Soils and Post-Construction Storm Water BMP Design

Leif Hauge, PE, P. Hydrologist
Sr. Civil Engineer
Waukesha County Land Resources Division

WDNR Design Standards

- 1001 Wet detention
- 1002 Site evaluation
- 1003 Infiltration
- 1004 Bioretention
- 1007 Infiltration trench
- 1008 Permeable pavement
- 1006 Proprietary sediment devices
- 1005 Vegetated swales
- S100 Compost

Wet Detention Pond
(1001)

Wisconsin Department of Natural Resources
Conservation Practice Standard

I. Definition

A permanent pool of water with designed dimensions, inlets, outlets and storage capacity, constructed to collect, detain, treat and release stormwater runoff.

II. Purposes

The primary purposes of this practice are to improve water quality and reduce peak flow.

III. Conditions Where Practice Applies

This practice applies to urban sites where stormwater runoff pollution due to particulate solids loading and attached pollutants is a concern. It also applies where increased runoff from urbanization or land use change is a concern. Site conditions must allow for runoff to be directed into the pond and a permanent pool of water to be maintained.

SLAMM, P8, DETPOND or equivalent methodology may also be used to evaluate the efficiency of the design in reducing TSS.

IV. Federal, State and Local Laws

The design, construction and maintenance of wet detention ponds shall comply with all federal, state and local laws, rules or regulations. The owner/operator is responsible for securing required permits. This standard does not contain the text of any federal, state or local laws governing wet detention ponds.

The location and use of wet detention ponds may be limited by regulations relating to stormwater management, navigable waters (Ch. 30, Wis. Stats.), floodplains, wetlands, buildings, wells and other structures, or by land uses such as waste disposal sites and airports. The pond embankment may be regulated as a dam under Ch. 31, Wis. Stats., and further restricted under NR 333, Wis. Adm. Code

Soil Testing Requirement

- Show soils, seasonally high groundwater level, and bedrock conditions to a minimum depth of 5 feet below the proposed bottom of the pond
- Minimum of two test pit or boring per pond.
- Characterize soils using both the USDA and USCS classification systems.

ii. The permanent pool surface area is sized based on the particle size and the peak outflow during the 1-yr., 24-hour design storm using Equation 1:

$$S_a = 1.2 * (q_o / v_s) \text{ [Equation 1(a)]}$$

or

$$q_o = (v_s * S_a) / 1.2 \text{ [Equation 1(b)]}$$

Where:

S_a = Permanent pool surface area measured at the invert of the lowest outlet of the wet detention pond (square feet)

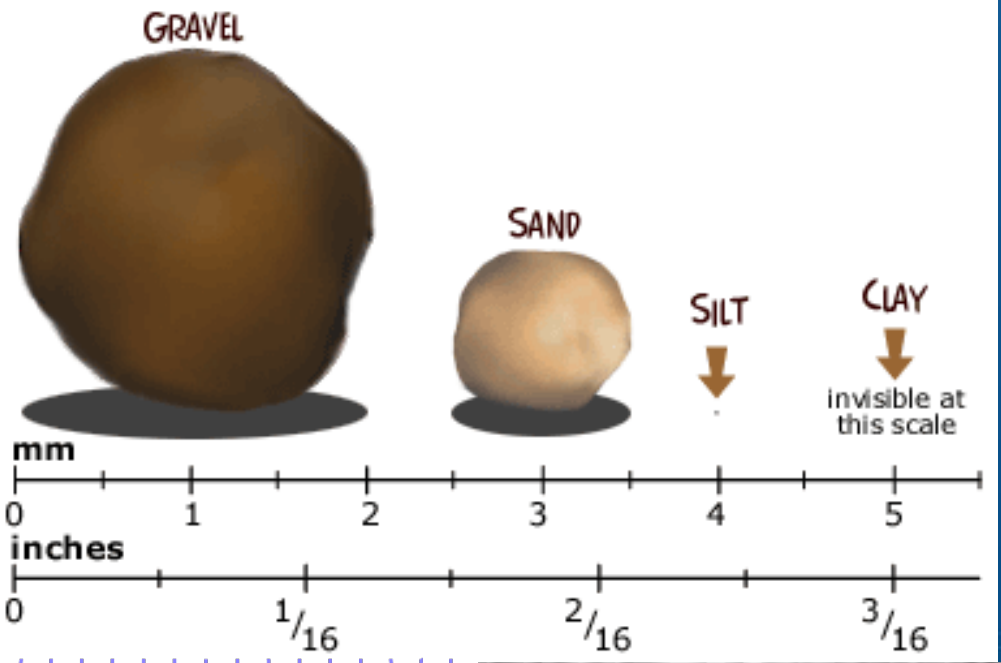
q_o = Post-construction peak outflow (cubic feet/second) during the 1-yr., 24-hour design storm for the principal outlet

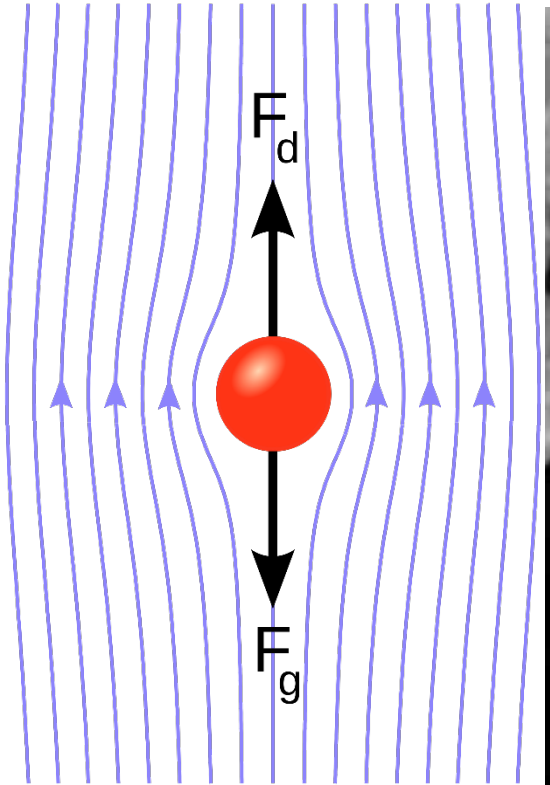
v_s = Particle settling velocity (feet/second)

