed facilities.

Floodplain

Based on a review of the Wisconsin Department of Natural Resources Floodplain map in the Surface Water Data Viewer, neither the proposed waste storage facility nor the animal mortality facility is believed to be in a 100-year floodplain.

Drain Tiles

A 4" diameter perforated perimeter drain tile with filter sock is proposed for the waste storage facility. The proposed tile outlet is to the southwest.

Karst Features

GLS advised they are unaware of karst features in the project area. See attached maps- Appendix A

Surface Water Features

The closest named body of water is Boydtown Creek which is approximately 4,050 feet southwest of the proposed waste storage facility. The closest body of surface water is an unnamed intermittent stream approximately 773 feet southeast of the proposed waste storage facility. There is also an unnamed surface water that is approximately 207 feet southwest of the proposed waste storage facility.

Site Maps

- Site Vicinity Map (See **sheets G-101** and **C-101** of the plan set).
- Existing Conditions Map (See **sheets C-101** and **C-102** of the plan set).
- Wetlands Map (see **Appendix A**).
- Floodplain Map (see **Appendix A**).
- Designated Waters Map (see **Appendix A**).

Potential Discharge Impacts

Waste Storage Facility

The waste storage facility is below ground, thus potential discharge would likely be from overflow. Overspills, if they were to occur from an unpredictable catastrophic event, would discharge over the walls of the waste storage facility. Equipment should be made available to construct an embankment to contain a spill in an emergency.

6. LOCATION CRITERIA

The proposed waste storage facility top of slat is planned to be at elevation 1045.0', with the waste storage facility top of floor at elevation 1037.0'. These elevations are based on the topographic survey by Johnson Engineering Group, LLC personnel. Johnson Engineering Group plans to establish two benchmarks once the site is cleared and the benchmarks can be established in an area on the site where they will not be disturbed. The benchmark datum will be set in Wisconsin State Plane Coordinates South District 4802, NAD1983. The vertical coordinate system will be NAVD1988 using a geoid model G12A USA. Natural ground in the proposed waste storage facility and animal mortality facility footprints varies in elevation from approximately 1025.0' to 1055.0'

Bedrock and Saturation Separation Criteria

Specific criteria outlined in *NRCS 522 – Table 3 Structural Concrete Liners with Secondary Liquid Containment System for Waste Storage Facilities in Sensitive Environmental Settings Column A – Liquid Tight Concrete with Waterstop* include depth to bedrock, depth to saturated soil, and well and sinkhole separation distances as follows:

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[3]	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.		
Soil 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 ft.		1.5 feet
Compaction of Placed Material	---	WI Spec 204		WI Spec 204
Separation Distances[4]				
Sinkhole or other Karst Features	250 feet	250 feet	250 feet	250 feet
Well Distance	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

A copy of WI-NRCS 522 is attached to this Design Report in **Appendix D**. Liquid tight concrete with waterstop is proposed for the floor and walls of the waste storage facility and animal mortality facility. In accordance with Table 3 in WI-NRCS 522, a minimum of 2 feet of separation to subsurface saturation and 1.5 feet of clearance from bedrock is required from the top of the facilities floors.

7. DESIGN – WASTE STORAGE FACILITY

The proposed waste storage facility is a cast-in-place design using USDA-NRCS design codes, criteria, and construction specification standards. Precast slats and beams are also planned for the

[3] 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)

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

facility. The waste storage facility has been designed to meet the requirements of the codes and construction standards as follows:

- NRCS Practice Standard 313 – Waste Storage Facility
- NRCS Practice Standard 522 – Pond Sealing or Lining – Concrete
- NRCS Practice Standard 606 – Subsurface Drain
- WI Construction Specification 002, Excavation
- WI Construction Specification 003, Earthfill
- WI Construction Specification 4, Concrete
- WI Construction Specification 004, WS – Embedded or Expansive Waterstop
- WI Construction Specification 044, Corrugated Polyethylene Tubing
- WI Construction Specification 204, Earthfill for Waste Storage Facilities
- Design loads are summarized on the drawings.

Refer to structural notes on sheets S-100 and Wisconsin Construction Specification 0004-WS Embedded or Expansive Waterstop for control joint and waterstop requirements. ACI 350 Table 7.12.2.1 Minimum S&T Steel Reinforcement Ratio must be 0.005 to allow for joint spacing of 40 ft or greater. ACI 360 Subgrade Drag Theory: L=(As x 2 x fs)/FW = 250 ft between joints. Therefore, no construction joints are needed. Provided floor reinforcement: #4's @ 8" O.C. which equates to 0.005 ratio. Provided horizontal wall reinforcement: #5's @ 7" O.C. which equates to 0.005 ratio.

Basin Floor Design

The basin floor is designed as a liquid tight concrete with waterstop in accordance with *Table 3, Column A of WI-NRCS Standard 522*. The concrete floor shall be a minimum of 5 inches thick and include control joints with waterstop spaced in accordance with the plans. The basin floor is planned to be 5" thick concrete with #4 rebar @ 8" O.C. both ways, meeting ACI 350.

Basin Wall Design

The basin walls are designed as liquid tight concrete with waterstop in accordance with *Table 3, Column A of WI-NRCS Standard 522*. Wall design in accordance with ACI-350. Backfill shall consist of soils (12% fines) excavated from the site. Exterior walls are designed with backfill full height and tank empty. The interior divide wall is designed with one side fully loaded and the other empty.

Days of Storage

Calculations indicate the proposed waste storage facility should provide the farm with approximately 372 days of storage. Days of storage calculations are presented on **sheet C-105** of the plan set.

8. Erosion Control and Storm Water Drainage Management

Erosion Control Practices

The project boundary for the construction area is greater than 1 acre in size. A WDNR WRAPP application has been submitted to the Wisconsin Department of Natural Resources for review. Erosion control practices during construction are presented on **sheets SW-101** through **SW-105** of the plan set and include:

- Stone tracking pad
- Silt fence to limit sediment from leaving the construction site
- Temporary sediment trap
- De-watering plan to remove accumulated rainfall from excavation (if necessary)
- The area disturbed by construction will be graveled for working pads or seeded and mulched with grasses to limit erosion once the area is final graded. The ditch channel slope is planned to be erosion matted using WDOT Class II, Type B erosion matting.

Storm Water Drainage

North: Storm water falling north of the proposed waste storage facility will flow northeast or southwest to a proposed drainage swale where it will flow southwest and exit down the embankment.

East: Storm water falling east of the proposed facility will overland flow east and west to a low point in the truck turn around and then flow southwest down the embankment and then follow the existing drainage pattern to the south.

South: Storm water falling south of the waste storage facility will flow south down the embankment and then follow the existing drainage pattern to the south.

West: Most of the storm water falling west of the proposed facility will flow down the embankment and then follow the existing drainage pattern to the south with the remainder entering the proposed drainage swale and flowing south and exit down the embankment.

9. Operation and Maintenance Plan

The Operation and Maintenance Plan is presented in a separate report that is included with this Design Report in the permit submittal.

10. Construction Plans and Specifications

Construction drawings are included with this Design Report in the permit submittal. The drawings provide the layout and details of the proposed waste storage and animal mortality facilities. Applicable NRCS Construction Specifications are referenced in the drawings and copies of the applicable specifications are included in the Construction Quality Assurance Plan.

11. Construction Schedule

Construction of the proposed waste storage and animal mortality facilities is planned to begin in fall 2025 upon approval of the plans and weather conditions. Construction is expected to be complete within six months after commencement unless inclement weather or contracting scheduling delays progress. If permitting or weather delays the start of construction, it is planned to begin in the spring of 2026.

12. Construction Quality Assurance Plan

The Construction Quality Assurance Plan is presented in a separate report that is included with this Design Report in the permit submittal.

APPENDIX A –

MAPS

WISCONSIN DEPARTMENT OF NATURAL RESOURCES

Wetland Map

Legend: (some map layers may not be displayed)

- Rivers and Streams
- Intermittent Streams
- 24K Intermittent Streams
- 24K Streams and Rivers

24K Flow Direction

- Primary Flow Direction
- County Boundaries

County and Local Roads

- Local Road
- Latest Leaf Off Imagery

Notes:

Map projection: NAD 1983 HARN Wisconsin TM

N

Map: 0 420 840 Feet
0 120 240 Meters

Service Layer Credits:
Wetland Indicators & Soils^: Surface Water Data Viewer Team, Latest Leaf Off: , Cities, Roads & Boundaries: , Surface Water (Cached): WiDNR, USGS, and other data, Wetland Inventory NWI (Dynamic): Calvin Lawrence, Dennis Weise, Nina Rihn

Date Printed: 7/16/2025 8:57 PM

WISCONSIN DEPARTMENT OF NATURAL RESOURCES

Floodplain Map

Legend: (some map layers may not be displayed)

- FIRM Panels
- Rivers and Streams
- Intermittent Streams
- 24K Intermittent Streams
- 24K Streams and Rivers

24K Flow Direction

- Primary Flow Direction
- County Boundaries

County and Local Roads

- Local Road
- Latest Leaf Off Imagery

Notes:

Map projection: NAD 1983 HARN Wisconsin TM

N

Map: 0 420 840 Feet
0 120 240 Meters

Service Layer Credits:
Digitial FEMA Floodplains (National Flood Hazard Layer)*: , Latest Leaf Off: , Paper FIRMS: Federal Emergency Management Agency, Wisconsin Department of Natural Resources, Cities, Roads & Boundaries: , Surface Water (Cached): WiDNR, USGS, and other data

Date Printed: 7/16/2025 9:01 PM

WISCONSIN DEPARTMENT OF NATURAL RESOURCES

Designated Waters

Legend: (some map layers may not be displayed)

- Rivers and Streams
- Intermittent Streams
- 24K Intermittent Streams
- 24K Streams and Rivers

24K Flow Direction

- Primary Flow Direction
- County Boundaries

County and Local Roads

- Local Road
- Latest Leaf Off Imagery

Notes:

Map projection: NAD 1983 HARN Wisconsin TM

N

Map: 0 440 880 Feet
0 130 260 Meters

Service Layer Credits:
Latest Leaf Off: , Cities, Roads & Boundaries: , Surface Water (Cached): WiDNR, USGS, and other data

Date Printed: 7/16/2025 8:47 PM

Gruber Livestock South-DNR Hillshade Map

9/11/2025

Wisconsin Hillshade from LiDAR

575

151

World Imagery

Low Resolution 15m Imagery

High Resolution 60cm Imagery

High Resolution 30cm Imagery

Citations

2.4m Resolution Metadata

Maxar

1:11,578

0 0.05 0.1 0.2 mi

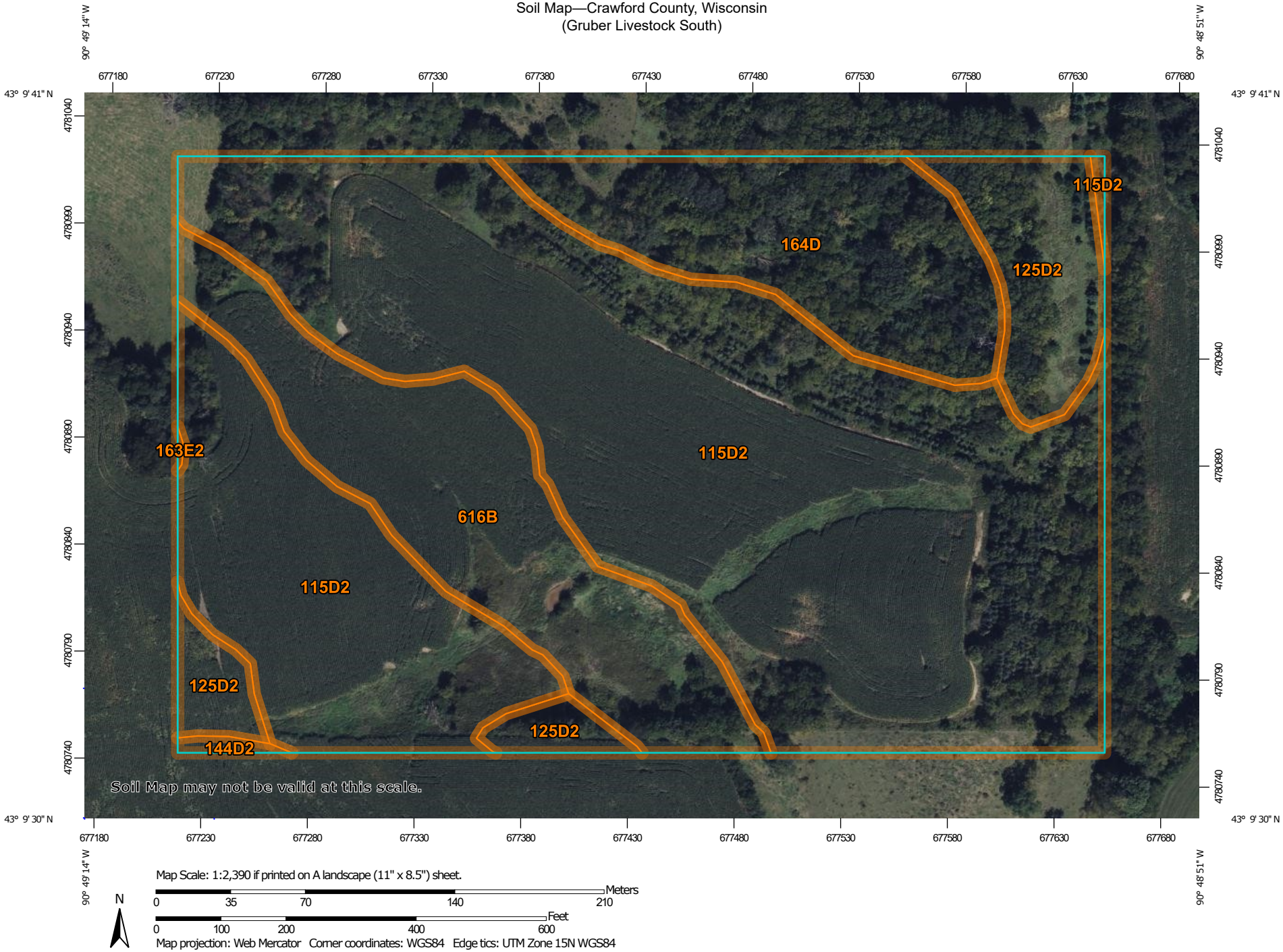
0 0.1 0.2 0.4 km

SINKHOLE MAP FROM CRAWFORD COUNTY
STEWARDSHIP-KARST GEOLOGY VIEWER

APPENDIX B –

SOILS INFORMATION

Soil Map—Crawford County, Wisconsin
(Gruber Livestock South)



