Supplemental Comments on Vegetated Swales & Bioretention

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Infiltration Swales Applicability

- Where sources are not too dirty (Tier 1, Tier 2, fueling)
- Filtering layer
- Water table, bedrock separation

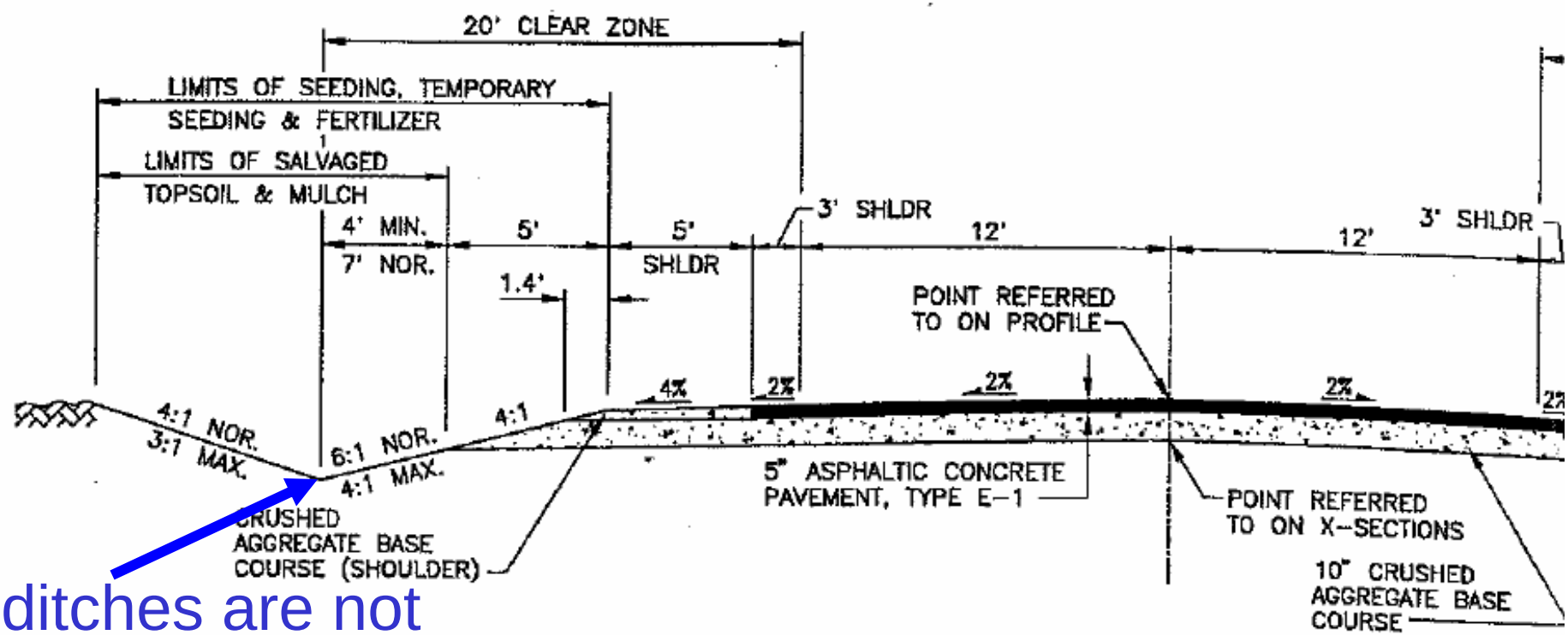
Swale Planning / Design Standards

- Process to Assess and Model Grass Swales – WDNR 4/24/2008
- Must be specifically designed for infiltration
- Not just a roadside ditch

Swale Design Criteria

- Infiltration area = ½ (wetted perim. at 1-in. flow depth) (length)
- Pre-treatment swales: based on 5-8 min. hydraulic residence time; do not count towards effective infiltration area
- $K_{swale} = ½ K_{static}$
- Planting implementation plan

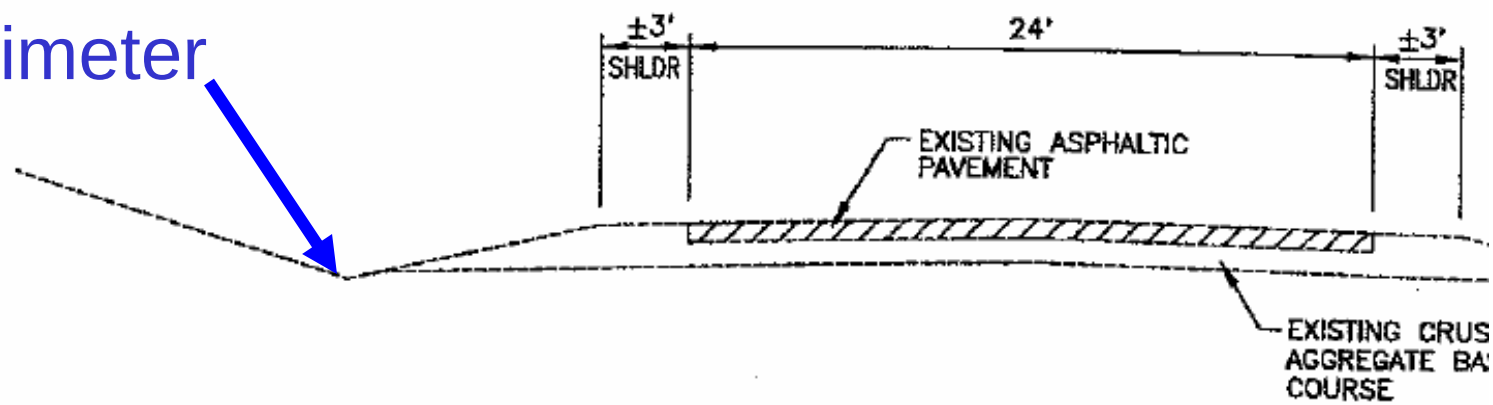
V-ditch
wetted perimeter = 8 inches?