1.2 = EPA recommended safety factor

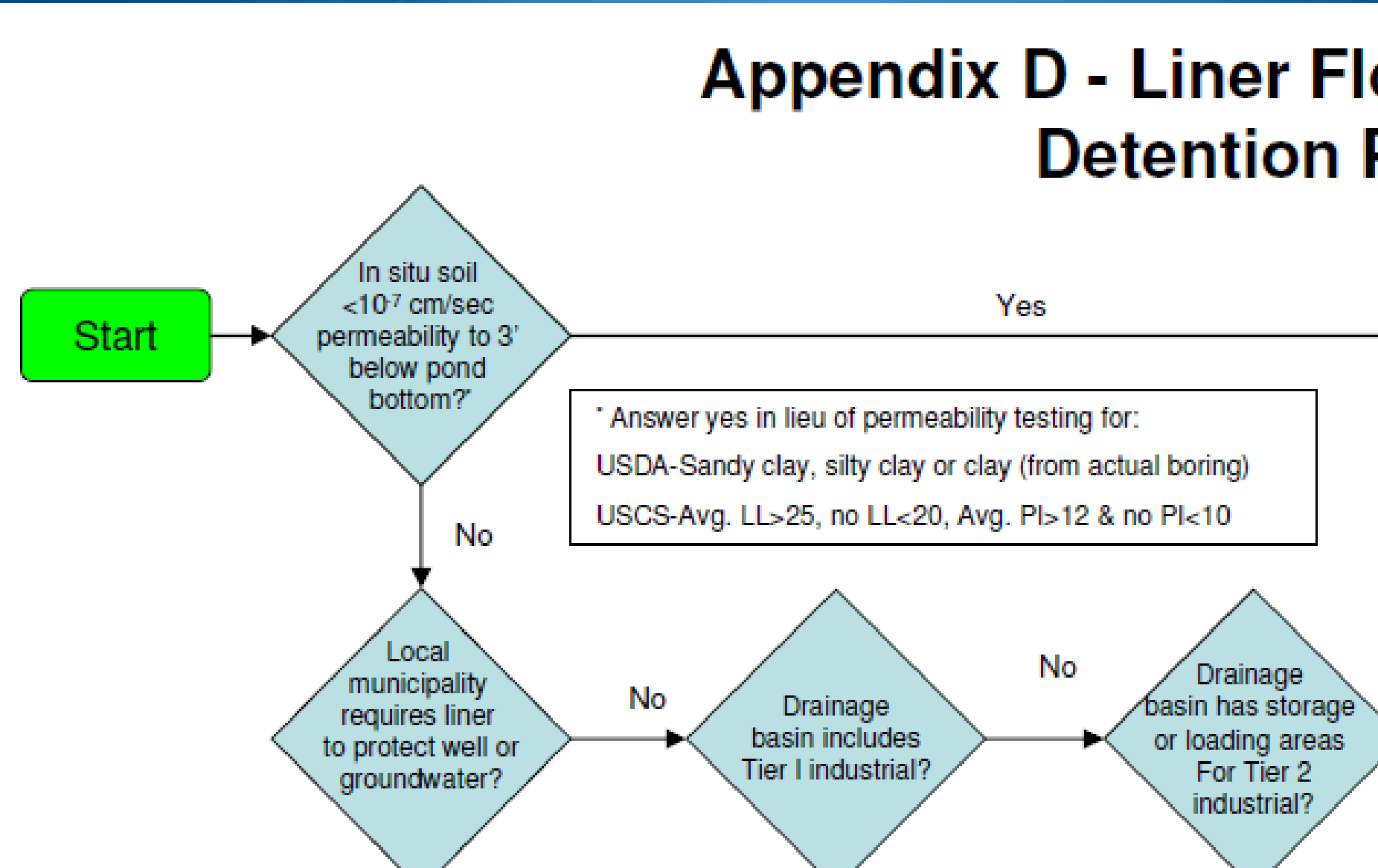
iii. Particle settling velocities (v_s) shall be based on representative particle sizes for the desired percent TSS reduction.