Map Scale: 1:2,390 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 35 70 140 210

Feet: 0 100 200 400 600

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 15N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:12,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Crawford County, Wisconsin
Survey Area Data: Version 18, Sep 3, 2024

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 2, 2022—Sep 28, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
115D2	Seaton silt loam, driftless ridge, 12 to 20 percent slopes, moderately eroded	19.3	64.3%
125D2	Pepin silt loam, 12 to 20 percent slopes, moderately eroded	2.4	7.9%
144D2	Newglarus silt loam, deep, 12 to 20 percent slopes, moderately eroded	0.1	0.3%
163E2	Elbaville silt loam, 20 to 30 percent slopes, moderately eroded	0.0	0.0%
164D	Elizabeth flaggy silt loam, 12 to 20 percent slopes	3.6	12.0%
616B	Chaseburg silt loam, 1 to 4 percent slopes, occasionally flooded	4.6	15.4%
Totals for Area of Interest		**30.1**	**100.0%**

USDA
NATURAL RESOURCES CONSERVATION SERVICE (NRCS)

WI LOG OF TEST PIT NUMBER 1

Wisconsin Job Sheet - 816 3-2020b

OWNER: Ouwber Livestock South LLC	**SURFACE ELEVATION (FEET):** 1035.6	**COUNTY:** Crawford
PRACTICE: 313	**PERCHED WATERTABLE ELEVATION (FEET):** 3' Not distinct	**LAT/LONG:**
EQUIPMENT: Backhoe	**SUBSURFACE SATURATION ELEVATION (FEET):** —	**LANDSCAPE POSITION:** Upland
LOGGED BY: Dennis Johnson	**OBSERVED FREE WATER ELEVATION (FEET):** —	**SOIL MAP UNIT:** 115D2 Seaton silt loam
DATE: 7/1/25	**TOP OF BEDROCK ELEVATION (FEET):** 1026.5 Bottom of boring	**KARST FEATURES WITHIN 1000 FT:** none

DEPTH		USCS		GRADATION					PLASTICITY	MUNSELL COLOR AND %		MOISTURE	STRUCTURE	GEOLOGY	ADDITIONAL COMMENTS	SAMPLES		
FROM (FT.)	TO (FT.)	SYMBOL (e.g.-ML)	GROUP NAME (e.g.-Silt w/Sand)	% B >12"	% C 3"-12"	% G 3"-1/4"	% S 1/4"-#200	% FINE <#200	Non, Slightly, Low, Medium, High.	MATRIX (e.g.-90% 10YR 4/4)	REDOX. (e.g.-10% 10YR 5/2)	Dry, Slightly Moist, Moist, Very Moist, Wet.	Stratified, Laminated, Fissured, Slicken-sided, Blocky, Prismatic, Lensed, Massive.	Alluvium, Slope Alluvium, Colluvium, Glacial Till, Glacial Lake Sed., Outwash, Residuum, Loess,	Description of lenses - mixed materials encountered; Dilatancy: None, Slow, Rapid; Odor (mention if unusual); Consistency (If very soft or soft in wet condition); Location of Seepage and Other Items such as caving or sloughing of pit and how the water enters the pit.	FROM (FT)	TO (FT)	#
0	1	ML	Sandy loam				50	50		7.5YR 4/2		Dry		Loess				
1	3	ML	silty clay loam				20	80		7.5YR 5/2		Dry						
3	4	ML	silty clay loam				20	80		7.5YR 6/2		Dry						
4	9	SM	sandy loam				60	40		7.5YR 6/2		Dry						

General Comments:

DISCLAIMER: ALL DATA ON THIS FORM HAS BEEN FIELD ESTIMATED (ASTM D2488). IF PRECISE SOIL PROPERIES ARE REQUIRED TO MEET PRACTICE STANDARDS, THE SOILS SHOULD BE TESTED AND CLASSIFIED IN ACCORDANCE WITH ASTM D2487.

USDA
NATURAL RESOURCES CONSERVATION SERVICE (NRCS)

WI LOG OF TEST PIT NUMBER 2

Wisconsin Job Sheet - 816 3-2020b

OWNER: Gruber Livestock South LLC	SURFACE ELEVATION (FEET): 1044.8	COUNTY: Crawford	
PRACTICE: 313	PERCHED WATERTABLE ELEVATION (FEET): -3' 1041.8 Ngt.	LAT/LONG:	
EQUIPMENT: Backhoe	SUBSURFACE SATURATION ELEVATION (FEET):	LANDSCAPE POSITION: Upland	
LOGGED BY: Dennis Johnson	OBSERVED FREE WATER ELEVATION (FEET):	SOIL MAP UNIT: 1152 Senton silt loam	
DATE: 7/1/25	TOP OF BEDROCK ELEVATION (FEET): 1032.8	KARST FEATURES WITHIN 1000 FT: none	

DEPTH		USCS		GRADATION					PLASTICITY	MUNSELL COLOR AND %		MOISTURE	STRUCTURE	GEOLOGY	ADDITIONAL COMMENTS	SAMPLES		
FROM (FT.)	TO (FT.)	SYMBOL (e.g.-ML)	GROUP NAME (e.g.-Silt w/Sand)	% B >12"	% C 3"-12"	% G 3"-1/4"	% S 1/4"-#200	% FINE <#200	Non, Slightly, Low, Medium, High.	MATRIX (e.g.-90% 10YR 4/4)	REDOX. (e.g.-10% 10YR 5/2)	Dry, Slightly Moist, Moist, Very Moist, Wet.	Stratified, Laminated, Fissured, Slicken-sided, Blocky, Prismatic, Lensed, Massive.	Alluvium, Slope Alluvium, Colluvium, Glacial Till, Glacial Lake Sed., Outwash, Residuum, Loess,	Description of lenses - mixed materials encountered; Dilatancy: None, Slow, Rapid; Odor (mention if unusual); Consistency (If very soft or soft in wet condition); Location of Seepage and Other Items such as caving or sloughing of pit and how the water enters the pit.	FROM (FT)	TO (FT)	#
0	1	SM	Sandy loam				60	40		7.5YR 4/2		Dry		Loess				
1	3	ML	Silty Clay loam				20	80		7.5YR 5/2		Dry						
3	12	CL	Silty clay					95		7.5YR 6/6		wet						

General Comments:

WI LOG OF TEST PIT NUMBER 3

USDA
NATURAL RESOURCES CONSERVATION SERVICE (NRCS)

Wisconsin Job Sheet - 816 — 3-2020b

OWNER: Gruber Livestock South LLC	SURFACE ELEVATION (FEET): 1047.8	COUNTY: Crawford
PRACTICE: 313	PERCHED WATERTABLE ELEVATION (FEET): —	LAT/LONG:
EQUIPMENT: Backhoe	SUBSURFACE SATURATION ELEVATION (FEET):	LANDSCAPE POSITION: Upland
LOGGED BY: Reynold Johnson	OBSERVED FREE WATER ELEVATION (FEET):	SOIL MAP UNIT: 115B2 - Fenton silt loam
DATE: 7/1/25	TOP OF BEDROCK ELEVATION (FEET): 1035.8 Bottom of Bag	KARST FEATURES WITHIN 1000 FT: none

DEPTH FROM (FT.)	DEPTH TO (FT.)	USCS SYMBOL (e.g.-ML)	USCS GROUP NAME (e.g.-Silt w/Sand)	GRADATION % B >12"	% C 3"-12"	% G 3"-1/4"	% S 1/4"-#200	% FINE <#200	PLASTICITY Non, Slightly, Low, Medium, High.	MUNSELL COLOR AND % MATRIX (e.g.-90% 10YR 4/4)	REDOX. (e.g.-10% 10YR 5/2)	MOISTURE Dry, Slightly Moist, Moist, Very Moist, Wet.	STRUCTURE Stratified, Laminated, Fissured, Slicken-sided, Blocky, Prismatic, Lensed, Massive.	GEOLOGY Alluvium, Slope Alluvium, Colluvium, Glacial Till, Glacial Lake Sed., Outwash, Residuum, Loess,	ADDITIONAL COMMENTS Bag Description of lenses - mixed materials encountered; Dilatancy: None, Slow, Rapid; Odor (mention if unusual); Consistency (If very soft or soft in wet condition); Location of Seepage and Other Items such as caving or sloughing of pit and how the water enters the pit.	SAMPLES FROM (FT)	SAMPLES TO (FT)	SAMPLES #
0	1	SM	Sandy loam				60	40		7.5YR 4/2		Dry		Loess				
1	6	CL	Silty clay					95		7.5YR 6/2		Dry						
6	12	CL	Silty clay					95		7.5YR 6/3		Dry						

General Comments:

DISCLAIMER: ALL DATA ON THIS FORM HAS BEEN FIELD ESTIMATED (ASTM D2488). IF PRECISE SOIL PROPERIES ARE REQUIRED TO MEET PRACTICE STANDARDS, THE SOILS SHOULD BE TESTED AND CLASSIFIED IN ACCORDANCE WITH ASTM D2487.

USDA
NATURAL RESOURCES CONSERVATION SERVICE (NRCS)

WI LOG OF TEST PIT NUMBER 4

Wisconsin Job Sheet - 816 3-2020b

OWNER: Gruber Livestock South, LLC	**SURFACE ELEVATION (FEET):** 1039.8	**COUNTY:** Crawford	
PRACTICE: 313	**PERCHED WATERTABLE ELEVATION (FEET):** 3' 1036.8	**LAT/LONG:**	
EQUIPMENT: Backhoe	**SUBSURFACE SATURATION ELEVATION (FEET):** —	**LANDSCAPE POSITION:** Upland	
LOGGED BY: Penny Johnson	**OBSERVED FREE WATER ELEVATION (FEET):** —	**SOIL MAP UNIT:** 115B2 Senton silt loam	
DATE: 7/1/25	**TOP OF BEDROCK ELEVATION (FEET):** 1030.8 Bottom of Bar	**KARST FEATURES WITHIN 1000 FT:** none	

DEPTH		USCS		GRADATION					PLASTICITY	MUNSELL COLOR AND %		MOISTURE	STRUCTURE	GEOLOGY	ADDITIONAL COMMENTS	SAMPLES		
FROM (FT.)	TO (FT.)	SYMBOL (e.g.-ML)	GROUP NAME (e.g.-Silt w/Sand)	% B >12"	% C 3"-12"	% G 3"-1/4"	% S 1/4"-#200	% FINE <#200	Non, Slightly, Low, Medium, High.	MATRIX (e.g.-90% 10YR 4/4)	REDOX. (e.g.-10% 10YR 5/2)	Dry, Slightly Moist, Moist, Very Moist, Wet.	Stratified, Laminated, Fissured, Slicken-sided, Blocky, Prismatic, Lensed, Massive.	Alluvium, Slope Alluvium, Colluvium, Glacial Till, Glacial Lake Sed., Outwash, Residuum, Loess,	Description of lenses - mixed materials encountered; Dilatancy: None, Slow, Rapid; Odor (mention if unusual); Consistency (If very soft or soft in wet condition); Location of Seepage and Other Items such as caving or sloughing of pit and how the water enters the pit.	FROM (FT)	TO (FT)	#
0	1	SM	Sandy loam				60	40		7.5 YR 4/2		Dry		Loess				
1	3	ML	silty clay loam				20	80		7.5 YR 5/2		Dry		Loess				
3	4	ML	silty clay loam				20	80		7.5 YR 6/2		Dry						
4	9	SM	Sandy loam				60	40		7.5 YR 6/2		Dry						

General Comments:

DISCLAIMER: ALL DATA ON THIS FORM HAS BEEN FIELD ESTIMATED (ASTM D2488). IF PRECISE SOIL PROPERIES ARE REQUIRED TO MEET PRACTICE STANDARDS, THE SOILS SHOULD BE TESTED AND CLASSIFIED IN ACCORDANCE WITH ASTM D2487.