TYPICAL SECTION CTH LO

V-ditches are not designed to infiltrate:

- Compaction
- Wetted perimeter
- Soils



EXISTING SECTION CTH LO

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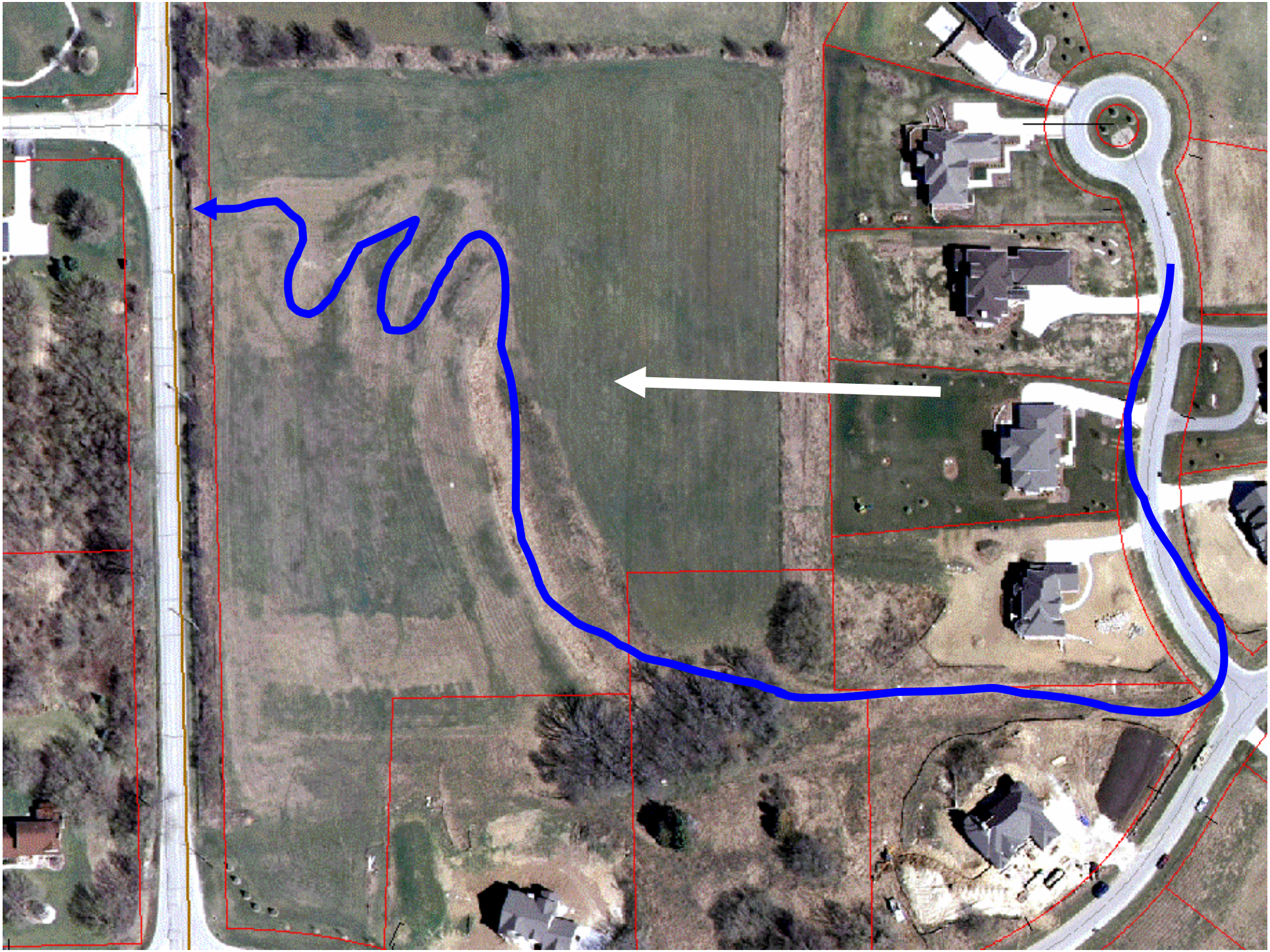
Swale Planning Criteria

- 100-foot private well setback
- Must be on outlot, if in land division
- Structure protection, 2/50-ft setbacks if ponding depth is 12 in.