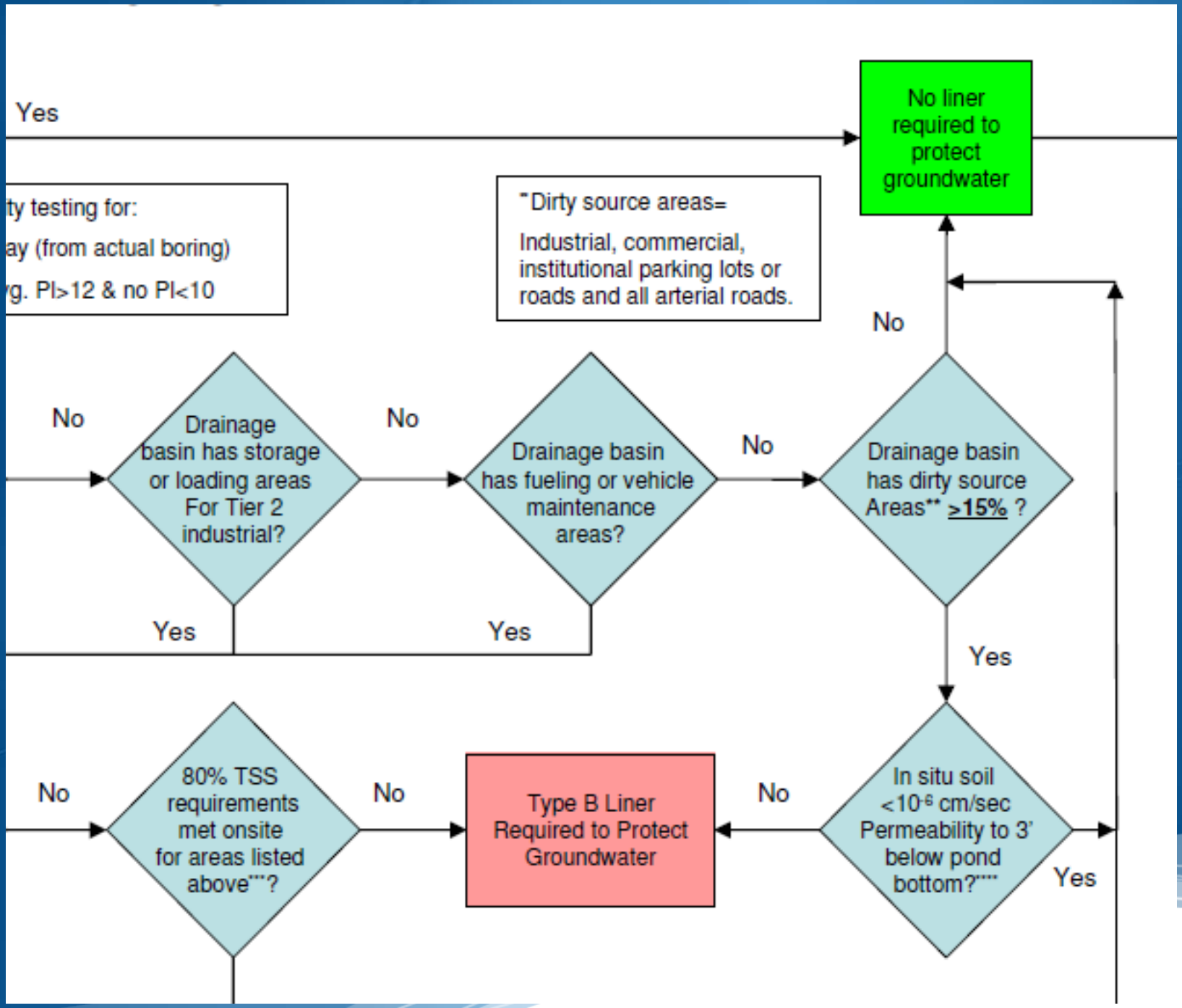
- 80% (3 micron):
  $v_s = 1.91 \times 10^{-5}$ ft./sec.
- 60% (6 micron):
  $v_s = 7.37 \times 10^{-5}$ ft./sec.
- 40% (12 micron):
  $v_s = 2.95 \times 10^{-4}$ ft./sec.