APPENDIX C –

MANURE AND WASTEWATER GENERATION

AND STORAGE CALCULATIONS

WASTE STORAGE FACILITY DESIGN - 313 STANDARD Ver. March 2016

CLIENT: GLS COUNTY: CRAWFORD DATE: 7/19/25

DSN BY: DJJ CHK BY: _____ DATE: _____

COMMENTS:

ANIMAL TYPE> 4 (1=DAIRY, 2=BEEF, 3=VEAL, 4=SWINE(finishing), 5=SWINE(farrowing), 6=POULTRY, 0=OTHER)

N/A N/A

MANURE AND WASTEWATER

LIVESTOCK		AVG. WT.	DAILY OUTPUT, CU FT			DAYS OF	VOLUME	ANIMAL
KIND	NUMBER	PER HEAD	MANURE	BEDDING	TOTAL	STORAGE	REQUIRED	UNITS
Finishing	2499	150	0.15	0.0	374.9	383	143,568	375

WASTEWATER: GAL/DAY 0.0 CU FT/DAY 375 TOT. A.U.

TOTAL DAILY VOLUME: 374.9 CU FT / DAY

1,073,885 GALLONS

Total Manure and Wastewater **143,568 CU FT**

Expected % solids in waste (Includes runoff and precip.) 11.3 %

RUNOFF VOLUME STORED BELOW THE MOL

RUNOFF VOLUME (ENTIRE DRAINAGE AREA)

MONTHLY RUNOFF

RCN 98 32.37 / 12 IN. X _____ Ft2 Drainage Area= 0 CU FT

(Do not include waste storage facility area)

25-Year, 24-HOUR RUNOFF **RUNOFF VOLUME STORED ABOVE THE MOL**

RCN 98 0.01 / 12.00 IN. X 0 Ft2 Drainage Area= 0 CU FT

'(Do not include waste storage facility area)

VOLUME STORED BELOW THE MOL

WASTEWATER (from other sources) _____ GALLONS (for entire storage period) 0 CU FT

LEACHATE VOLUME

	Area #1	Area #2	Area #3
Length =			
Width =			
Height =			

0 CU FT

1,073,885 GALLONS

Total for Manure, Milking Center, Runoff Volume, and 25 Yr Runoff **143,568 CU FT**

PRECIPITATION

Does the facility collect precipitation? (No roof or lid) 2 (1 for yes, 2 for no)

Beginning Month for Precip. Collection 4 (1=Jan, 2=Feb, etc.)

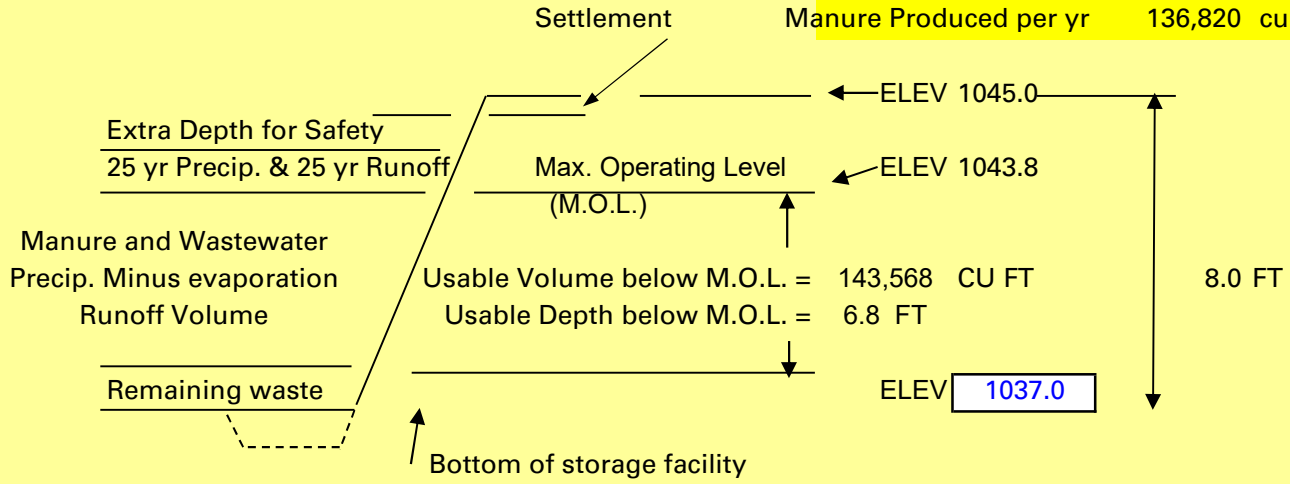
Precipitation minus evaporation

Average Precipitation on Storage Surface		0.0 INCH	0.0 FT
Average Evaporation from Storage Surface	-	0.0 INCH	0.0 FT
Net Precipitation on Storage Surface		0.0 INCH	0.0 FT
25-Yr, 24-Hr Precip on Storage Surface		0.0 INCH	0.0 FT

REMAINING WASTE	(If no sump, use these minimums: ponds -2', tanks-1')	0.0	FT
EXTRA DEPTH FOR SAFETY	(1-ft. Minimum)	1.2	FT
SETTLEMENT	(5% of Embankment Height)	0.0	FT
M.O.L. DEPTH	(Depth to hold Manure, Wastewater, Runoff, and Precip.)	6.83	FT
	Total Depth of the Storage Facility	**8.0**	FT

STORAGE FACILITY ELEVATIONS

Design Storage Volume 143,568 cu ft
Manure Produced per yr 136,820 cu ft



STORAGE SIZING	IS STORAGE RECTANGULAR OR ROUND ?	1	(1= Rectangular; 2= Round)
	SIDE SLOPES OF STORAGE	0.0 :1	(Use "0" for walls)
	CHOOSE A BOTTOM WIDTH	101	FT
	BOTTOM LENGTH REQUIRED	208	FT
	ROUND STORAGE BOTTOM DIAMETER REQUIRED	N.A.	FT

STORAGE SIZING SUMMARY

RECTANGULAR	BOTTOM SIDE 1:	101	FT		
	BOTTOM SIDE 2:	208	FT		
	M.O.L. VOLUME PROVIDED:	143,568	CU FT	1,073,885	GALLONS
	DAYS STORAGE PROVIDED:	383	DAYS		
	TOTAL VOLUME FROM BOTTOM TO SETTLED TOP:	168,087	CU FT	1,257,293	GALLONS
ROUND	CHOOSE BOTTOM:	N.A.	FT DIAM		
	M.O.L. VOLUME PROVIDED:	0	CU FT	0	GALLONS
	DAYS STORAGE PROVIDED:	0	DAYS		
	TOTAL VOLUME FROM BOTTOM TO SETTLED TOP:	0	CU FT	0	GALLONS

APPENDIX D –

WI-NRCS 313, WASTE STORAGE FACILITY

WI-NRCS 522, POND SEALING OR LINING, CONCRETE

WI-NRCS 606, SUBSURFACE DRAIN

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 the following purpose–

- 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, where soils, geology, and topography are suitable for construction of the facility, and where the construction, operation, and maintenance will protect the soil and water resources.

For structures and conduits used to transfer waste and other byproducts, use the Wisconsin NRCS Conservation Practice Standard (WI NRCS CPS) Waste Transfer (Code 634).

For liquid waste storage facilities implemented with an embankment, this practice applies only to low hazard facilities as defined in the NRCS National Engineering Manual (NEM), Part 520 subpart C with a maximum effective height of 25 feet.

This standard applies to:

- Waste storage impoundments or structures up to 25 feet of impoundment depth; and
- Facilities that are part of a planned agriculture waste management system intended to meet the facility management goals, regulatory requirements, or nutrient management plans by providing storage of waste.

For the purposes of this standard, liquid waste is used to describe any waste that is too wet to stack. It includes both liquid and slurry waste.

This practice does not apply to the storage of human waste, routine animal mortality, the unstacked waste that accumulates in animal housing units (barns) or animal production areas not intended to store waste (animal confinement/feed areas).

CRITERIA

General Criteria Applicable to All Purposes

The following criteria establish minimum allowable limits for design parameters, acceptable installation processes, or performance requirements for all waste storage facilities (impoundments and structures).

Laws and Regulations

Plan, design, and construct the waste storage facility to meet all Federal, Tribal, State, and local laws and regulations. This standard does not contain the text of the federal, tribal, state, or local laws governing waste storage facilities. Regulatory approval may be needed prior to accepting off- site material(s) or adding chemicals to the waste storage facility. The operator is responsible for securing required permits.

Location

Locate and design the waste storage facility such that it is outside the 100-year floodplain unless site restrictions require locating it within the floodplain. Where waste storage facilities are located in flood prone areas, protect these facilities from inundation, structural damage, and instability. Design these facilities to accommodate any additional loading resulting from static water levels or saturated soils. The lowest point at which floodwater could potentially enter the waste storage facility must be 2 feet above the maximum flood elevation resulting from a 100-year, 24-hour rainfall event. Additionally, follow the policy found in the NRCS General Manual (GM) 190, Part 410.25, Flood Plain Management.

Management Assessment

Conduct, document, and incorporate a management assessment into the design. Perform the assessment with the owner/operator to explore options and to determine the purpose of storage components, available resources, manure disposal schemes, sand and manure solids separation methods, and waste characteristics.

The management assessment shall address the following as appropriate to the system being designed:

- Waste Characterization
  - Sources, volumes, and consistency of manure, contaminated runoff, manure processing derivatives, leachate, wastewater, and other inputs to the waste storage facility
  - Animal type, size, number and weight
  - Bedding types and quantit
  - Chemical characteristics which may impact facility design
- Land base available for utilization of waste
- Method of distribution of manure onto the land base
- Planned storage period
- Waste handling and transfer methods from the waste source to the storage facility
- Facility waste removal methods
- Storage facility liner possibilities and preferences
- Access needs and limitations
- Safety needs, including those to address the hazards of manure gases
- Labor and equipment needs
- Potential odor concerns
- Provisions for facility expansion

When the intent of the owner/operator is to process and/or treat the various waste streams within the animal production area, provide a narrative describing the system. The description will include the intent and purpose of the processing or treatment strategies relative to land spreading or waste distribution strategies, stabilization of organic by-products, separation of sand bedding, reducing pollutant loads, nutrient concentration, waste consistencies, odor control, energy production, and volume reduction.

Site Assessment

Conduct, document, and incorporate a site assessment into the design. Perform the assessment to determine physical site characteristics that will influence the placement, construction, maintenance, and environmental integrity of a proposed waste storage facility, liner(s) and transfer components. Include input from the owner/operator in the site assessment. The site assessment shall include:

- Locations and elevations of buildings, roads, lanes, soil investigations, property lines, setbacks, easements, wells, springs, floodplains, surface waters, surface drains, subsurface drains, utilities, overhead lines, cultural resources, and wetlands.
- The location of sinkholes and other karst features and conduits to groundwater within 1,000 feet of the facility. Features within 1,000 feet of the facility must be further analyzed per WI NRCS Engineering Field Handbook Supplement Chapter 4, Exhibit A (Chapter 4, Exhibit A) to determine if they pose a hazard to the facility or environment.
- Log subsurface investigations for all waste storage facilities sufficient in detail and analysis to support the design in accordance with Chapter 4, Exhibit A. Describe the soil material encountered, location of any seeps, depth to subsurface saturation, and depth to bedrock (Note: Chapter 4, Exhibit A follows NRCS NEM Part 531, Geology, by utilizing ASTM D2488 procedures).
    - Document the location of test pits or soil borings, soil test results, photos taken during the soils investigation, and a narrative describing the design parameters that have been derived from the soils data. Note the bedrock type, if encountered, such as sandstone, limestone, dolomite, or granite.
    - Locate test pits and borings used to meet the criteria within the footprint or no more than 100 feet from the footprint. A minimum of one test pit or boring per 15,000 square feet of facility footprint, with a minimum of two per facility, is required. Extend these test pits/soil borings to bedrock, a free water surface, or to a minimum depth to ensure subsurface saturation and bedrock separation distances required in this standard or associated Pond Sealing or Lining standards are achieved.
    - Complete soil tests for soils (in-place), sub-soil or sub-liner soils in a laboratory on representative samples of soil beneath the proposed grade at a rate of 1 test per 30,000 square feet of facility footprint, with a minimum of two tests. The Plasticity Index (PI) shall be determined in accordance with ASTM D4318 and the percent fines (% fines) in accordance with ASTM D1140.
    - Increase the number and distribution of test pits and soil borings needed to characterize the subsurface (soils, saturation, and bedrock) if there is inconsistency within or between test pits or borings.
    - Characterize soil for liners and sub-liners according to Chapter 4, Exhibit A. Soils for liners and sub-liners may be located within the footprint of the storage, on site, or off site and transported to the site for construction. Include locations, dimensions and elevations, soil volumes, soil samples, testing results, and reclamation plans of any borrow areas. Complete soil characterization at a rate of one test per 30,000 square feet of borrow source, with a minimum of two tests per area. Distribute the test pit or borings evenly across the borrow source. Additional soils testing may be needed to meet the requirements of the selected liner type. See the appropriate Pond Sealing or Lining standards and Wisconsin construction specifications for additional criteria.

Separation from Subsurface Saturation or Bedrock

The separation is determined to be the closest distance from any point on the inside surface (bottom and sides) of the storage facility to the feature from which separation is required.