Swale Modeling

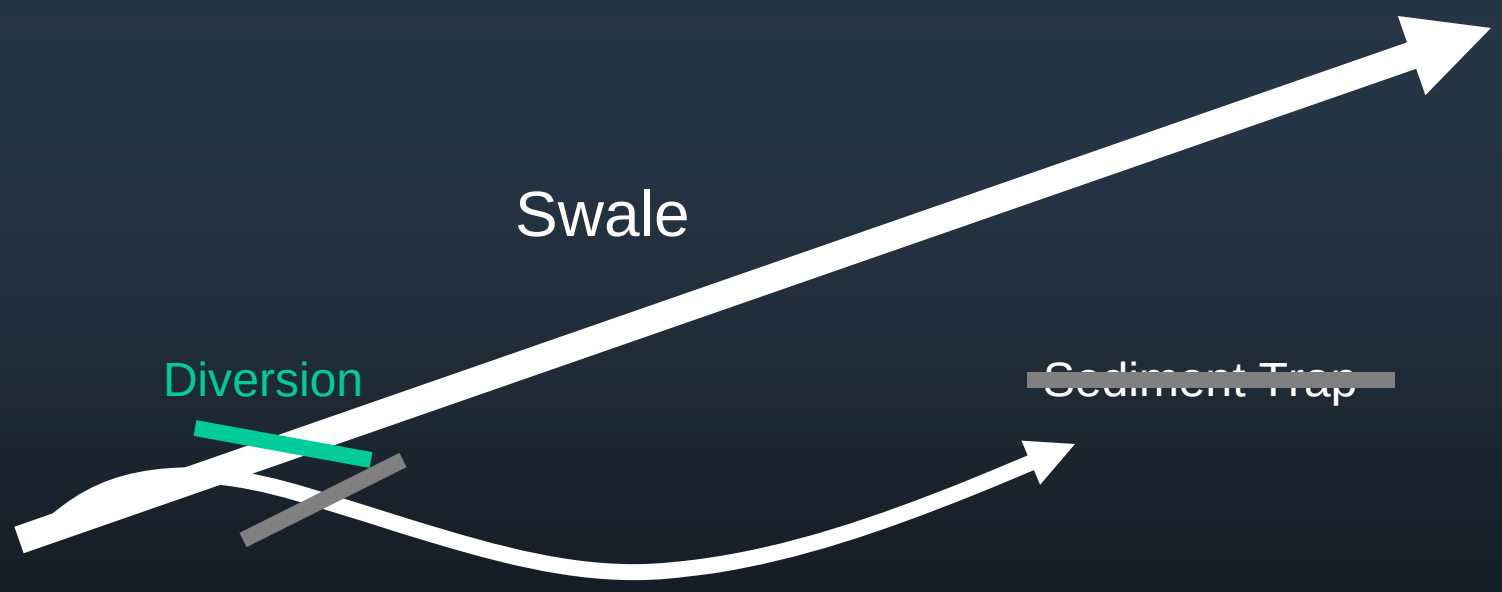
- Infiltration volume credit:
  - Use RECARGA to determine effective infiltration area
  - WinSLAMM or P8
- 2-year 24-hr event versus average annual basis
- Selection of design infiltration rate

Example Data Summary Sheet for Infiltration Swale Design

Design Element	Design Data
Site assessment data: (see attached maps)	
Contributing drainage area to swale (subwatershed A)	120 acres
Distance to nearest private well (including off-site wells)	> 100 feet
Distance to municipal well (including off-site wells)	> 1200 feet
Wellhead protection area involved?	No
Ground slope at site of proposed basin	average 3%
Any buried or overhead utilities in the area?	No
Proposed outfall conveyance system/discharge (w/ distances)	35 ft. to CTH "U" Road ditch 1000 ft. to wetland
Any downstream roads or other structures? (describe)	Yes – 36" cmp road culvert
Floodplain, shoreland or wetlands?	No
Soil investigation data (see attached map & soil logs):	
Number of soil investigations completed	3 (in swale area)
Do elevations of test holes extend 4 ft. below proposed bottom?	Yes (see map)
Average soil texture at pond bottom elevation (USDA)	Sandy loam subsoil, sandy loam engineered fill
Infiltration rate at swale bottom and method of analysis	2 in/hr, double-ring infiltrometer
Distance from swale bottom to bedrock	> 5 feet
Distance from swale bottom to seasonal water table	Swale bottom 2 ft above mottling No water observed in test holes
General Swale design data (see attached detailed drawings):	
Swale bottom area	0.5 acres

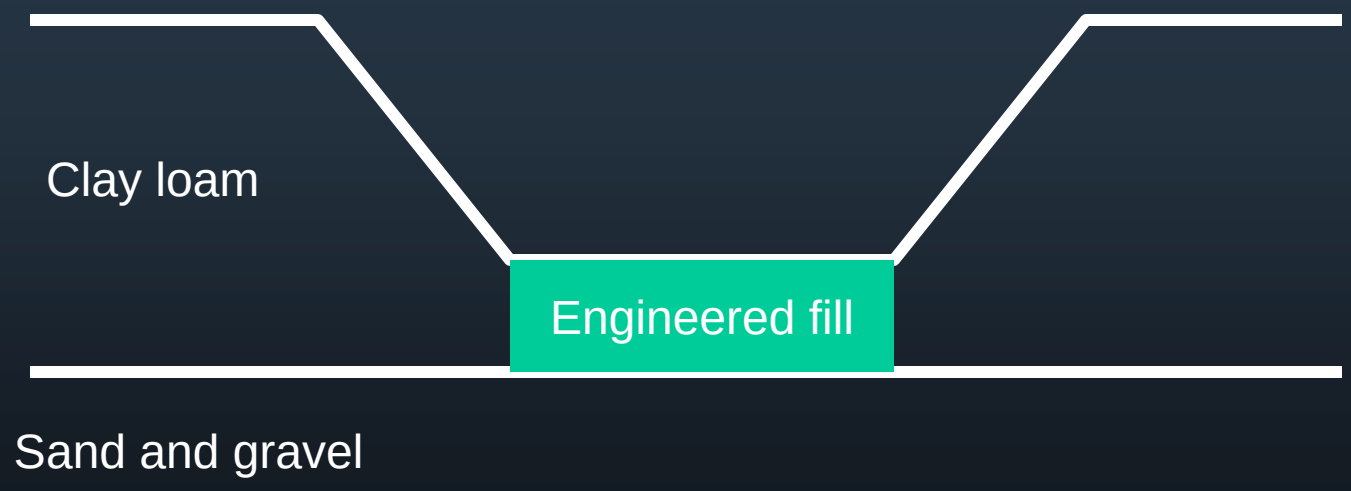
Swale Construction

- Erosion control
  - Bypass until stable, if possible



Swale Soils

- Amend / engineer if necessary
- Particle size distribution testing before implementation



Swale Maintenance

- Maintenance agreement
- Vegetation management, invasives
- Sediment removal
- Erosion repair
- Channelized flow, standing water

Swale Drainage

- Swales are continuously sloped at 1-4%, so should not have any standing water even if soil fails to drain
- Std. calls for length-wise dividers if swale bottom is wider than 6 ft. To reduce concentration of flow?