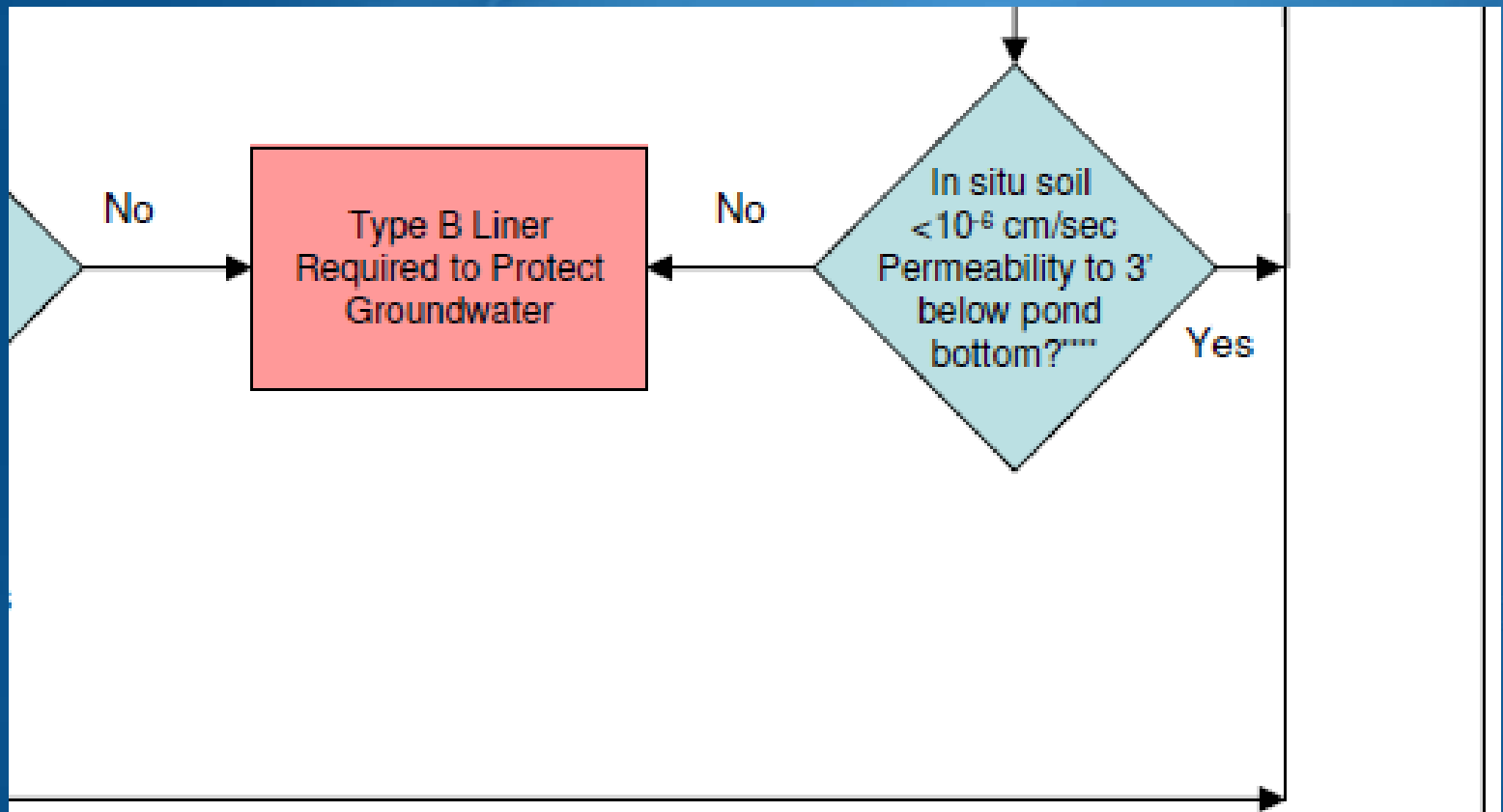




Is a liner required?




Yes
No liner required to protect groundwater
ty testing for:
ay (from actual boring)
g. PI>12 & no PI<10
"Dirty source areas=
Industrial, commercial, institutional parking lots or roads and all arterial roads.
No
No
Drainage basin has storage or loading areas For Tier 2 industrial?
No
Drainage basin has fueling or vehicle maintenance areas?
No
Drainage basin has dirty source Areas** >15% ?
Yes
Yes
Yes
No
80% TSS requirements met onsite for areas listed above***?
No
Type B Liner Required to Protect Groundwater
No
In situ soil <10-6 cm/sec Permeability to 3' below pond bottom?****
Yes



**** Answer yes in lieu of testing for:

USDA-Silt loam, sandy clay loam, clay loam, silty clay loam (from actual boring)

USCS-Avg. LL>16, no LL<14,Avg. PI>7 & no PI<5

See considerations for a Type C liner for safety, to prevent erosion or for aesthetics.

Site Evaluation for Stormwater Infiltration
(1002)

Wisconsin Department of Natural Resources
Conservation Practice Standards

I. Definition

This standard defines site evaluation procedures to:

1. Perform an initial screening of a *development site*[1] to determine its suitability for infiltration.
2. Evaluate each area within a development site that is selected for infiltration.
3. Prepare a site evaluation report.

II. Purpose

1. Establish methodologies to characterize the site and screen for exclusions and exemptions under Chapter NR 151 Wis. Adm. code.
2. Establish requirements for siting an *infiltration device* and the selection of design infiltration rates.
3. Define requirements for a site evaluation report that insures appropriate areas are selected for infiltration and an appropriate *design infiltration*

V. Criteria

The site evaluation consists of four steps for locating the optimal areas for infiltration, and properly sizing infiltration devices.

- Step A. Initial Screening.
- Step B. Field Verification of information collected in Step A.
- Step C. Evaluation of Specific *Infiltration Areas*.
- Step D. Soil and Site Evaluation Reporting.

The steps shall coincide, as much as possible, for when the information is needed to determine the following: 1) the potential for infiltration on the site, 2) the optimal locations for infiltration devices, and 3) the design of the infiltration device(s). Steps A and B shall be completed as soon as possible in the approval process. See Consideration VI.M for an example.