For the purposes of this standard, factors used to identify subsurface saturation shall include observed saturation, gleyed soil, gray redoximorphic features, and soil color in conjunction with nearby surface water features. The highest subsurface saturation elevation in a test pit/soil boring will be identified by any of the following soil properties:

- Free water or wet soil identified by glistening, due to the slow release of water
- Gleyed soil, that may extend uninterrupted from an observed free water surface.
- The presence of distinct gray redoximorphic features with a chroma of 2 or less based on Munsell color charts.
- Depleted matrices having a value of 4 or more and chroma of 2 or less based on Munsell color charts. In some cases soil parent materials have a natural color with a chroma of 2 or less or gleyed color that is not due to saturation. In these cases other indicators may be used such as landscape position, relative elevation or soils in relation to nearby water features.

In soils not conducive to mottling, such as sand, establish the subsurface saturation elevation by evaluating the soil morphology of the soil profile. Other indicators that may be considered in making the determination are the position of the soil in the landscape, topography, nearby wetlands and well construction logs. In sites susceptible to groundwater contamination or complex hydrogeological sites, additional saturation verification methods may be required. Verification methods could include but are not limited to groundwater monitoring wells, piezometers, and soil test pits conducted during the wet season. Other information to consider includes historic precipitation and groundwater elevation records from nearby locations, which can indicate whether or not the area is experiencing a local high or low trend in groundwater elevation.

If the site assessment indicates artesian features, complete a hydrogeologic and geotechnical evaluation of the site to determine the site suitability for an in-ground waste storage facility. Include a groundwater monitoring well or piezometer below the apparent confining layer and a water table observation monitoring well in the evaluation. Monitor the site through the wettest portion of the annual groundwater recharge cycle.

Construct and develop groundwater monitoring wells and piezometers according to WI NRCS CPS Monitoring Well (Code 353) or appropriate state monitoring well construction requirements.

Subsurface saturation, pockets of sand and gravel, or water-bearing materials, if encountered, shall not be removed or drained except for perched conditions. Include documentation to demonstrate that subsurface saturation is perched and its effects can be eliminated.

Excavation of bedrock is permitted to achieve the required separation distance as specified in Table 5 of this standard and tables in associated Pond Sealing or Lining standards. Do not remove bedrock by blasting. Evaluate the exposed bedrock surface to ensure a structurally sound base for a liner or other soil material. Treat fractures or voids to prevent migration of soil material. The entire surface of the excavated bedrock shall have a positive grade, minimum of 1 percent, under and away from the storage facility, as to prevent any significant ponding on the rock surface. If bedrock is excavated, the material placed between the liner and the bedrock shall meet the requirements of sub-liner soil in the appropriate Pond Sealing or Lining standards.

Perched Conditions
Pockets of sand and gravel, or other water-bearing materials may be removed or drained to achieve separation distances in Tables 1 and 5 within this standard, or tables in associated Pond Sealing or Lining standards, and to relieve hydrostatic loads on the facility and its liner(s). All drainage systems shall drain to the ground surface or surface water by gravity. Evaluate the effect of temporary tailwater on the structure or liner and the effects of out-letting to perennial and intermittent waterways. Locate a drainage system around the outside perimeter of the facility footprint and drain to a surface outlet. Protect outlets against erosion and undermining of the conduit, entry of vegetation, damaging periods of submergences, and entry of rodents or other animals into the subsurface drain. A drainage system may also be located around the outside perimeter of an impoundment floor within the facility footprint if the drainage system enters an observation and pumping port and then continues by gravity to a surface outlet. Design the port such that the outlet can be blocked and a pump can be utilized to remove the polluted liquids until the source is identified and repairs can be completed.

Sensitive Environmental Settings
Wisconsin Sensitive Environmental Settings are sites where one or more of the following conditions are met:

- Bedrock or subsurface saturation separation distances are less than those listed in Tables 1 of this standard, Table 1 of WI NRCS CPS Pond Sealing or Lining – Compacted Soil Treatment (Code 520), Tables 5 and 6 of WI NRCS CPS Pond Sealing or Lining – Geomembrane or Geosynthetic Clay Liner (Code 521), or Table 2 of WI NRCS CPS Pond Sealing or Lining – Concrete (Code 522);
- Sub-liner soils do not meet both the required thickness and percent fines listed in Table 1 of WI NRCS CPS 520, Tables 5 and 6 of WI NRCS CPS 521, or Table 2 of WI NRCS CPS 522;
- For facilities with one or more sloped sides or structures with vertical sides with any part of the storage floor below existing ground surface, a sinkhole or other karst feature is present within 400 feet horizontally from the footprint of the proposed storage facility; or
- For above ground structures where the storage floor is entirely above existing ground surface, a sinkhole or other karst feature is present within 200 feet horizontally from the footprint of the proposed storage facility.

In-situ soils that do not meet both the sub-liner required thickness and percent fines listed in the applicable liner standard can be removed and replaced with compliant materials. When designed and constructed in this manner, the site is no longer classified as Wisconsin Sensitive Environmental Settings.

Where liquid-storage is to be provided in sensitive environmental settings, design according to WI NRCS CPS Pond Sealing or Lining – Concrete (Code 522), Sensitive Environmental Settings.

Storage Period
The storage period is the maximum length of time anticipated between emptying events. Base the minimum storage period on the timing required for environmentally safe waste utilization considering the climate, crops, soils, equipment, in accordance with the operations and maintenance plan, nutrient management plan and Federal, State, and local regulations.

Design Storage Volume
Calculate design storage volumes with the procedures and default values found in the Wisconsin supplement to Chapter 10 of the NRCS Agricultural Waste Management Field Handbook (AWMFH) or site-specific estimates and measurements documented in the design. Include the sum of the following during the storage period in the design volume:

The maximum operating level (MOL) for liquid storage facilities is the level that provides the operational volume (Figure 1 contains a diagram of this information). This includes the following:

- Manure, wastewater, bedding, and all other wastes accumulated during the storage period.
- For liquid 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. Exclude clean water from the facility to the fullest extent practical except where including the runoff is advantageous to the operation of the agricultural waste management system.
- Additional storage when required to meet management goals or regulatory requirements.

Emergency Volume (liquid storages only) includes the following:

- 25-year, 24-hour precipitation on the surface of the liquid storage facility at the maximum level of the required design storage.
- 25-year, 24-hour runoff from the facility's drainage area.

Remaining Waste
Add a minimum of two feet to storage depth for facilities with side slopes and one foot for vertical walled facilities for planned maximum remaining waste. The additional storage depth can be reduced if a sump is installed or other provisions to empty the facility have been made. 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 and maintained.

Freeboard Volume
This volume applies to liquid waste storage exposed to precipitation. Add a minimum of one foot of depth to the design storage volume to reduce the risk of over-topping. This depth is not intended to add storage capacity.

Inlet
Design inlets to resist corrosion, plugging, freeze damage, and ultraviolet deterioration. Incorporate erosion protection for in-place earth (Table 1 of this standard), soil liner (WI NRCS CPS 520, Table 1), and geosynthetic clay liners (WI NRCS CPS 521, Table 6).

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 ramp slopes to accommodate anticipated equipment and traction available. Use WI NRCS CPS Nutrient Management (Code 590) for land application of stored material or follow other disposal options outlined in a Comprehensive Nutrient Management Plan (CNMP).

Outlet
An outlet that can automatically release stored material is not permitted except for outlets leading to another storage facility with adequate capacity for releases due to accident or system component failure. 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.

Staff Gauge
Place a staff gauge or other permanent marker that does not compromise the integrity of the liner 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)
- State or local codes may require additional markers

For storages where the contents or staff gage are not visible, such as below a slatted floor, identify the method for the operator to measure the depth of stored waste.

Safety
Identify and minimize the hazards to animals and people in the safety design. In particular, waste storage facility designs may create confined spaces, which may pose significant hazards in terms of the inhalation of poisonous gases, asphyxiation, or explosion. At a minimum, the safety design shall include the following:

- 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). Design and operate confined spaces where human entry might occur in compliance with the provisions contained in ASABE EP470, Manure Storage Safety.
- Characterize and identify any combination of effluent and amendments currently in use that may have the potential to create hazardous conditions.
- 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 facilities, as necessary, to prevent explosion, poisoning, or asphyxiation.

- Install safety stops, gates, or both at push-off ramps and load-out areas of impoundments and structures to reduce the potential for accidental entry of machinery.
- Ensure equipment access ramps and embankment slopes are compatible with the equipment intended to be used.
- 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 WI NRCS CPS Fence (Code 382) for design of a fence that will restrict access to safety hazards by people and animals likely to be on-site.
- Post universal warning signs to warn children and others from entering liquid waste storage facilities.
- Safety features should be added to the Operation and Maintenance Plan.

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

Failure Analysis
Evaluate the overall functionality of the waste storage facility for possible malfunctions which could lead to sudden breach of embankment or accidental release of waste from the storage facility under normal operational conditions. Identified failure modes should be addressed in the design phase, the operation and maintenance plan, and the emergency action plan.

The Failure Analysis should include features, safeguards, and/or management measures to minimize the risk of failure or accidental release, or to mitigate impact of this type of failure when any of the features listed below might be significantly affected:

- Human safety
- Surface water bodies – perennial and intermittent streams, lakes, wetlands and estuaries
- Conduits to groundwater
- Artesian well features
- Critical habitat for threatened and endangered species
- Riparian areas
- Farmstead, or other areas of habitation
- Off-farm property
- Historical and archaeological sites or structures

Seeding and Mulching
Seed and mulch disturbed areas and embankments in accordance with WI NRCS CPS Critical Area Planting (Code 342).

Additional Criteria for Liquid Waste Storage Impoundments
The following criteria establish additional design parameters, acceptable installation processes, or performance requirements for liquid waste storage impoundments.

Foundation
Locate the impoundment in soils with a permeability that meets all applicable regulations (Table 1 meets the specific discharge requirements specified in the National Engineering Handbook (NEH), Part 651, Agricultural Waste Management Field Handbook (AWMFH), Chapter 10, Appendix 10D). Alternately, line

the impoundment with suitable material. If a liner is needed, use liners which meet or exceed WI NRCS CPS 520, 521, or 522. Construction shall not occur on or with organic soils.

A combination of liners is acceptable. Join the liners so as to preserve the performance and integrity of all liner types. Concrete walls used within impoundments shall maintain the integrity of any liner. Construct and maintain any penetration and overfall/outfalls of the liner to maintain the performance and integrity of the liner used.

Waste storage impoundments that store milkhouse waste or feed storage runoff may be subject to the requirements of Wisconsin Administrative Code, Chapter NR 213 (NR 213) if the operation is considered a concentrated animal feeding operation or if compliance with NR 213 is required by other NRCS standards. NR 213 contains requirements not contained within this standard. If the waste storage impoundment is regulated under NR 213, the design must meet the requirements of both NR 213 and this standard.

Embankments
Non liner components of an impoundment embankment shall be constructed with mineral soil material compacted to WCS-204 requirements. The impoundment embankment shall be lined with (CPS 313) Table 1 Soils (In Place) material, a soil liner (CPS 520), or the selected liner component and soil component (WI NRCS CPS 521 or 522). The soil component shall be compacted following the Wisconsin Construction Specification listed in the applicable standard. The bottom of the liner shall be extended until it daylights the embankment. Minimum embankment top widths are shown in Table 2. Design the combined side slopes of the settled embankment to be equal to or flatter than 5 horizontal to 1 vertical. Interior side slopes must meet the design requirements listed in either Table 1 or the selected liner requirements, found in the pond liner standards (WI NRCS CPS 520, 521, and 522). Exterior side slopes may be no steeper than 2 horizontal to 1 vertical.

The top of the embankment may be constructed to drain, either toward or away from the stored waste, as desired by the designer. Add additional material above the required top width to accommodate desired drainage.

Increase the constructed embankment height by at least 5 percent to allow for settlement. After settlement, the top of the embankment shall be greater than or equal to 1 foot above the surrounding grade. Stabilize all embankments to prevent erosion or deterioration. Compact according to WI FOTG Construction Specification 204, Earthfill for Waste Storage Facilities or Construction Specification 300, Clay Liner, as applicable. 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.

Any diversion or waterway along the embankment shall have a capacity for 25-year, 24-hour storm plus 0.5 feet of freeboard, with a minimum depth of 1 foot.

Construct a core trench whenever the settled embankment fill height at the centerline is greater than or equal to 10 feet. Minimum dimensions of the core trench shall be 8-foot bottom width, 2-foot depth, and 1 horizontal to 1 vertical or flatter side slopes.

Spillway or Equivalent Protection
For a facility having an effective height greater than 20 feet, construct an auxiliary (emergency) spillway designed to handle the peak flow or routed peak flow from the 25-year, 24 hour precipitation event, as defined in the Design Storage Volume section of this standard. The crest of the spillway shall be sited above the design storage volume elevation.

Excavations
Design embankments and excavated side slopes to meet the requirements of WI NRCS CPS 313, 520, 521 and 522, as applicable.