Swale Problems

- Vegetation establishment in a conveyance
- Compaction
- Erosion / sediment flowing in during site grading, home construction

Swale Solutions

- Plant plugs
- Extensive use of matting
- Rigorous erosion control outside of swale

Bioretention and Engineered Soils

- SiO_2 sand availability
- Fines content
- Verification through particle size distribution testing before installation
  - Topsoil component
  - Final mix
- Importance of structure
- S100 standard compliance

WDNR CPS 1004

Invasive plants and noxious weeds shall not be used.

(6) Woody vegetation shall not be specified at inflow locations. Trees and vegetation shall not block flow paths, create traffic or safety issues, or obstruct utilities.

(7) The planting plan shall cover plant placement, planting sequence, planting time of year, fertilizing, watering and protection from other stresses such as animals, wind and sun to maximize plant growth and survival.

(8) If the engineered soil will be left to settle prior to planting, the surface shall be mulched.

b. Surface Mulch Layer – Shredded hardwood mulch or chips, aged a minimum of 12 months, shall be placed on the surface of the bioretention area. The mulch shall be 2 to 3 inches in depth. The mulch shall be free of foreign material, including other plant material.

6. Engineered Soil Planting Bed

a. Surface Area – The surface area shall be determined using an approved model. (See Consideration L.)

b. Surface Slope – The surface slope of the device shall not exceed 1%.

c. Engineered Soil Depth – After settling, there shall be sufficient soil to support the rooting depth of the vegetation. If the storage layer (V.B.7.) uses gravel, a lens of pea gravel not to exceed 4 inches shall separate the engineered soil from the storage layer. The soil layer (including the pea gravel lens) shall be at least 3 feet deep.

d. Engineered Soil Composition– The soil shall be engineered to the following specifications:

Table 1. Engineered Soil Mix

Engineered Soil Component	Percentage Composition (by Volume)
Mineral (SiO_2) Sand	40%
Topsoil	20% if loam texture
	30% if sandy loam or loamy sand texture
Compost	30% - 40%

Note: This mixture meets the equivalency requirements of s. *NR 151.12(5)(c)5.i., Wis. Adm. Code.*

(2) The sand shall meet one of the following gradation requirements:

- USDA Coarse Sand (.02 - .04 inches)
- ASTM C33 (Fine Aggregate Concrete Sand)
- Wisconsin Standards and Specifications for Highway and Structure Construction, Section 501.2.5.3.4. (Fine Aggregate Concrete Sand) 2005 edition, or an equivalent as approved by the administering authority.

0.5-1.0 mm

The sand component shall consist of mineral sand that is at least 97% SiO_2. Substitutions, such as calcium carbonated sand, dolomitic sand, manufactured sand or stone dust are not allowed. The sand shall be washed to remove clay and silt particles, and well-drained prior to planting.

(3) The topsoil component shall be a USDA classified sandy loam, loamy sand or loam texture. The topsoil component textural class shall be verified by a laboratory analysis or a professional acceptable to the jurisdiction having authority.

(4) The compost component shall meet the requirements of Wisconsin Department of Natural Resources Specification S100, Compost.