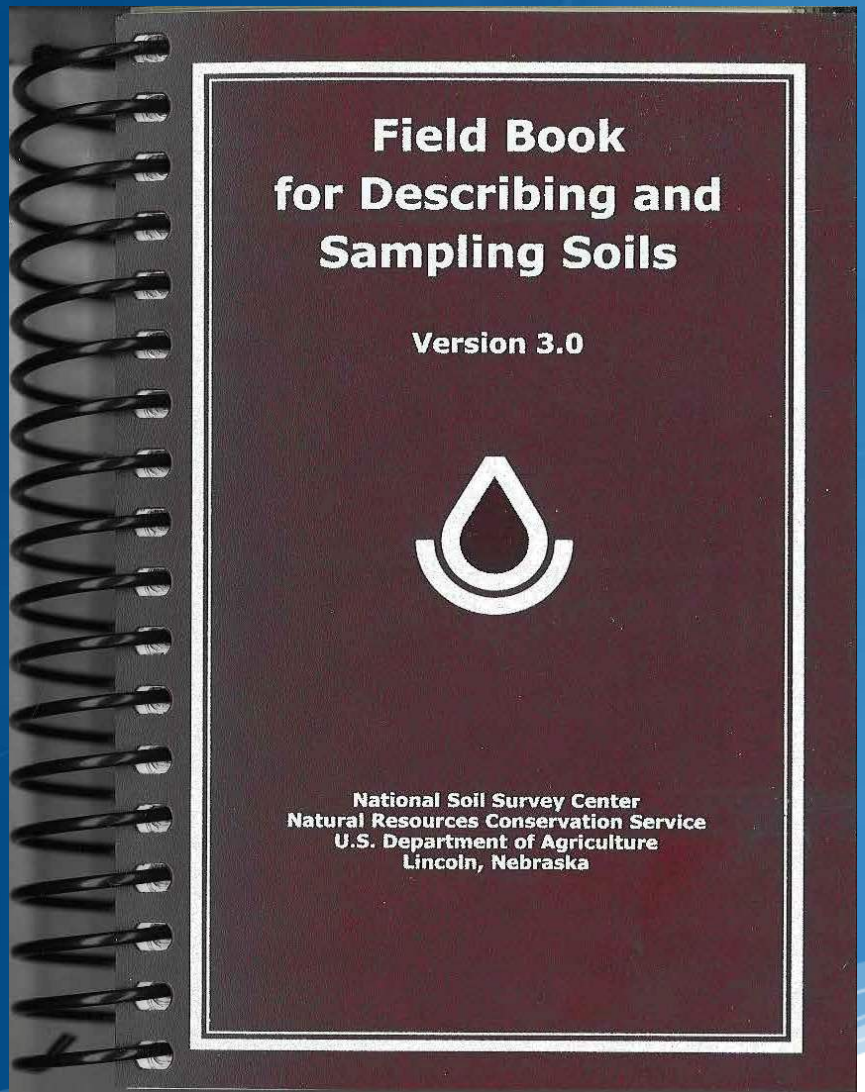
Step A. Initial Screening

The initial screening identifies potential locations for infiltration devices. The purpose of the initial

Exemptions

Sites shall be tested for depth to groundwater, depth to bedrock and *percent fines* information to verify any exemption and exclusion

Methods



Soil profile descriptions must be written in accordance with the descriptive procedures, terminology and interpretations found in the Field Book for Describing and Sampling Soils, USDA, NRCS, 1998

How Many Tests?

Table 1: Evaluation Requirements Specific to Proposed Infiltration Devices

Infiltration Device	Tests Required[1]	Minimum Number of Borings/Pits Required	Minimum Drill/Test Depth Required Below the Bottom of the Infiltration System
Irrigation Systems[2]	Pits or borings	NA[2]	5 feet or depth to *limiting layer*, whichever is less.
Rain Garden[2]	Pits or Borings	NA[2]	5 feet or depth to limiting layer, whichever is less.
Infiltration Trenches (≤ 2000 sq feet impervious drainage area)	Pits or borings	1 test/100 linear feet of trench with a minimum of 2, and sufficient to determine variability	5 feet or depth to limiting layer, whichever is less.
Infiltration Trenches (> 2000 sq ft of impervious drainage area)	• Pits or borings • Mounding potential	1 pit required and an additional 1 pit or boring/100 linear feet of trench, and sufficient to determine variability	Pits to 5 feet or depth to limiting layer Borings to 15 feet or depth to limiting layer
Bioretention Systems	• Pits or borings • Mounding potential	1 test/50 linear feet of device with a minimum of 2, and sufficient to determine variability	5 feet or depth to limiting layer
Infiltration Grassed Swales	Pits or borings	1 test/1000 linear feet of swale with a minimum of 2, and sufficient to determine variability	5 feet or depth to limiting layer
Surface *Infiltration Basins*	• Pits or borings • Mounding potential	2 pits required per infiltration area with an additional 1 pit or boring for every 10,000 square	Pits to 10 feet or depth to limiting layer Borings to 20 feet or depth to

How to Apply?

Correction factor is ratio of infiltration rates of soil at basin bottom and least-permeable layer below

Table 3: Total Correction Factors Divided into Measured Infiltration Rates

Ratio of Design Infiltration Rates[1]	Correction Factor
1	2.5
1.1 to 4.0	3.5
4.1 to 8.0	4.5
8.1 to 16.0	6.5
16.1 or greater	8.5

[1]Ratio is determined by dividing the design infiltration rate (Table 2) for the textural classification at the bottom of the infiltration device by the design infiltration rate (Table 2) for the textural classification of the least permeable soil horizon. The least permeable soil horizon used for the ratio should be within five feet of the bottom of the device or to the depth of the limiting layer.

Infiltration Basin

(Acre-Feet)
(1003)

Wisconsin Department of Natural Resources
Conservation Practice Standard

I. Definition

An infiltration basin is defined as an open impoundment (greater than 15 feet wide in its minimum dimension) created either by excavation or embankment with a flat, densely vegetated floor dedicated to the infiltration of runoff through the ground surface.

II. Purpose

The practice may be applied as part of a structural stormwater management practice system to support one or more of the following purposes:

- Reduce stormwater pollutants
- Increase discharge to groundwater
- Decrease runoff peak flow rates and volumes
- Preserve base flow in streams
- Reduce temperature impacts of runoff.

III. Conditions Where Practice Applies

V. Criteria

A. Screening criteria located in the WDNR Conservation Practice Standard Site Evaluation for Stormwater Infiltration (1002) shall be followed. In addition, the following site location criteria shall be met.

1. Building location – The basin shall not be *hydraulically connected*[1] to foundations or pavements, or cause negative impacts to structures. These negative impacts could include: water in basements and foundation instability.