Table 1. In-Place Earth Criteria for Waste Storage Facility Impoundments 20 Feet Deep or Less [Note 1, 2]

Size		
Design Storage Volume	≤ 300,000 cu. feet	> 300,000 cu. feet
Manure Produced at Farm per Year	≤ 600,000 cu. feet	> 600,000 cu. feet
Waste Characteristics	≥ 4% manure solids in stored waste, ruminant animals only	All
Soils (In Place)		
% Fines	≥ 40%	≥ 40%
Plasticity Index (PI)	≥ 7	≥ 12
Total Thickness (measured perpendicular to storage surface, includes thickness of recompacted layer)	≥ 5 feet [Note 3]	≥ 5 feet [Note 3]
Thickness of Recompacted Surface Layer	≥ 1 foot	≥ 1 foot
WI FOTG Construction Specification for Recompacted Layer	204, Earthfill for Waste Storage Facilities	300, Clay Liner
Sub-Soil [Note 4]		
% Fines	≥ 20%	≥ 20%
Plasticity Index (PI)	—	—
Thickness (bottom and sides)	≥ 3 feet	≥ 3 feet
Separation Distances		
Well Distance [Note 5]	≥ 250 feet	≥ 250 feet
Sinkholes or Other Karst Features	≥ 800 feet	≥ 400 feet
Subsurface Saturation	≥ 8 feet	≥ 8 feet
Bedrock	≥ 8 feet	≥ 8 feet
Impoundment		
Inside Slope	2.5:1 or flatter	
Other		
Scour Protection	Stationary Agitation and Pumping Locations	Minimum 20 feet wide x 30 feet long x 4 inches thick concrete pad or sump in bottom and 20 feet wide ramp or a 16-foot wide ramp with 12-inch high curbs to the top of the facility.
	Scraping and Other Mechanical Means of Removing Accumulated Solids and Sand	Protect with hard surfacing designed for the expected conditions and loads, a minimum of 4 inches thick concrete.
Existing Field Drain Tile	Additional site investigation shall be completed to determine the presence of existing subsurface drain or underground outlet within 100 feet of the footprint of the facility. Any tile found must be abandoned or removed.	

Note 1 The depth is measured from the bottom of the impoundment to the maximum operating level.

Note 2 Facilities in this table do not meet the requirements of NR 213.

Note 3 Thickness is calculated based on a maximum permeability of 1x10-7 cm/sec

Note 4 Sub-soils are located beneath the required in place soils and above subsurface saturation or bedrock. Sub-soils must be in situ materials.

Note 5 Community water system wells may require larger separation distances (see Wisconsin Administrative Code, Chapter NR 811 (NR 811)).

Table 2. Minimum Embankment Top Widths

Effective Height (feet)	Top width (feet)
< 15	8
15–19.9	10
20–25	12

Additional Criteria for Fabricated Structures

The following criteria establish additional design parameters, acceptable installation processes, or performance requirements for waste storage 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.

Total and Differential Settlement.

Where a non-uniform foundation cannot be avoided or where applied loads may create highly variable foundation loads, calculate both total and differential settlement based upon site-specific soil test data. Index tests (such as Atterberg limits, moisture content, etc.) of site soils may allow correlation with similar soils for which test data is available.

Bearing Capacity

If no site specific test data are available, presumptive bearing strength values for assessing actual bearing pressures obtained from Table 3 or another nationally recognized building code may be used. In using presumptive bearing values, provide adequate detailing and articulation to avoid distressing movements in the structure (i.e., settlement).

Structuctural 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 subsurface saturation, frost or ice. If a dense ice cover can be expected, account for the additional point load associated with an ice sheet against a vertical wall.

Calculate loading from lateral earth pressures using soil strength values determined from the results of appropriate soil tests and procedures described in NRCS Technical Release 210-74, Lateral Earth Pressures. Table 4 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 as indicated in footnote 4 in Table 4 in the wall analysis.

For the lateral load from stored waste not protected from precipitation, use a minimum 65 pounds/square foot/foot of depth as the design internal lateral pressure. Use a minimum value of 60 pounds/square foot/foot 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 pounds/square foot/foot of depth for sand-laden

manure storage if the percentage of sand exceeds 20 percent. Designers may use lesser values if supported by measurement of actual pressures of the waste to be stored.

Design structure covers to withstand both dead and live loads. Use the minimum live load values for covers contained in ASABE EP378, Floor and Suspended Loads on Agricultural Structure Due to Use, and in ASABE EP393, Manure Storages. Use the actual axle load for tank wagons having more than a 2,000 gallon capacity.

If the structure is to have a roof, use WI NRCS CPS Roofs and Covers (Code 367) for design of waste storage facility covers or roofs, as needed. Use snow and wind loads specified in American Society of Civil Engineers (ASCE) SEI/ASCE 7-10 or newer version, Minimum Design Loads for Buildings and Other Structures. If the facility is to serve as part of a foundation or support for a building, consider the total load in the structural design.

Concrete Joints

Wall control joints with embedded waterstop – Cast-in-place cantilevered vertical walls shall have a control joint spacing less than or equal to 100 feet of running wall length, including around corners and bends. This criterion does not apply to hoop strength design or tanks with pin connections at both the top and bottom of the wall or to liquid-tight concrete walls designed in compliance with ACI- 350.

Table 3. Presumptive Allowable Foundation and Lateral pressure [Note 1]

Class of materials	Allowable foundation pressure (pounds per square foot)	Lateral bearing	Coefficient of friction	Cohesion (pounds per square foot)
Crystalline bedrock	12,000	1,200	0.70	-
Sedimentary 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 silt (CL, ML, MH, and CH)	1,500	100	-	130

[Note 1] International Building Code (IBC), 2015, International Code Council (ICC)

Waterstop

Use embedded or expansive waterstop in accordance with WI Construction Specification 004-WS Embedded or Expansive Waterstop. The type of waterstop is based on the joint movement criterion indicated below.

Install an embedded waterstop at the wall to footing intersection if the joint is designed for movement. Install either an expansive or embedded waterstop at this joint if it is not designed for movement (fixed).

If there is no embedded waterstop at the wall base, cast the wall joint waterstop a minimum of 4 inches into the footing. If there is an embedded waterstop between the footing and the bottom of the wall, weld the wall joint waterstop to a factory fabricated intersection at the base of the wall.

Floor joints in vertical walled structures, if used, should be extended through the footing and continue to the top of the vertical wall. Joints and liner shall meet the criteria listed in WI NRCS CPS Pond Sealing or Lining – Concrete (Code 522).

Joints for pre-cast walls shall demonstrate evidence of equivalent performance to waterstop joints as determined by the NRCS State Conservation Engineer.

Make transitions from concrete wall footings to concrete slabs at a ratio of one inch of thickness change to one inch of run (1:1) or flatter.

Table 4. Lateral Earth Pressure Values Note 1

Description of Backfill Material Note 2	**Unified Soil Classification** Note 3	**Design lateral soil load (pounds/square foot/foot of depth)** Note 4
Well-graded, clean gravels; gravel-sand mixes Note 5	GW	60
Poorly graded clean gravels; gravel-sand mixes	GP	60
Silty gravels, poorly graded gravel-sand mixes	GM	60
Clayey gravels, poorly graded gravel-sand mixes	GC	60
Well-graded, clean sands; gravely sand mixes	SW	60
Poorly graded, clean sands; gravely sand mixes	SP	60
Silty sands, poorly graded sand-silt mixes	SM	60
Sand-silt clay mix with plastic fines	SM-SC	100
Clayey sands, poorly graded sand-clay mixes	SC	100
Inorganic silts and clayey silts	ML	100
Mixture of inorganic silt and clay	CL-ML	100
Inorganic clays of low to medium plasticity	CL	100
Inorganic clayey silts, elastic silts	MH	Note 6
Inorganic clays of high plasticity	CH	Note 6

Description of Backfill Material Note 2	Unified Soil Classification Note 3	Design lateral soil load (pounds/square foot/foot of depth) Note 4

Note 1 Table 1610.1, Lateral Soil Load, International Building Code (IBC), 2015, International Code Council (ICC). For lightly compacted soils (85% to 95% maximum standard density). Includes compaction by use of typical farm equipment.

Note 2 Base the definition and classification of soil in accordance with ASTM D2487 and D2488.

Note 3 All definitions and procedures in accordance with ASTM D2488 and D653.

Note 4 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. Pressures are calculated for level backfill for a distance equal to the wall height. If backfill exceeds wall height at a distance equal to or less than the wall height, increase pressures accordingly. If equipment loads are expected or are possible to operate within a distance equal to the wall height behind the wall, use an additional live load soil surcharge equal to 2 feet of backfill for 5,000 pound wheel loads and more or less for other wheel loads, as appropriate.

Note 5 Generally, only washed materials are in this category.

Note 6 Not recommended. Requires special design if used.

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, construction quality, waterstops, pipe penetration, channel penetrations, anchor plates, or other attachments to walls such as fence posts. Ensure that the material used for a fabricated structure is compatible with the waste product to be stored.

Indicate design assumptions and construction requirements on the construction plans. Construct any penetration of the structure to maintain the performance and integrity of the structure.

Tanks may be designed with or without a cover. Design covers, beams, or braces that are integral to structural performance accordingly and indicate their location and design requirements on the construction drawings. 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.

Fabricated structures shall be designed according to the following criteria:

- 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, American Concrete Institute (ACI) 318. Concrete design calculations shall use a minimum design compressive strength of 3,500 psi.
  - Code Requirements of Environmental Engineering Concrete Structures, ACI 350.
  - Concrete used as part of a structure: WI Construction Specification 4, Concrete.

Separation Distance

Fabricated structures must meet the separation distances listed in the liner standard(s) used; see WI NRCS CPS 520, 521 and 522, as applicable.

Additional Criteria for Stacking Facilities

This criteria applies to stacking the following materials at the animal production area:

- Separated manure solids
- Compost
- Dewatered, recycled sand storage
- Poultry litter (turkey or broiler operations)
- Dry poultry layer manure
- Bedded manure (> 50% solids)
- Waste feed

Criteria for stacking facilities are shown in Table 5. Solids stacking within the animal production area may be done in an impoundment, fabricated structure or stacking slab, when provisions are made to capture seepage and runoff.

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.

Reduced seepage concrete with waterstop is allowed as a liner in place of the soil requirements of Table 5.

Seepage

All facilities lacking permanent, engineered roofs are considered not roofed for the purposes of this standard. Tarps, plastic coverings, or other temporary measures are considered not roofed. Facilities that are not roofed must have floors sloped to control surface drainage and all leachate and runoff (up to the 25-year, 24-hour storm) must be managed. Prevent influent seepage in amounts that would infringe on designed storage capacity. Seepage control may not be necessary on sites that have a roof or waste material with little seepage potential.

Internal Drainage

Make provisions for drainage of leachate, and rainfall from the stacking areas without a roof. Collect leachate and runoff in a facility suitable for liquid containment (as defined within this standard) or transfer receptacle meeting WI NRCS CPS Waste Transfer (Code 634), until land applied in accordance with WI NRCS CPS Nutrient Management (Code 590), or provide other acceptable treatment.

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. Compost facilities should be designed and operated to meet the requirements of WI NRCS CPS Composting Facility (Code 317).

Design facilities to prevent run-on and runoff, and operate them to prevent ponding and significant hydrostatic head. Facilities may commonly be located near the ground surface, but may be above or below ground. Determine the wall height using the anticipated stacking angle of the waste material.

Table 5. Liner Criteria for Permanent Solids Stacking Facilities at the Animal Production Area Note 1

	Roofed		Not Roofed	
	Work Surface Note 2	**No Surface** Note 3	**Work Surface** Note 2	**No Surface** Note 3
Soils In-Place Liner Note3				

	Roofed		Not Roofed	
% Fines	≥ 30%	≥ 30%	≥ 40%	≥ 40%
Plasticity Index (PI)	-	≥ 7	-	≥ 7
Thickness	≥ 2 feet	≥ 2.5 feet	≥ 3 feet	≥ 5 feet
Soils Compacted Liner Note 3				
% Fines	≥ 30%	≥ 40%	≥ 40%	≥ 40%
Plasticity Index (PI)	≥ 5	≥ 7	≥ 7	≥ 7
Thickness	≥ 1.5 feet	≥ 2 feet	≥ 2 feet	≥ 3 feet
Compaction	WI Spec 204	WI Spec 204	WI Spec 204	WI Spec 204
Separation Distances				
Sinkholes	≥ 400 feet	≥ 400 feet	≥ 400 feet	≥ 400 feet
Well Distance Note 4	≥ 100 feet	≥ 100 feet	≥ 100 feet	≥ 100 feet
Subsurface Saturation	≥ 3 feet	≥ 3 feet	≥ 5 feet	≥ 5 feet
Bedrock	≥ 3 feet	≥ 3 feet	≥ 5 feet	≥ 5 feet
Stacking Area	Stacking area not to exceed 7 acres for unroofed managed compost, 2 acres for sand, 2 acres for roofed facilities, or 1 acre for all other materials.			

Note 1 Solids and sand stacking facilities, treatment areas and other production area structures and systems may be subject to surface water setbacks and other requirements under state and local rules. MOL requirements do not apply to this Table.

Note 2 The work surface may be constructed of any of the following: minimum 3 in. for asphalt; minimum 4 in. for concrete; or minimum 8 in. for macadam, and designed for anticipated equipment loads. Refer to industry standard design criteria for each work surface material. The purpose of the work surface is to protect the liner material.

Note 3 Facilities without a work surface must be operated to minimize rutting and removal of the soil liner. Ruts must be repaired and the soil liner thickness maintained after material handling. Stacking height is not to exceed 10 feet.

Note 4 Additional separation distances to wells may be necessary on WDNR regulated farms.

CONSIDERATIONS

Additional recommendations relating to design which may enhance the use of, or avoid problems with, this practice, but are not required to ensure its basic conservation function are as follows:

Consider using the companion documents located in Chapter 10 of the NRCS, Agriculture Waste Management Field Handbook (AWMFH).

Consider using the Waste Storage Design spreadsheet located in Chapter 10 of the NRCS AWMFH for design storage volume, liner thicknesses, and other calculations described in this standard.