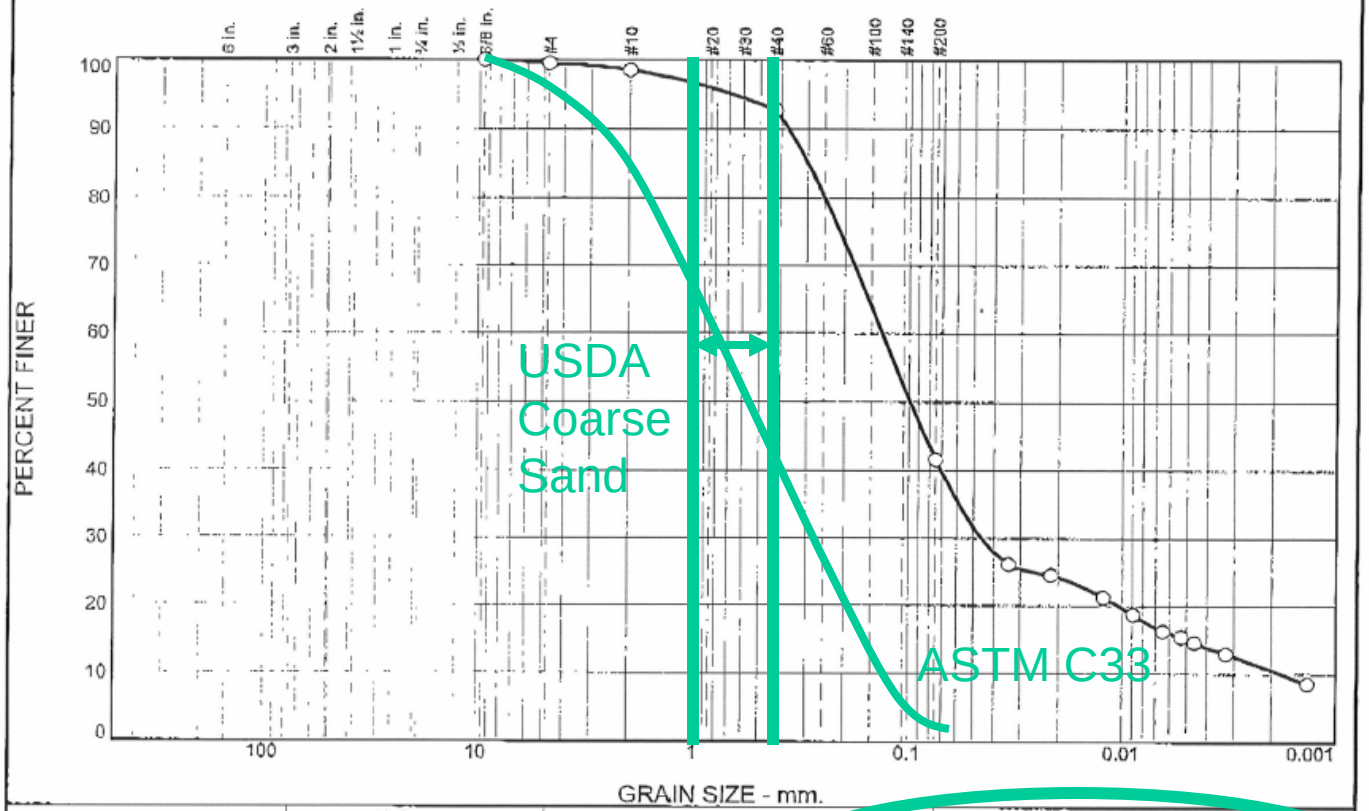
(5) The engineered soil mix shall be free of

Soil mixed with S100 compost

Sample of engineered fill from failed infiltration basin

Failed Infiltration Basin – Engineered Fill

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.5	1.0	5.7	51.1	26.6	15.1

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
0.375	100.0		
#4	99.5		
#10	98.5		
[illegible]	[illegible]		
#200	41.7		

Soil Description

Dark Gray Silty Sand, little Clay

Atterberg Limits (ASTM D 4318)

PL= LL= PI=

Classification

USCS= AASHTO=

Coefficients

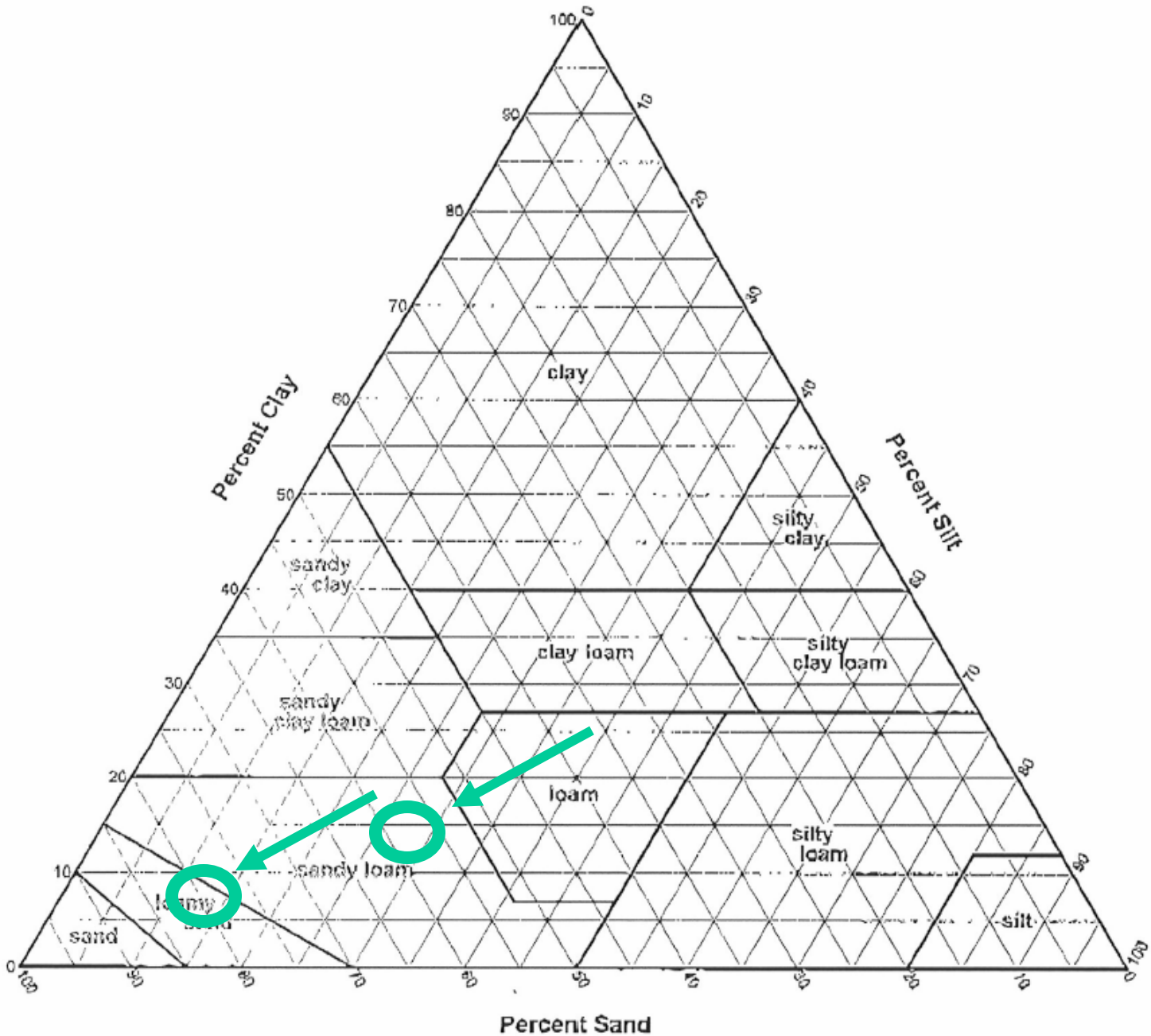
D_{85}= 0.2977 D_{60}= 0.1334 D_{50}= 0.0986
D_{30}= 0.0458 D_{15}= 0.0049 D_{10}= 0.0018
C_u= 74.32 C_c= 8.76