2. 20% Slopes - Infiltration shall not cause seepage, contribute to hill slope failure or increase erosion on down gradient slopes. A minimum horizontal setback distance of 200 feet shall be maintained from down gradient slopes greater than 20% unless slope stability calculations demonstrate that the slope is stable under saturated conditions at a shorter distance from the practice. Note: Berms constructed as part of the practice are

Construction Restrictions

Construction shall remain suspended if ponded water is present or if residual soil moisture contributes significantly to the potential for soil smearing, clumping or other forms of compaction

Keeping Basin Off-Line

The basin shall be brought on-line when the area draining to the basin has achieved 90% build out of all lots in any of the first 3 years or 75% build out in any subsequent year

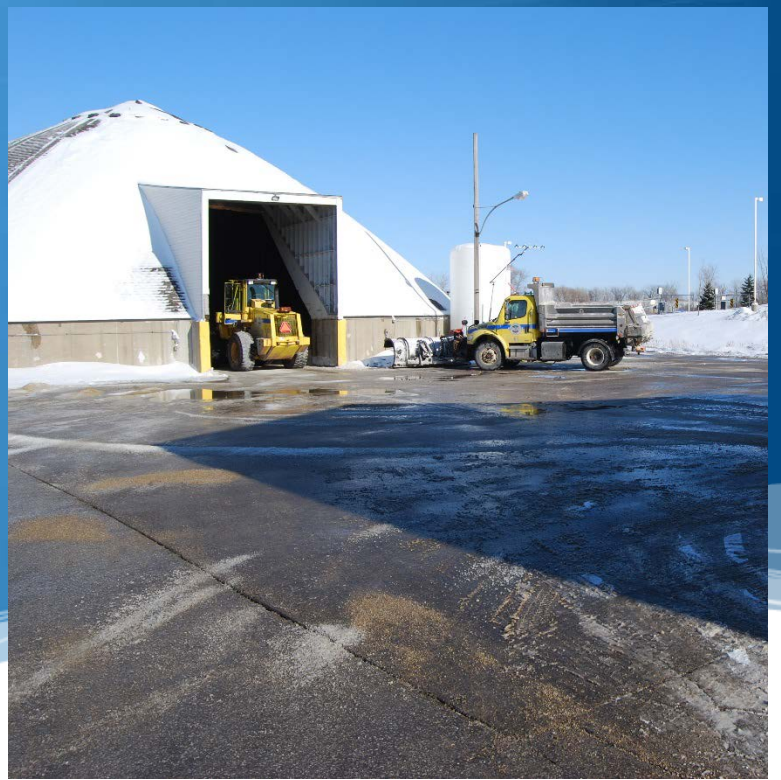
Soil Amendment

Effects of compaction shall be mitigated with:

- two inches of compost mixed into two inches of topsoil
- a chisel plow or rotary device with the capability of reaching to 12 inches

Winter Drawdown

All draw down devices in the pond shall be opened during winter months to discourage infiltration of runoff water containing high levels of chlorides



Bioretention For Infiltration
(1004)

Wisconsin Department of Natural Resources
Conservation Practice Standard

I. Definition

A bioretention device is an *infiltration device*[1] consisting of an excavated area that is back-filled with an engineered soil, covered with a mulch layer and planted with a diversity of woody and herbaceous vegetation. Storm water directed to the device percolates through the mulch and engineered soil, where it is treated by a variety of physical, chemical and biological processes before infiltrating into the *native soil*.

II. Purpose

A bioretention device may be applied individually or as part of a system of stormwater management practices to support one or more of the following purposes:

- Enhance storm water *infiltration*
- Reduce discharge of storm water pollutants to surface and ground waters
- Decrease runoff peak flow rates and volumes
- Preserve base flow in streams
- Reduce temperature impacts of storm water runoff

III. Conditions Where Practice Applies

IV. Federal, State and Local Laws

Users of this standard shall be aware of applicable federal, state and local laws, rules, regulations or permit requirements governing bioretention devices. This standard does not contain the text of federal, state or local laws.