This standard does not preclude the addition of other off farm organic materials not specifically prohibited by standard, pending approval by the appropriate regulatory authority. During planning, consider discussing the potential for off farm organic material storage with the landowner. Encourage the landowner to investigate the impact of accepting off farm organic material to waste consistency, toxic gas generation, nutrient management, and remaining volume prior to accepting any off farm waste. Incorporate any additional operation or maintenance requirements resulting from these discussions.

Consider implementing erosion control methods on the top half of the inside slopes of earthen impoundments.

Consider adding agitation locations on different sides of the storage facility, or different cardinal directions, allowing the location of agitation to be adjusted if wind direction changes.

Consider adding curbs, structural or visual components to all agitation and pumping locations, which may reduce the risk of accidental entry and damage to the liner during agitation.

When designing impoundment embankments, consider using flatter slopes on the outside embankment slope for better operation access and easier maintenance.

Consider adding an auxiliary spillway, additional embankment height, or both as needed to help protect the embankment, particularly for systems that store large volumes of runoff. Factors such as downstream hazards and receiving waters should be evaluated in this consideration.

Consider adding or including steel reinforcement in slabs that will be scraped; this may prevent vertical displacement at crack locations.

Consider placing a permanent marker to designate the empty level. This consideration is particularly important for operations considering future herd expansion to WPDES permit size (see Figure 1).

Monitoring and leakage collection systems should be considered for larger waste storage facilities, especially where the site assessment indicates the area is sensitive for groundwater impacts. This is particularly important for operations considering future expansion to WPDES permit size. Components of a designed system may include secondary containment (soil or synthetic), leachate collection, leachate recirculation, monitoring sumps, and/or monitoring wells. See Wisconsin Administrative Code, Chapter NR 141 (NR 141) for regulations concerning monitoring wells.

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 facility.

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.

Consider using well construction logs within ½ mile of the proposed facility, available from the Wisconsin Geologic and Natural History Survey and/or the Wisconsin Department of Natural Resources, which promote understanding of water supply aquifers in the area along with area hydrogeology.

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 WI NRCS 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. Additionally, consider adding the following components: siting of livestock housing or feedlots, manure storage, and land application; biofilters; feed ration additives and adjustments; manure additives, disinfectants, or aeration; incorporation of manure when land-applied; moisture and dust control within livestock housing areas; and dead animal disposal plans.

For additional information on odor abatement, see ASABE EP379.54 April 2012, Management of Manure Odors.

Adjusting pH below 7 may reduce ammonia emissions from the waste storage facility but may increase odor when waste is surface applied, see WI 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. This should include:

- Plan view of system layout.
- Minimum of two cross sections, perpendicular to each other, for each waste storage facility.
- Structural details of all components, including reinforcing steel, type of materials, thickness, anchorage requirements, and lift thickness, sufficient to clearly show the construction requirements
- Locations, sizes, and type of pipelines and appurtenances including a profile of the waste transfer system.
- Requirements for foundation and preparation and treatment, including bedrock treatment.
- Surface Drainage/Grading plan.
- Subsurface drainage details.
- Location of soil test pits within 100 feet of the facility footprint on the plan view, and a summary of soil logs plotted on the cross sections or profile, with subsurface saturation and bedrock elevations marked, if encountered.
- Safety features, roof covers, fencing, ladders, and safety signs.
- Construction site erosion control practices.
- Specifications for materials and installation.
- Vegetative requirements.
- Quantity of materials.
- Approximate location of utilities and notification requirements.
- Other site-specific information necessary to construct the waste storage facility.
- Applicable Wisconsin Construction Specifications.
- Signature of the person responsible for the design, their engineering stamp, NRCS Job Approval or WDATCP Agricultural Engineering Practitioner Certification level, the date, and a statement attesting the plans meet the requirements of this standard and appropriate liner standard(s).

The following information should be included only if applicable to the project:

- Details for joining different liner types or new liners to existing liners.
- Waterstop joint layout for slabs and walls.
- References to components supplied by others (pumps, etc.).
- Identification of borrow source location(s).
- Reclamation plans for borrow area.

Engineering Design Documentation. Prepare engineering design documentation in compliance with the Design Deliverables in the WI NRCS Statement of Work for the WI NRCS CPS Waste Storage Facility

(Code 313), and demonstrate that the criteria in the NRCS practice standard have been met. Include all substantiating data, assumptions, computations and analyses in design documentation. The design documentation shall include:

- Management assessment,
- Site assessment,
- Operation and maintenance plan,
- Construction plan,
- Construction Quality Assurance Plan,
- Engineering computations, such as runoff, structural (unless using NRCS Standard Drawings), earthwork quantities, and volumetric computations for sizing of waste storage facility.

Construction Quality Assurance Plan

A construction quality assurance plan is required that describes the type and frequency of testing, items requiring observation, and the documentation required. The plan shall be approved by a person with NRCS Job Approval, WDATCP Agricultural Engineering Practitioner Certification, a Wisconsin registered professional engineer, or staff under the direction and control of the person holding the aforementioned credentials. The construction quality assurance plan shall address all the following items:

- Contact information and responsibilities of key parties (including owner, designer, construction observer, and contractor).
- Pre-construction meeting agenda items (including quality assurance plan, construction plans and specifications, design change procedures, and critical project-specific items).
- Observation and construction verification (including items to be verified, sequencing, layout/staking, notification requirements, and on-site materials testing documentation).
- Items to be noted on as-built plans, job diary, and other certification (attesting) documentation.

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 contain where appropriate:

Include a narrative describing the purpose of the system or structure and how it is intended to operate. This narrative should include design criteria such as number and type of animals, type of waste, type of bedding, days of storage, method for emptying, vehicle sizes intended to operate within or near the system and other pertinent operational information. Include the operational requirements for emptying the storage facility, including the expected storage period. 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 and WI NRCS CPS Nutrient Management (Code 590).

Manage the stored waste such that it remains below the maximum operating level during normal operating conditions. Include a contingency plan, which shall be implemented when the maximum operating level is reached. The contingency plan shall include how to handle unexpected volumes of wastewater and/or runoff that could cause the system to overflow or negatively impact the liner before scheduled emptying can occur. The contingency plan shall provide for the safe disposition of waste. Include requirements for location and methods of waste removal and emergency disposal.

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 requirements for monitoring the waste level relative to the permanent maximum operating level markers or indicators.

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 facility to fill to capacity prematurely.

If an observation and pumping port is installed, develop a monitoring protocol to detect discharge and pollutant content. If pollutants are identified, block any gravity outlet and utilize a pump to remove the polluted liquids until the source is identified and repairs can be completed. Pump pollutants to an appropriate location (e.g. pumped back to the structure or spread per a nutrient management plan).

Describe safety issues and procedures/requirements connected with waste storage facilities, including confined spaces. Include additional measures needed to address the fatal or serious inhalation hazards of gases including, but not limited to, hydrogen sulfide (H2S), carbon dioxide (CO2), methane (CH4), and ammonia (NH3), which may or may not exist where manure gases are generated through the handling of liquid or semi-solid manure through activities such as pumping, mixing, agitating, spreading, or cleaning-out. Agitating open-air manure storage facilities can be especially hazardous when high humidity and low winds may cause hydrogen sulfide gas to reside near the storage.

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 requirement to contact the appropriate regulatory authority for approval prior to storing any off-farm waste material in a waste storage facility that has been constructed using the criteria in this standard.

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 and requirements for inspecting and maintaining the structural components and mechanical systems.

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.

REFERENCES

American Society for Testing and Materials. Annual Book of ASTM Standards. Standards D 653, D 698, D 1140, D 1760, D 2487, D 2488, D5084. ASTM, Philadelphia, PA.

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

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

Wisconsin Administrative Code, Department of Natural Resources, Chapters NR 141, NR 213, NR 243 and NR 811.

DEFINITIONS

Animal Production Area – Means any part of the livestock operation that is used for the feeding and housing of livestock. This includes the entire animal confinement and feeding area, and any adjacent manure storage areas, raw materials storage areas, and waste containment areas. This does not include pasture and cropland.

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.

Note: Although solid or consolidated bedrock can sometimes be removed with typical excavation equipment, these materials are included in the above definition.

Clean Water – Water that has not been mixed with manure, wastewater or other contaminants

Conduits to Groundwater – Sinkholes, swallets, fractured bedrock at the surface, mine shafts, non-metallic mines, tile inlets discharging to groundwater, quarries, or depressional groundwater recharge areas over shallow fractured bedrock. Wells were intentionally left out of this NR 151 list.

Confined Space – Confined Space is a space that 1) contains or has the potential to contain a hazardous atmosphere; 2) is large enough and so configured that a person can bodily enter; 3) has limited or restricted means for entry or exit; and 4) is not designed for continuous human occupancy.

Contaminated Runoff – Runoff that has come through or across a barnyard or animal lot or feed storage area. It generally includes the runoff and any manure, sediment, feed, or other material carried in the runoff. It contains lower concentrations of contaminants than leachate from feed or manure.

Control Joints – Control joints, often called contraction 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.

Cultural Resources – Cultural resources are the traces of any past activities and accomplishments of people. They include tangible traces such as historic districts, sites, buildings, structures, historical

documents and cemeteries. They also include traces of less tangible objects such as dance forms, aspects of folk-life, cultural or religious practices, and some landscapes and vistas.

Drainage System – Water conveyance measures of specified capacity, location, and material that insure the removal of water to a free outlet.

Effective Height – 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 at existing ground surface.

Flood Prone Areas – These include areas delineated as floodplains on Federal Emergency Management Agency (FEMA) maps, or local floodplain maps as well as areas along perennial streams (blue lines) shown on the United States Geologic Survey quadrangle sheets that may be subject to out of bank flows.

Footprint – This is the horizontal area within the perimeter of a facility liner, or the perimeter of a work surface that may cover a liner. For a liquid or solids containment facility, the footprint is the maximum horizontal extent of containment. For a liquid impoundment facility or pond, the footprint is normally defined by the inside top of the embankment. For a solids storage facility, the footprint is normally defined by the edge of the pad, the curb on a pad, or the inside surface of bunker walls.

Gleyed Soil – A soil condition resulting from prolonged soil saturation, which is manifested by the presence of grayish, bluish or greenish colors through the soil matrix. Gleying occurs under reducing conditions, by which iron is reduced predominantly to the ferrous state.

Impoundment – A waste storage facility constructed of an earthen embankment(s) (which is lined) and/ or excavations for the purpose of storing waste. The impoundment, below the existing ground, may be lined or unlined if meeting CPS 313, Table 1 Soils (In Place).

Impoundment depth – Depth is the distance from the bottom of the impoundment up to the maximum operating level (M.O.L.).

In-Place Earth – A waste storage facility impoundment where the entire bottom surface is sited where in-situ soils have sufficiently low hydraulic conductivity to provide waste storage without a constructed liner. The bottom is excavated a minimum depth of one foot into the in-situ soils as measured from the planned floor elevation.

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.

Leachate – Concentrated liquid waste which has percolated through or drained by gravity from a pile of manure, manure processing derivative, or animal feed. It contains much higher concentrations of contaminants than Contaminated Runoff.

Liquid Waste Storage Impoundment – A facility where the stored material does not consistently stack and is either a manmade excavation, or diked area formed primarily of earthen materials, such as soil (although the unit may be lined with earthen or manmade materials) .

Manure Processing Derivatives – The by-products and waste components that are produced as a result of treatment and processing practices. These include, but are not limited to, the following waste

components: separated sand, separated manure solids, precipitated manure sludges, supernatants, digested liquids, composted biosolids, process waters.

Nutrient Management Plans – A planning document that outlines the requirements for managing the amount, form, placement, and timing of applications of plant nutrients to cropland.

Perched Conditions – A soil moisture condition consisting of limited area including 1) saturated soil 2) depleted, gleyed or reduced matrices or, 3) reduced redoximorphic features, located above or part of a barrier to downward flow. Directly below the barrier to downward flow and above the normal free water elevation a soil moisture condition exists in a soil layer(s) which does not display 1) saturation; 2) depleted, gleyed or reduced matrices; or 3) reduced redoximorphic features.

Percent Fines (% Fines) – Percentage of given sample of soil which passes through a #200 sieve.

Permeability – The coefficient of permeability (K) is a measure of the ability of soil to transmit liquids. It is used to compute the flow rate of liquid through a soil liner for specific conditions of soil thickness and fluid head (e.g., 1x10-7 cm/s).

Plasticity Index (PI) – A soil property indicating moldability. Measured by ASTM D4318.

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.

Sub-Soil – The soil directly below the bottom of the liner. This must be in-situ material.

Wastewater – Milking center waste, flush water, leachate from feed holding areas, and similar waste materials generated at the animal production area.