Date Tested: **Tested By:**

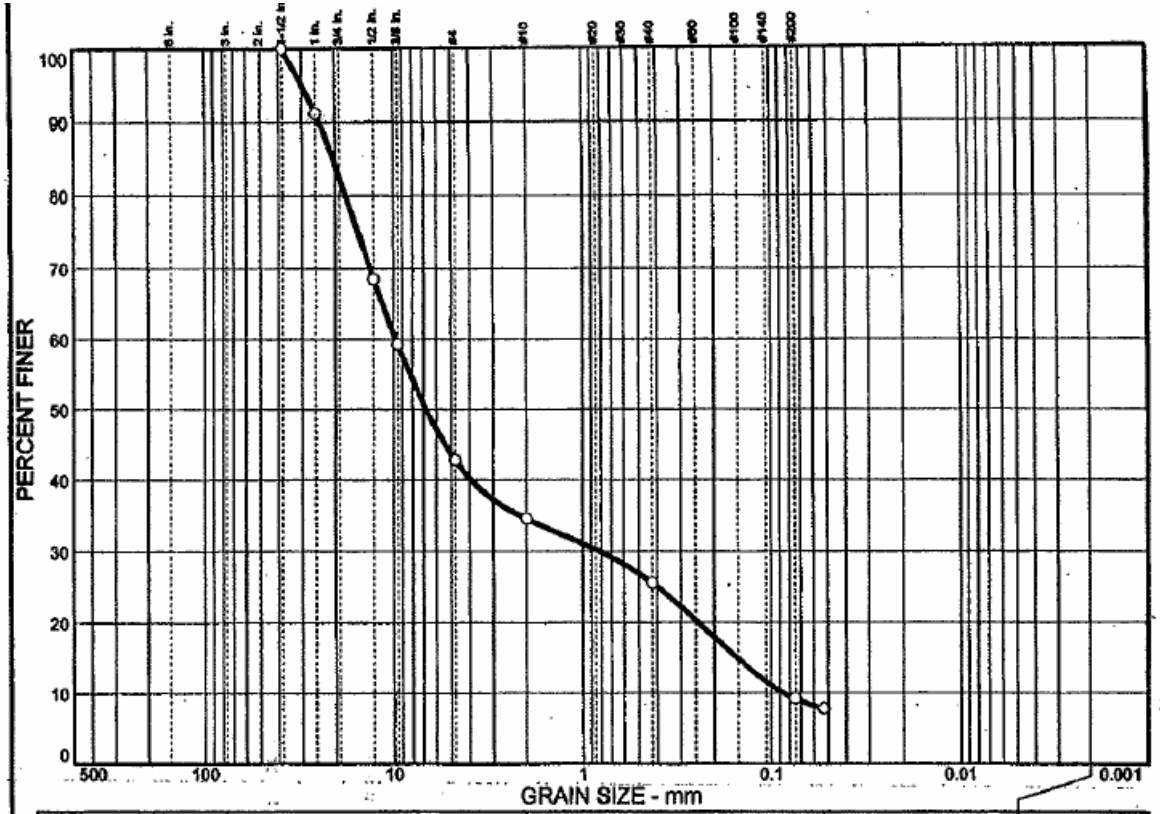
Remarks

Organic Content 9.0%

USDA Soil Classification



- Underlying subsoil



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	65.4	26.8	7.8	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1.5 in.	100.0		
1 in.	91.1		
.5 in.	68.5		
.375 in.	59.3		
#4	42.8		
#10	34.6		
#40	23.0		
#200	9.2		
#270	7.8		

* (no specification provided)

Soil Description

Light Brown (10YR 6/3) extremely gravelly sand

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 20.6 D_{60}= 9.75 D_{50}= 6.76
D_{30}= 0.805 D_{15}= 0.152 D_{10}= 0.0858
C_u= 113.62 C_c= 0.78