V. Criteria

A. Site Criteria

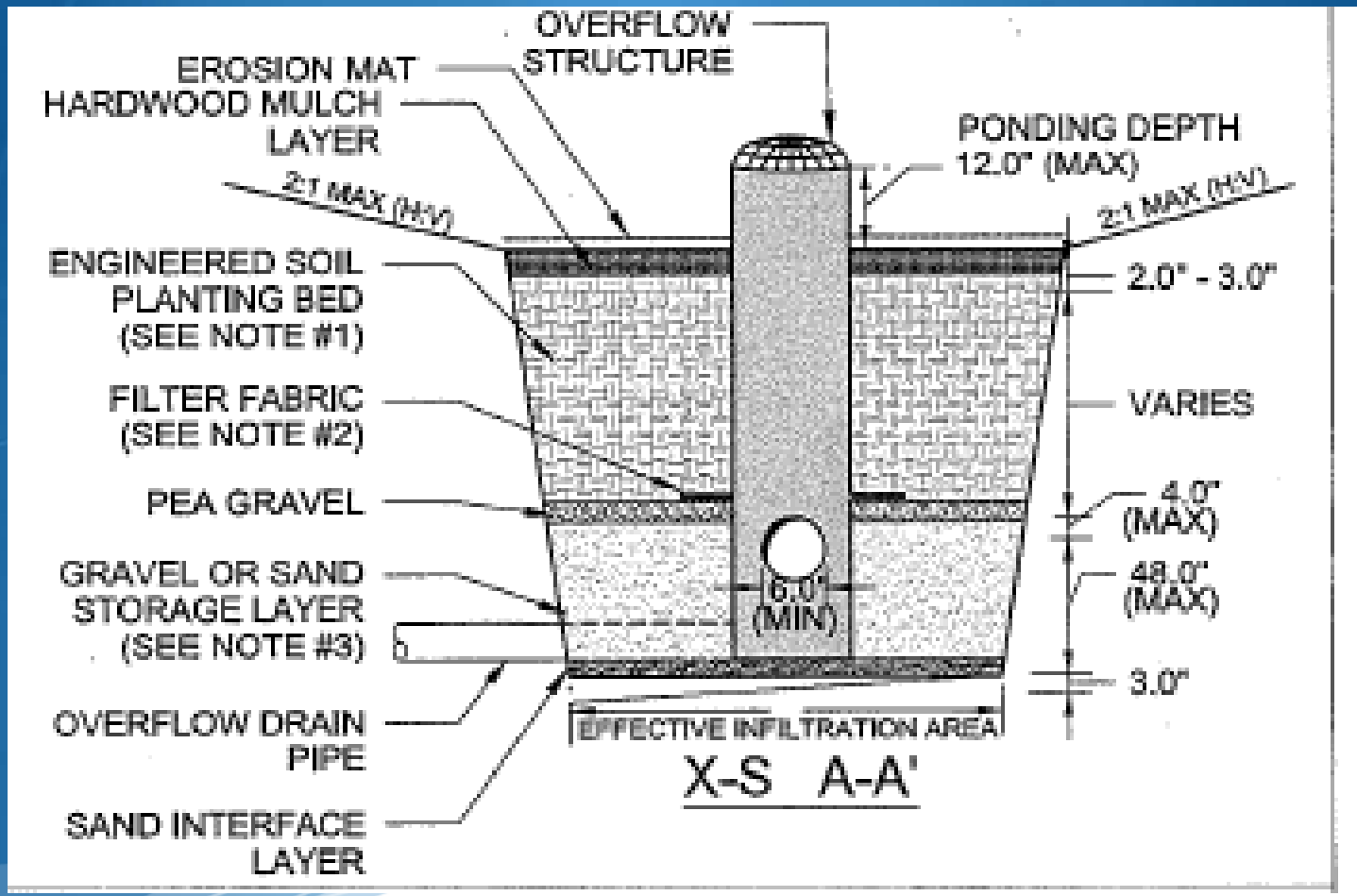
1. A site selected for construction of a bioretention device shall be evaluated in accordance with the WDNR Conservation Practice Standard 1002, "Site Evaluation for Stormwater Infiltration" and shall meet the site requirements of that standard.

2. The following site criteria shall also be met:

   a. Private Onsite Wastewater Treatment System (POWTS) – The bioretention device shall be located a minimum of 50 feet from any POWTS and shall not be *hydraulically connected* to the POWTS dispersal cell or cause negative impacts such as cross contamination.

Storage Layer, Underdrain, Interface Layer

- Required when design infiltration rate of native soil <3.6 in/hr



Construction

- If compaction occurs, soil shall be refractured to a depth of at least 12 in.
- If smearing occurs, correct by raking or roto-tilling

Vegetated Infiltration Swale
(1005)
Interim Technical Standard
Wisconsin Department of Natural Resources
Conservation Practice Standard

I. Definition

Vegetated infiltration swales are stormwater conveyance systems designed to enhance the infiltration runoff. A vegetated infiltration swale can be a natural elongated depression or a constructed channel. A vegetated infiltration swale differs from a conventional drainage channel or ditch in that it is constructed specifically to promote infiltration.

II. Purposes

The primary purpose of this practice is to infiltrate storm water, while limiting groundwater contamination by providing filtering of pollutants. Vegetated swales can also help attenuate peak flows through reducing runoff velocities and volumes.

III. Conditions where Practice Applies

Vegetated infiltration swales are best suited for

- *low- to medium-density residential land uses*[1], and
- Non-residential areas where infiltration of runoff is allowable under Chapter NR 151.

Swales are often placed along roads and in drainage easements in side/back lot lines. Swales are intended to treat relatively flat and small drainage areas with contributory areas less than 5 acres. Swales are not suitable in areas of steep topography or areas with erodible soils without implementation of additional measures to reduce flow velocities and protect against erosion.

permit requirements governing vegetated infiltration swales. This standard does not contain the text of Federal, State, or local laws.

V. Criteria

Vegetated infiltration swales shall be designed to infiltrate runoff and can be a component of a system intended to meet the runoff infiltration requirements of Chapter NR 151. The swale may also be a component of the stormwater conveyance/storage system.

A. **Site Assessment -** A site assessment shall be conducted and documented meeting the requirements of the WDNR Conservation Practice Standard "Site Evaluation for Stormwater Infiltration" (1002). In addition, the site assessment shall evaluate the alignment of the infiltration swale in relation to ground slopes; drainage patterns; and proximity to buildings.

B. **Determination of *Effective Infiltration Area* –** In order to take credit towards the infiltration requirements in NR 151.12(5)(c), the swale must meet the criteria outlined in this standard.

The effective infiltration area is the area that can be counted toward the requirements in NR 151.12(5)(c) and is calculated based on wetted perimeter of the vegetated infiltration swale at a flow depth of 1-inch multiplied by the length of vegetated infiltration swale.