Figure 1

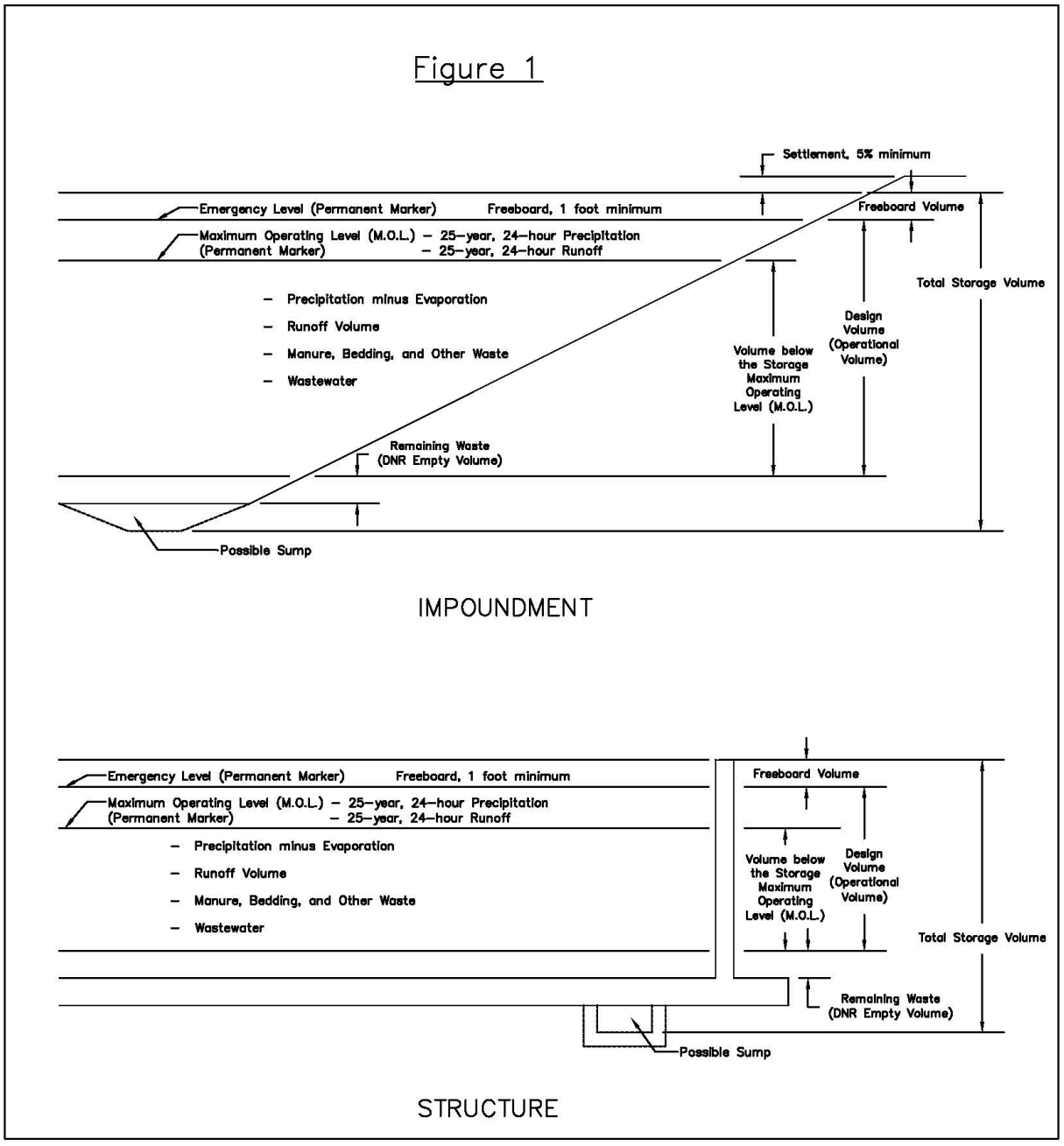
Figure 1
Settlement, 5% minimum
Emergency Level (Permanent Marker)
Freeboard, 1 foot minimum
Freeboard Volume
Maximum Operating Level (M.O.L.) – 25–year, 24–hour Precipitation
(Permanent Marker) – 25–year, 24–hour Runoff
Total Storage Volume
– Precipitation minus Evaporation
– Runoff Volume
– Manure, Bedding, and Other Waste
– Wastewater
Design Volume (Operational Volume)
Volume below the Storage Maximum Operating Level (M.O.L.)
Remaining Waste (DNR Empty Volume)
Possible Sump
IMPOUNDMENT
Emergency Level (Permanent Marker)
Freeboard, 1 foot minimum
Freeboard Volume
Maximum Operating Level (M.O.L.) – 25–year, 24–hour Precipitation
(Permanent Marker) – 25–year, 24–hour Runoff
– Precipitation minus Evaporation
– Runoff Volume
– Manure, Bedding, and Other Waste
– Wastewater
Volume below the Storage Maximum Operating Level (M.O.L.)
Design Volume (Operational Volume)
Total Storage Volume
Remaining Waste (DNR Empty Volume)
Possible Sump
STRUCTURE

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

POND SEALING OR LINING, CONCRETE

CODE 522

(sf)

DEFINITION

A liner for an impoundment constructed using reinforced or nonreinforced 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 Purposes

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	WI Spec 300	WI Spec 204
Sub-Liner Soils (Soil Directly Below 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 Note 1				
Sink hole or other Karst Features	250	250	250	250
Well	100	100	100	100
Subsurface Saturation	2	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. As a minimum, 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.*

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

SUBSURFACE DRAIN

CODE 606

(ft)

DEFINITION

A conduit, or system of conduits, installed beneath the ground surface to manage soil water conditions.

PURPOSE

Use this practice to accomplish one or more of the following purposes:

- Remove or distribute soil water
- Remove salts and other contaminants from the soil profile
- Mitigate degraded plant health and vigor and undesirable plant productivity due to saturated soil, ponding, and flooding
- Mitigate degraded animal health productivity due to saturated soil, ponding, and flooding

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to all land uses where a shallow water table exists or where a subsurface drainage system can mitigate one or more of the following adverse conditions caused by excessive soil moisture:

- Poor health, vigor, and productivity of plants
- Poor field trafficability
- Accumulation of salts in the root zone
- Health risk and livestock stress due to pests
- Adverse soil conditions around farmsteads, structures, and roadways

This practice also applies to water distribution through subsurface drain pipe for utilization or treatment.

CRITERIA

General Criteria Applicable to All Purposes

Plan, design, and construct this practice to comply with all applicable Federal, State, Tribal, and local laws and regulations. The landowner must obtain all necessary permissions from regulatory agencies or document that no permits are required. The landowner or contractor is responsible for locating all buried utilities in the project area, including drainage tile and other structural measures.

If wetlands are present, complete an appropriate wetland determination per established procedures. Avoid adverse effects of the drainage system on the ecology and hydrology of the site and on adjacent lands, especially potential or delineated wetlands, existing easements, and wildlife habitat.

Capacity

Base design capacity on the following, as applicable:

- *The minimum drainage coefficients for the acreage drained are shown in Tables 1 and 2. For additional background, refer to the National Engineering Handbook (NEH), Part 650, Chapter 14, Water Management (Drainage), Subchapter C−Subsurface Drainage, 650.1423 Field drainage system design, Items (a) through (h).*
- The yield of ground water based on the expected deep percolation of irrigation water from the overlying fields, including leaching requirement.
- Comparison of the site to other similar sites with known subsurface drain yields
- Measurement of the rate of subsurface flow at the site during a period of adverse weather and ground water conditions
- Application of Darcy's law to lateral or artesian subsurface flow. *Use Darcy's law to estimate flow rate for interceptor drains which lowers soil saturation below the waste storage pond bottom. Refer to NEH, Part 624, Chapter 10, Water Control Table.*
- Contributions from surface inlets based on hydrologic analysis or flow measurements
- Drain inlet opening size versus drain intake rate

Table 1 Drainage Coefficient (No Open Inlets)

Soil	*Field Crops (inches)*	*Truck Crops (inches)*
Mineral	*3/8 - 1/2*	*1/2 - 3/4*
Organic	*1/2 - 3/4*	*3/4 - 1 1/2*

The condition in Table 1 assumes that surface drainage is adequate. The selected drainage coefficient applies to the entire area being drained.

Table 2 Drainage Coefficient (Surface Inlets in Subsurface Drains)

Soil	*Field Crops (Inches)*		*Truck Crops (Inches)*	
	Blind Inlet	*Open Inlet*	*Blind Inlet*	*Open Inlet*
Mineral	*1/2 - 3/4*	*1/2 - 1*	*3/4 - 1*	*1 - 1 1/2*
Organic	*1/2 - 1*	*1/2 - 1 1/2*	*3/4 - 2*	*2 - 4*

Note: A 1/2-inch coefficient may be used if the organic soil occurs only as a small pocket in the vicinity of the inlet.

The selected drainage coefficient from Table 2 will apply to the entire watershed contributing runoff to the surface inlet, except where only a small amount of runoff will be impounded at the location of the inlet with the remainder flowing away in a confined channel. For the latter case, the drain (tile) shall be large enough to remove the impounded water in 24 hours, plus providing additional capacity for the required internal drainage. Blind inlets should only be used in areas where surface drainage will handle most of the surface water.

Size

Compute the drain size by applying Manning's formula, using roughness coefficients recommended by the manufacturer of the conduit or coefficients adopted by the regulating authority. Base the size on the maximum design flow rate and compute using one of the following:

- The hydraulic grade line parallel to the bottom grade of the subsurface drain with the conduit flowing full at design flow (normal condition, no internal pressure)
- Conduit flowing partly full where a steep grade or other conditions require excess capacity
- Conduit flowing under internal pressure with hydraulic grade line set by site conditions, which differs

from the bottom grade of the subsurface drain

All subsurface drains must have a nominal diameter that equals or exceeds 3 inches.

Internal hydraulic pressure
Drains are normally designed to flow with no internal pressure, and the flow is normally classified as open channel. Maintain the design internal pressure of drains at or below the limits recommended by the manufacturer of the conduit.

Horizontal alignment
Accomplish a change in horizontal direction of the subsurface drain by one of the following methods:

- The use of manufactured fittings
- The use of junction boxes or manholes
- A gradual curve of the drain trench on a radius in accordance with the limitations of the installation equipment and the recommendations of the pipe manufacturer while maintaining grade

Location, depth, and spacing
Base the location, depth, and spacing of the subsurface drain on site conditions including soils, plants, topography, ground water conditions, crops, land use, outlets, saline or sodic conditions, and proximity to wetlands.

The minimum depth of cover over subsurface drains may exclude sections of conduit near the outlet or through minor depressions, providing these sections of conduit are not subject to damage by frost action or equipment travel.

In mineral soils, provide a minimum depth of cover over subsurface drains of 2 feet.

In organic soils, provide a minimum depth of cover after initial subsidence of 3 feet. If water control structures are installed and managed to limit oxidation and subsidence of the soil, the minimum depth of cover may be reduced to 2.5 feet.

For flexible conduits, base maximum burial depth on the manufacturer's recommendations for the site conditions or on a site-specific engineering design consistent with methods in NRCS National Engineering Handbook (NEH) (Title 210), Part 636, Chapter 52, "Structural Design of Flexible Conduits."

For computation of maximum allowable loads on subsurface drains of all materials, use the trench and bedding conditions specified and the compressive strength of the conduit. Base the design load on the conduit from a combination of embedment, backfill, and live loads.

Base live loads on the maximum equipment or vehicle wheel loads. Equipment loads on the conduit may be neglected when the depth of cover exceeds 6 feet.

Refer to NEH, Part 650, Chapter 14, Water Management (Drainage), Table 14-6 for determining maximum trench depths for corrugated plastic tubing buried in loose, fine- textured soils. Specials designs using bedding, or reinforced concrete pipe, or other pipe of similar strength shall be used where drainage tile or tubing will not provide adequate strength.

Minimum velocity and grade
In areas where sedimentation of fine sands and silts is not a hazard, design the minimum grade based on site conditions and velocity of not less than 0.5 feet per second. If a sedimentation potential exists, use a velocity of not less than 1.4 feet per second to establish the minimum grade. Otherwise, include provisions for preventing sedimentation by use of filters or by collecting and periodically removing sediment from installed traps, or by periodically cleaning the lines with high-pressure jetting systems or cleaning solutions. Prior to using high-pressure jetting systems, verify that the jetting system will not damage the pipe or the pipe embedment.

Maximum velocity
Limit the maximum velocity in a perforated corrugated plastic drainage pipe under open channel flow to 12 feet per second unless further restricted by the manufacturer's recommendation.

Limit the maximum design velocities in open-joint pipe (clay or concrete) to those given in table 3 if protective measures are not installed. Refer to NRCS 210-NEH, Section 16, Chapter 4, "Subsurface Drainage."

Table 3. Maximum Flow Velocities by Soil Texture

Soil Texture	Velocity (ft/s)
Sand and sandy loam	3.5
Silt and silt loam	5.0
Silty clay loam	6.0
Clay and clay loam	7.0
Coarse sand or gravel	9.0

Protective measures for high velocities in open-joint pipe may include the following, as appropriate:

- Bed the conduit in a sand and gravel envelope that is filter-compatible with the joint openings and surrounding soil
- Wrap the joints with nonwoven geotextile

Releases from water control structures must not cause flow velocities in perforated or open-joint drains to exceed allowable velocities in table 3, unless protective measures are installed.

Thrust control
Follow pipe manufacturer's recommendations for thrust control or anchoring where the following conditions exist:

- Axial forces that tend to move the pipe down steep slopes
- Thrust forces from abrupt changes in pipeline grade or horizontal alignment that exceed soil-bearing strength
- Reductions in pipe size

In the absence of manufacturer's data, design thrust blocks in accordance with NRCS 210-NEH-636-52.

Outlets
Provide drainage outlets adequate for the quantity and quality of water to be discharged.

Avoid submerged outlets unless intermittent submerged outlets are designed for protection from root clogging. For discharge to streams or channels, locate the outlet invert above the elevation of normal flow and at least 1 foot above the channel bottom.