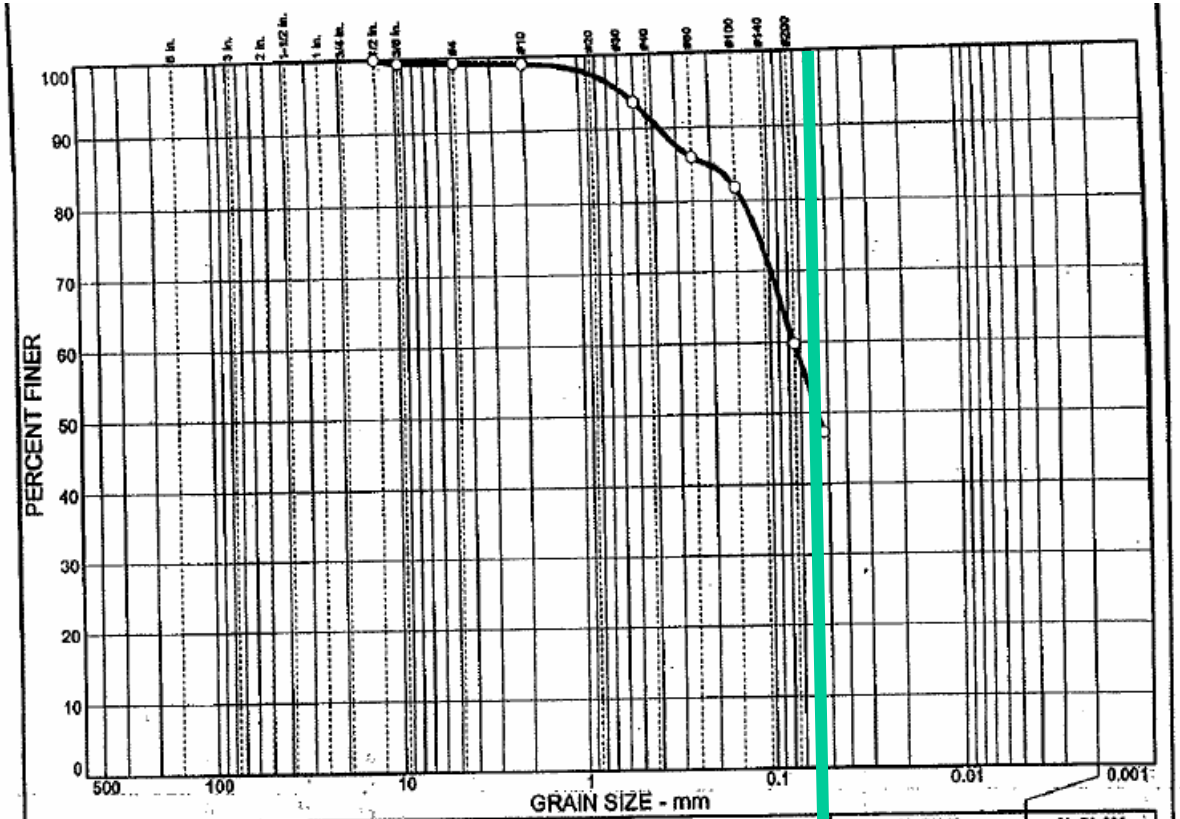
Classification

USCS= AASHTO=

Remarks

F.M.=0.98

Sample No.: 2-BS **Source of Sample:** Infiltration Test Excavation **Date:** 1-31-06
Location: NE Site (Test Boring No. 2) **Elev./Depth:** 6.5 ft. bgs



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	1.0	51.7	47.3	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.5 in.	100.0		
.375 in.	99.4		
#4	99.3		
#10	99.0		
#35	93.6		
#60	86.0		
#100	[illegible]		
#200	59.8		
#270	47.3		

* (no specification provided)

Soil Description

Light Brown (10YR 5/4) sandy loam

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 0.207 D_{60}= 0.0754 D_{50}= 0.0572
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

F.M.=0.19

Sample No.: 1-BS **Source of Sample:** Infiltration Test Excavation **Date:** 1-26-06

Location: NB Site (Test Boring No. 2) **Elev./Depth:** 4.5 ft. bgs

DOUBLE RING INFILTROMETER TEST RESULTS		
Test Depth[1] (feet)	Infiltration Rate	USDA Soil Type
4½±	0.45 inch/hour	sandy loam
6½±	5.3 inches/hour	extremely gravelly sand
1) Depth is referenced to the existing surface grade at the test location.		

Laboratory Testing

Two particle-size distribution analyses were performed on soil samples obtained from the infiltration test excavation at the approximate infiltration test grades, to determine the relative percentage of gravel, sand and fine-grained material (material finer than the No. 270 sieve) within the soils. The results of the particle-size distribution analyses are summarized briefly in the table below and also in more detail on Figures 1 and 2.

PARTICLE SIZE DISTRIBUTION ANALYSIS TEST RESULTS[1,2]					
Location	Depth of Sample[3] (feet)	USDA Soil Type	% Gravel	% Sand	% Fines
Test Boring No. 2 / Infiltration Test	4½ ± to 5±	sandy loam	1.0	51.7	47.3
	6½± to 7±	extremely gravelly sand	65.4	26.8	7.8

Fines Content in Engineered Fill

- 1004 standard does not specify limit
- Sand specification has little or no fines
- Topsoil fraction could have up to 70% fines prior to dilution
- Problems with failure if fines content >10%

S100 Standard Compliance

- Self-certifying
- Require particle size test
- Submit sample to demonstrate maturity
- Contractors want to use bark mulch

Wisconsin Department of Natural Resources Specification
S100 Compost

1. SCOPE

Compost is a mixture that consists largely of aerobically decayed organic waste. This specification outlines the minimum material requirements for compost intended to be used in accordance with the criteria of Wisconsin Department of Natural Resources (WDNR) Stormwater Management technical standards. Compost meeting this specification is appropriate to use for compaction mitigation and as the component of an engineered soil mixture.