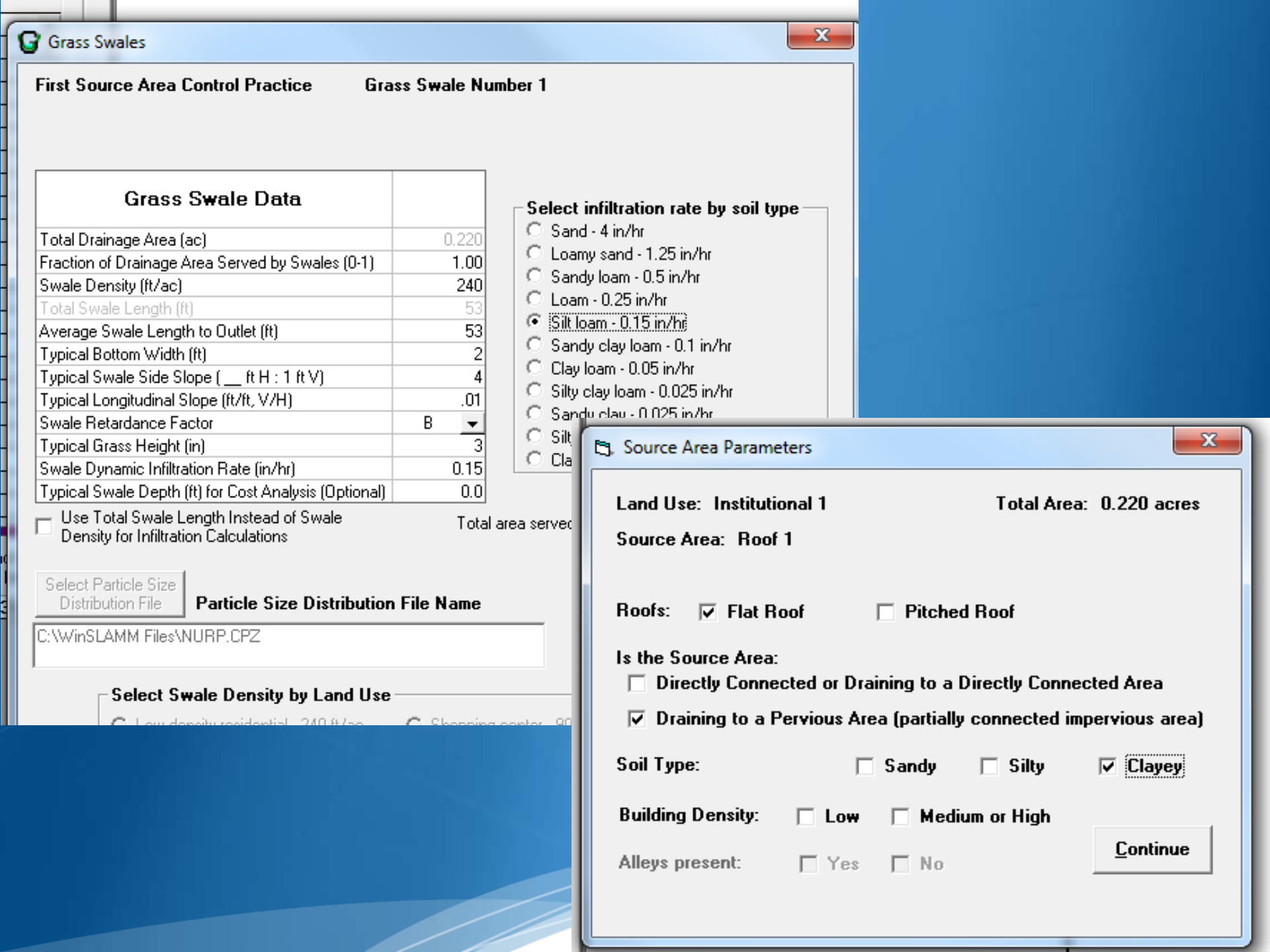
*Effective Infiltration Area (ft^2) = ½ * Wetted Perimeter (ft) at 1-inch depth of flow * Length of Vegetated Infiltration Swale (ft)*

At present, swales are treated as linear infiltration basins

- Site evaluation per 1002 std required (~1 test / 1,000 l.f.)
- Pollutant removal mechanism is infiltration
- $K_{swale} = ½ * K_{static}$
- Mitigate for compaction by amending soil and / or chisel plowing
- New vegetative filtration standard being developed

WinSLAMM and Watershed Soils

- Soil type as part of source area parameters – impervious surfaces draining to undeveloped areas
- Soil type as part of BMP parameters – default infiltration rates for basins, swales


Grass Swales
First Source Area Control Practice
Grass Swale Number 1
Grass Swale Data
Total Drainage Area (ac) 0.220
Fraction of Drainage Area Served by Swales (0-1) 1.00
Swale Density (ft/ac) 240
Total Swale Length (ft) 53
Average Swale Length to Outlet (ft) 53
Typical Bottom Width (ft) 2
Typical Swale Side Slope (__ ft H : 1 ft V) 4
Typical Longitudinal Slope (ft/ft, V/H) .01
Swale Retardance Factor B
Typical Grass Height (in) 3
Swale Dynamic Infiltration Rate (in/hr) 0.15
Typical Swale Depth (ft) for Cost Analysis (Optional) 0.0
Select infiltration rate by soil type
Sand - 4 in/hr
Loamy sand - 1.25 in/hr
Sandy loam - 0.5 in/hr
Loam - 0.25 in/hr
Silt loam - 0.15 in/hr
Sandy clay loam - 0.1 in/hr
Clay loam - 0.05 in/hr
Silty clay loam - 0.025 in/hr
Use Total Swale Length Instead of Swale Density for Infiltration Calculations
Total area served
Select Particle Size Distribution File
Particle Size Distribution File Name
C:\WinSLAMM Files\NURP.CPZ
Select Swale Density by Land Use
Source Area Parameters
Land Use: Institutional 1
Total Area: 0.220 acres
Source Area: Roof 1
Roofs: Flat Roof Pitched Roof
Is the Source Area:
Directly Connected or Draining to a Directly Connected Area
Draining to a Pervious Area (partially connected impervious area)
Soil Type: Sandy Silty Clayey
Building Density: Low Medium or High
Alleys present: Yes No
Continue

Questions?