For outlets into sumps, locate the discharge elevation above the elevation at which pumping is initiated.

Protect outlets against erosion and undermining of the conduit, entry of tree roots, damaging periods of submergence, and entry of rodents or other animals into the subsurface drain.

Use a continuous section of rigid pipe, without open joints or perforations and with stiffness necessary to withstand expected loads at the outlet end of the drain line. Table 4 shows minimum lengths for the outlet section of the conduit. Unsupported single-wall corrugated plastic pipe is not suitable for the section that outlets into a ditch or channel.

Table 4. Minimum Length of Outlet Pipe Sections

Pipe Diameter (in)	Minimum Section Length (ft)
8 and smaller	10
10 to 12	12
15 to 18	16
Larger than 18	20

The use and installation of outlet pipe must conform to the following requirements:

- If burning vegetation on the outlet ditch bank is likely to create a fire hazard, select fireproof material for the pipe
- Bury at least two-thirds of the rigid outlet pipe section in the ditch bank and project the cantilever section past the toe of the ditch side slope; or protect the side slope from erosion below the outlet pipe
- If ice or floating debris may damage the outlet pipe, protect the pipe by recessing the cantilevered part of the pipe to protect it from the current of flow in the ditch or channel
- Headwalls used for subsurface drain outlets must be adequate in strength and design to avoid washouts and other failures

Protection from biological and mineral clogging
Drains in certain soils are subject to clogging of perforations by bacterial action in association with ferrous iron, manganese, or sulfides. Iron ochre can clog drain openings and seal manufactured (fabric) filters. Manganese deposits and sulfides can clog drain openings.

Where bacterial activity is expected to lead to clogging of drains, provide access points for cleaning the drain lines.

Where possible, outlet individual drains to an open ditch to isolate localized areas of contamination and to limit the translocation of contamination throughout the system.

Protection from root clogging
Problems may occur where drains are near perennial vegetation. Drain clogging may result from root penetration by water-loving trees, such as willow, cottonwood, elm, and soft maple, and some shrubs, grasses, and deep-rooted perennial crops growing near subsurface drains. Refer to the USDA PLANTS Database website as a preliminary planning tool for obtaining vegetation properties and qualities information.

Use one or more of the following steps to reduce the incidence of root intrusion:

- Install a continuous section of nonperforated pipe or tubing with sealed joints through the root zone
- Remove water-loving trees for a distance of at least 100 feet on each side of the drain and locate drains a distance of 50 feet or more from noncrop tree species
- Provide for intermittent submergence of the drain to limit rooting depth by installing a structure for water control that allows for raising the elevation of the drain outlet (e.g., an inline weir with adjustable crest)

Utilize the intermittent submergence option only when the raised elevation of the drain outlet will not adversely impact the performance of the land use supported by the subsurface drain, and where the raised elevation will not adversely impact flooding on neighboring properties.

Water quality
Do not connect septic systems to the subsurface drainage system, nor allow animal waste to be directly introduced into the subsurface drainage system.

Materials
Subsurface drains include flexible conduits of plastic, bituminized fiber, or metal; rigid conduits of vitrified clay or concrete; or other materials of acceptable quality.

The conduit must meet strength and durability requirements for the site. All conduits must meet or exceed the minimum requirements of the appropriate and current specifications published by the American Society for Testing and Materials (ASTM), American Association of State Highway Transportation Officials (AASHTO), or the American Water Works Association (AWWA); *and the minimum requirements in NRCS Wisconsin Construction Specification 44, Corrugated Polyethylene Tubing.*

Conduit foundation
If soft or yielding foundation conditions are encountered, stabilize the conduit foundation and protect the area from settlement. The following methods are acceptable foundation treatments:

- Remove the unstable material and provide stable bedding of granular envelope or filter material.
- Provide continuous cradle support for the conduit through the unstable section.
- Bridge unstable areas using long sections of a conduit having adequate strength and stiffness to ensure satisfactory subsurface drain performance.
- Place conduit on a flat, treated plank. This method must not be used for flexible conduits (e.g., plastic pipe) without proper bedding between the plank and conduit.
- Use bedding to avoid laying the pipe on rock, rocky soil, or extremely hard soil.

Conduit Placement and bedding
Placement and bedding requirements apply to both trenching and plow-type installations.

Place the conduit on a firm foundation to ensure proper alignment.

The conduits must not be placed on exposed rock, stones greater than 1.5 inches for conduits 6 inches or larger in diameter, or stones greater than three-fourths of an inch for conduits less than 6 inches in diameter. Where site conditions do not meet this requirement, the trench must be over-excavated a minimum of 6 inches and refilled to grade with suitable bedding material. For trench installations where a sand-gravel envelope or compacted bedding is not specified, the conduit embedment must be suitable backfill. Soil excavated from the trench may be used for backfill as long as it contains no hard objects larger than the specified stone sizes above. Place initial backfill to a minimum of 3 inches above the conduit. Compact backfill to a density similar to the surrounding soil material. Mound the backfill over the trench to provide material for settling.

If installation will be below a water table or where unstable soils are present, special equipment, installation procedures, or bedding materials may be needed. These special requirements may also be necessary to prevent soil movement into the drain or plugging of the envelope if installation will be made in materials such as soil slurries.

For the installation of corrugated plastic pipe with diameter of 8 inches or less, specify one of the following bedding methods:

- Provide a shaped groove with an angle of support of 90 degrees or greater in the bottom of the trench for tubing support and alignment
- Provide a sand-gravel envelope, at least 3 inches thick, for support
- Provide compacted embedment material beside and to 3 inches above the conduit

For the installation of corrugated plastic pipe with diameter larger than 8 inches, the same bedding requirements apply except that a semicircular or trapezoidal groove shaped to fit the conduit with a support angle of 120 degrees will be used rather than a V-shaped groove.

For rigid conduits installed in a trench, the same requirements apply except that a groove or notch is not required.

Filter envelopes and materials
Design filters around conduits, as needed, to enhance water entry and stabilize the structure of the surrounding soil material. Determine the need for a filter by the characteristics of the surrounding soil material, site conditions, and the velocity of flow in the conduit. Use a suitable filter if any of the following conditions exist:

- Local experience with soil site conditions indicates a need
- Soil materials surrounding the conduit are dispersed clays, silts with a plasticity index less than 7, or fine sands with a plasticity index less than 7
- The soil is subject to cracking by desiccation
- The method of installation may result in inadequate consolidation between the conduit and backfill material

Design the sand or sand-gravel filter gradation in accordance with NRCS 210-NEH, Part 633, Chapter 26, “Gradation Design of Sand and Gravel Filters.”

Specified filter material must completely encase the conduit such that all openings are covered with at least 3 inches of filter material, except where the top of the conduit and side filter material will be covered by a sheet of plastic or similar impervious material to reduce the quantity of filter material required. In all cases, the resulting flow path through the filter material must be a minimum of 3 inches in length.

Use geotextile filter materials with the effective opening size, strength, durability, and permeability to prevent soil movement into the drain throughout the expected life of the system. Where the silt content in the soil exceeds 40 percent, ensure the geotextile filter material will not clog during its design life.

Waste Storage Ponds: Install clean, granular filter material, compatible with the trench soil and conduit perforations, from the conduit to the elevation of existing soil saturation to ensure effective drawdown. Use a geosynthetic (polyester) filter sock over the conduit to facilitate a broader filter gradation. Filter material also can act as bedding for lateral structural support of the conduit for deep installations.

Hydraulic envelopes and materials
Use an envelope around subsurface drains, as needed, to improve flow conditions in the area immediately adjacent to the drain.

Materials used for envelopes must not contain materials that will cause an accumulation of sediment in the conduit or render the envelope unsuitable for bedding of the conduit.

Envelope materials must consist of sand-gravel, organic, or similar material. Use an envelope gradation such that 100 percent of sand-gravel passes a 1.5-inch sieve, not more than 30 percent passes a number 60 sieve, and not more than 5 percent passes a number 200 sieve.

Organic or other compressible envelope materials must not be used below the centerline of flexible conduits. If organic or other compressible materials are used they must be of a type that will not readily decompose within the expected lifespan of the practice.

Refer to NRCS 210-NEH, Part 650, Chapter 14, “Water Management (Drainage),” for more complete definitions of envelopes (e.g., hydraulic envelope, filter envelope, and bedding).

Auxiliary structures and protection
The capacity of any structure installed in the drain line must be no less than that of the line or lines feeding into or through the structure.

Structures for water table management, with provisions to elevate the outlet and allow submergence of the upstream drain, must meet applicable design criteria in NRCS Conservation Practice Standard (CPS) Structure for Water Control (Code 587). Mark buried boxes with surface evidence or referenced to fixed aboveground markings or structures.

Underground outlets connected to the subsurface drainage system must meet the applicable provision of NRCS CPS Underground Outlet (Code 620). Design the capacity of the surface water inlet to be no greater than the maximum design flow in the downstream drain line or lines. *Covers or trash racks will be used to ensure that no foreign materials are allowed in the drain lines. Inlets must be protected from entry of animals or debris.* Install sediment traps if sediment might pose a problem.

Specify pressure relief wells as needed to allow excess flow to escape the conduit and flow over the ground surface. Use pressure relief wells where there is a stable outlet for the flow from the relief well. Cover the relief well with a grate or other appropriate means to prevent accidental entry of machines, animals, humans, and debris. Design the subsurface drain system to have a positive hydraulic grade to the relief well flow line. Base the relief well system capacity on the flow from the drainage system and other site conditions. Capacity must be adequate to lower the water head to the desired level. Relief wells must not be less than 4 inches in diameter.

Junction boxes, manholes, catch basins, and sediment traps must be accessible for maintenance. Provide a clear opening of not less than 2 feet in diameter or 2 feet by 2 feet square.

Surface inlets, vents, or relief wells shall be installed using manufactured intakes or an approved equivalent. Refert to NEH, Part 650, Chapter 14, Water Management (Drainage), Subchapter C−Subsurface Drainage, 650.1426 Appurtenances, Items (a) through (d).

Protect the drain system against turbulence created near outlets, surface inlets, or similar structures. Use continuous nonperforated or closed-joint pipe in drain lines adjoining the structure where excessive velocities will occur.

As an alternative to manufactured fittings, install a junction box where three or more lines join or if two lines join at different elevations. Use a solid cover if the junction box is buried. The junction box should have a minimum of 1.5 feet of soil cover. Protect buried boxes from traffic.

If not connected to a structure, close the upper end of each subsurface drain line with a tight-fitting cap or plug of the same material as the conduit, or other durable materials.

Use watertight conduits designed to withstand the expected loads where subsurface drains cross under irrigation canals, ditches, or other structures.

CONSIDERATIONS

When planning, designing, and installing this practice, consider—

- Protection of shallow drains, auxiliary structures, and outlets from damage due to freezing and thawing
- Proper surface drainage to reduce the required capacity of the subsurface drainage system
- Designs that can incorporate drainage water management practices (or facilitate future incorporation of drainage water management) to reduce nutrient loading of receiving waters, including downstream drinking water sources.
- Drainage laterals oriented along elevation contours to improve the effectiveness of drainage water management structures
- The effects of drainage systems on runoff volume, seepage, and the availability of soil water needed for plant growth
- Confirmation of soil survey information with site investigation, including augering and shallow excavations to identify soil profile hydraulic characteristics, soil texture layering, water table depth,

etc

- Maximizing wetland functions and values to the extent practicable
- Subsoiling or ripping of soils with contrasting texture layers to improve internal drainage. Where this treatment is needed use NRCS CPS Deep Tillage (Code 324)
- Installations in a dry soil profile to minimize problems of trench stability, conduit alignment, and soil movement into the drain
- The effects to surface water quality
- Using measures to reduce the risk of drain water contamination from surface applications of manure (e.g., temporary flow-blocking devices)
- Using NRCS CPSs Drainage Water Management (Code 554), Constructed Wetland (Code 656), Saturated Buffer (Code 604), or Denitrifying Bioreactor (Code 605) in conjunction with this standard where removal of nitrate nitrogen in subsurface drainage is needed
- Including a tailwater reuse system that conforms to NRCS CPS Irrigation and Drainage Tailwater Recovery (Code 447) in conjunction with this standard where excess soil water will be reused for irrigation
- The potential existence of a hazardous atmosphere in junction boxes or manholes

PLANS AND SPECIFICATIONS

Prepare plans and specifications for installing subsurface drains according to the applicable criteria that describe the requirements for implementing the practice to achieve its intended purpose.

At a minimum, plans and specifications must include, as applicable—

- Location and plan view of the drainage system
- Conduit lengths, grades, spacing, sizes, and type of materials
- Requirements and typical cross sections or details for the subsurface drain, filter, envelope, and bedding
- Structure locations, dimensions, and elevations
- Outlet locations, elevations, and protection required
- Location of utilities and notification requirements
- Construction specifications describing site-specific installation requirements of the subsurface drain

OPERATION AND MAINTENANCE

Provide an operation and maintenance (O&M) plan with specific instructions for operating and maintaining the system to ensure proper function as designed. At a minimum, the O&M plan must address—

- Necessary periodic inspection and prompt repair of system components (e.g., structures for water control, underground outlets, vents, drain outlets, trash, and rodent guards)
- Winterization protection from freezing conditions (if applicable) for drainage systems in cold climates
- Protection requirements during manure applications (if applicable)

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