2. MATERIAL REQUIRMENTS. The following material requirement shall be met:

a. Particle Size – 98% of the compost shall pass through a 0.75-inch screen.

b. Physical Contaminants – Less than 1% combined glass, metal and plastic.

c. Organic Matter/Ash Content – At least 40% organic matter; less than 60% ash content.

d. Carbon to Nitrogen Ratio – 10-20:1 C:N ratio.

e. pH – Between 6 and 8.

f. Soluble Salts – Electrical conductivity below 10 dS m^{-1} (mmhos cm -1)

g. Moisture Content – Between 35% and 50% by weight.

h. Maturity – The compost shall be resistant to further decomposition and free of compounds, such as ammonia and organic acids, in concentrations toxic to plant growth.

i. Residual Seeds & Pathogens – Pathogens and noxious seeds shall be minimized.

j. Pathogens – The compost shall meet the Class A requirements for pathogens as specified in s. NR 204.07(6)(a), Wis. Adm. Code.

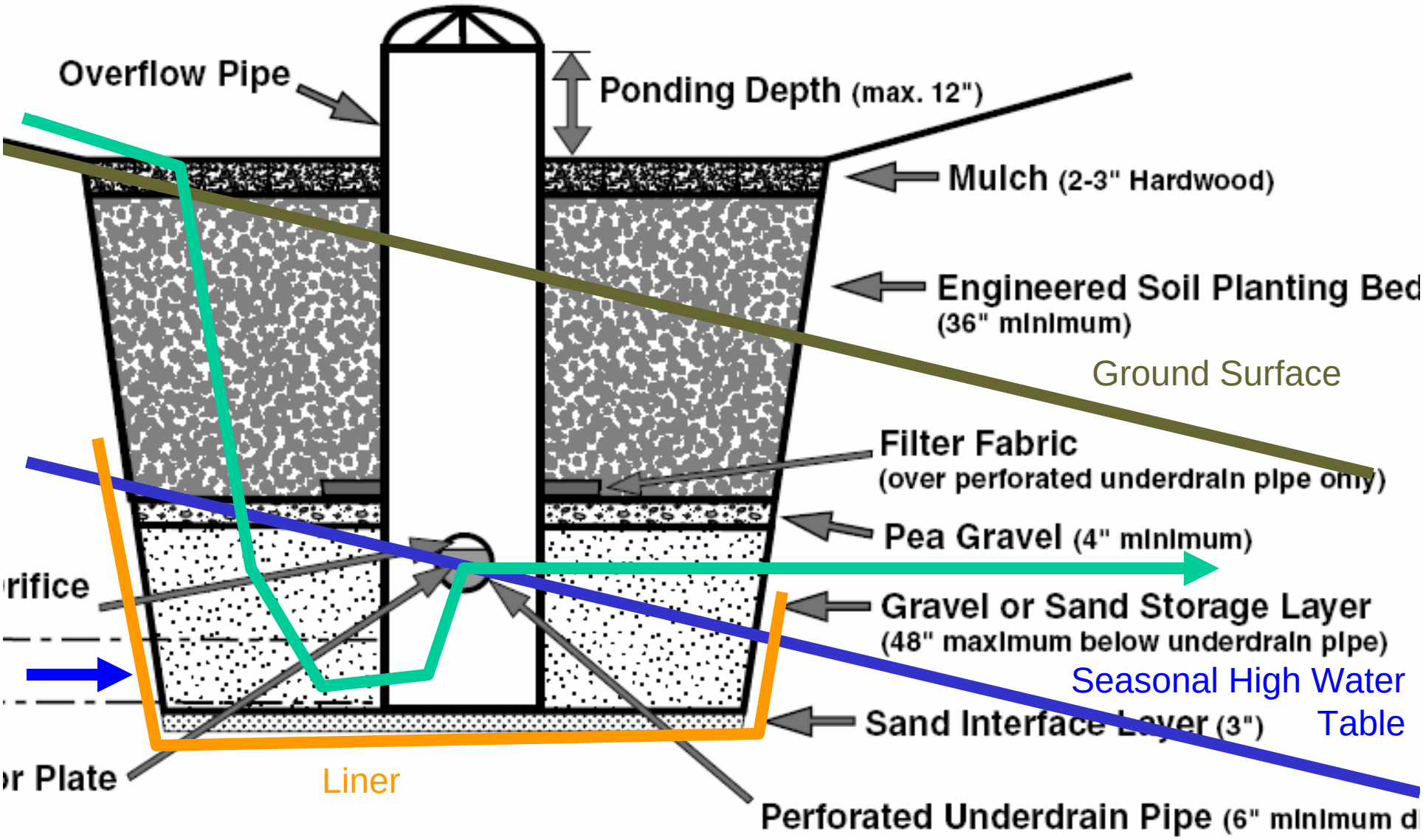
k. Other Chemical Contaminants – The compost shall meet the high quality pollutant concentrations as specified in s. NR 204.07(5)(c), Wis. Adm. Code.

Material	C:N Ratio
Coffee Grounds	20:1
Corn Stalks	60:1
Cow Manure	20:1
Fruit Wastes	35:1
Grass Clippings	20:1
Horse Manure w/ Litter	50:1
Leaves	60:1
Newspaper	50-200:1
Oak Leaves (Green)	26:1
Peat Moss	58:1
Pine Needles	60-110:1
Rotted Manure	20:1
Sawdust / Wood	600:1
Sawdust Weathered for two months	325:1
Straw	80-100:1
Table Scraps	15:1
Vegetable Trimmings	12-20:1

Solutions

- Cut way back on topsoil component – 50% sand, 50% compost? (Bannerman)
- Eliminate loam as topsoil component?
- Limit total fines to <10%
- Require particle size distribution testing of topsoil, sand before installation
- Keep basins off-line until soil structure develops

Hardwood Mulch

- Flotation problem
- Use coconut matting instead
- Hold down with netting

Bioretention and Shallow Groundwater