The “Site Evaluation for Stormwater Infiltration - Technical Standard 1002” has been revised. This technical standard revises the procedures, updates the submittal requirements, and clarifies methods that can be used to design infiltration systems in compliance with NR 151, Wis. Adm. Code.

The Department is soliciting comments from the public on this draft technical standard. Once the 21 day notice period is complete, all comments will be considered by the Department. After considering all public comments, revisions may be made to the technical standard document and the final standard will be made available to internal and external stakeholders. Comments related to this draft standard document should be sent to: DNRTECHNICALSTANDARDS@wisconsin.gov.
DEFINITION
This standard defines site evaluation procedures to:
(1) Perform an initial screening of a development site\textsuperscript{1} to determine its suitability for infiltration,
(2) Evaluate each area within a development site that is selected for infiltration, and
(3) Prepare a site evaluation report.

PURPOSE
(1) Protect groundwater from surface water pollution sources,
(2) Identify areas suitable for infiltration,
(3) Establish methods to a) characterize the site, and b) screen for exclusions and exemptions under ch. NR 151, Wis. Adm. Code,
(4) Establish requirements for siting an infiltration device and the selection of design infiltration rates,
(5) Define requirements for a site evaluation report documenting that appropriate areas are selected for infiltration and that an appropriate design infiltration rate is used, and
(6) Define requirements for measuring infiltration in existing vegetated swales and calculating a dynamic infiltration rate in existing vegetated swales.

CONDITIONS WHERE PRACTICE APPLIES
This standard is intended for development sites being considered for storm water infiltration devices, and also includes a method to establish an infiltration rate for existing swales. Additional site location requirements may be imposed by other storm water infiltration device technical standards.

Be aware of applicable federal, state and local laws, rules, regulations or permit requirements governing infiltration devices. This standard does not contain the text of federal, state or local laws. Note that infiltration devices are commonly regulated as plumbing when in connection with a piping system, see ch. SPS 382, Wis. Adm. Code.

CRITERIA
The site evaluation consists of four steps (Steps A – D) for locating the optimal areas for infiltration and establishing the design infiltration rate for properly sizing infiltration devices (below, and Figure 1). Additionally, Step C.2. (Infiltration Option 4) addresses measuring dynamic infiltration rates in existing vegetated swales.

\textsuperscript{1} Words in the standard that are shown in italics are described in the Definitions section. The words are italicized the first time they are used in the text.
Step A. Initial Site Screening

The purpose of the initial site screening is to use existing available information to identify potential locations for infiltration devices based on in situ soil conditions. The initial site screening will also determine if installation is limited by s. NR 151.124 (3)(a) or (4), Wis. Adm. Code, and where field work is needed. Optimal locations for infiltration testing are confirmed in Step B.

Information collected in Step A will be used to explore the potential for multiple infiltration areas versus relying on a regional device. Infiltration devices dispersed around a development are usually better able to sustain the existing hydrology than a single regional device.

Figures and Attachments:

- Figure 1. Site Evaluation for Infiltration Flow Chart of Steps
- Figure 2. Example Bioretention Basin Section
- Figure 3. Example Bioretention Basin Section with Underdrain Section
- Figure 4. Example Infiltration Basin Section
- Attachment 1. Soil and Site Evaluation Form
- Attachment 2. Technical Note for Infiltration in Compacted Soils

In order to efficiently evaluate a site for infiltration, it is advantageous to perform the investigation in strict accordance with local ordinance. The final location for infiltration devices may be impacted by local permitting requirements. Permitting process requirements for development sites vary across the state and may vary within a municipality depending on the number of lots being developed. To avoid costly redesigns, complete Step A before the preliminary plat, and Step B before the final plat or Certified Survey Map (CSM) is approved. For regional infiltration devices, and for devices constructed on public right-of-ways, public land, or jointly owned land, complete Step C before the final plat or final CSM approval.

Record information for Steps B and C as noted in Step D. Prepare a single report for the infiltration investigation.
The initial screening may be conducted without fieldwork to determine the following:

(See a list of references and resources in the Considerations section)

1. Copy of official soil survey map of the site as found on the USDA-NRCS Web Soil Survey, including soils legend,
2. Site topography map and slopes greater than 20%,
3. Site soil infiltration capacity characteristics as defined in NRCS County soil surveys or other relevant source,
4. Soil parent material obtained from published soil descriptions,
5. NRCS Climate Analysis for Wetlands Tables (WETS Tables),
6. Soil map unit, depth to groundwater and depth to restrictive features; use seasonally high groundwater information where available,
7. Distance to sites listed on the Wisconsin Remediation and Redevelopment Database (WRRD) sites within 500 feet from the perimeter of the development site,
8. Known presence of endangered species habitat,
9. Presence of flood plains and flood fringes,
10. Location of mapped wetland, hydric soil and potentially hydric soil based on the Wisconsin Wetland Inventory (WWI), which can be accessed via the WDNR Surface Water Data Viewer,
11. An evaluation of the site relative to where the installation of storm water infiltration devices is prohibited by s. NR 151.124(3)(a) and (4)(a), Wis. Adm. Code, including setbacks from direct conduits to groundwater such as wells, sinkholes, and karst features due to the potential for groundwater contamination,
12. An evaluation of the site to determine an exemption by ss. NR 151.124 (3)(b) and (4)(c) Wis. Adm. Code from the requirement to install infiltration devices,
13. Potential impact to utilities, and
14. Potential impact to adjacent property.

**Step B. Preliminary Field Verification of the Initial Site Screening**

The purpose of Step B is to field-verify information from Step A for all potential areas of the development site considered suitable for infiltration. Test the sites for depth to groundwater, depth to bedrock, and soil texture to verify any exemption and exclusion found in Step A. Soil borings are acceptable for the preliminary investigation, but pits are required for design (refer to Step C).

Sandy loams, loams, silt loams, silts and all clay textural classifications are assumed to meet the percent fines limitations of a filtering layer in s. NR 151.002(14r), Wis. Adm. Code, for both 3 and 5 foot soil layers. Coarse sand does not meet s. NR 151.002(14r), Wis. Adm. Code, limitations for a 3 foot soil layer consisting of 20% fines. Other sand textures and loamy sands may require the percent fines level be verified with a sieve analysis.

A wetland determination or delineation may be needed to identify whether a wetland is present within or near the site. WDNR “Wetland Screening and Delineation Procedures,” dated Dec. 15, 2016, was developed to assist in making this decision (http://dnr.wi.gov/topic/waterways/construction/wetlands.html).
Step C. Establishment of Design Infiltration Rate

The purpose of this step is to determine if locations identified for infiltration devices are suitable for infiltration and to provide the required information to design the device.

Step C.1. Field Evaluation of Specific Infiltration Areas.

(1) Construct the minimum number of pits for each infiltration device as defined in Table 1. Local agencies may require additional pits for soil investigation.

(2) Excavate pits to a depth of at least 5 feet below the native soil interface elevation (Figures 2-4) or to a limiting layer, such as bedrock or groundwater.

If no limiting layer is encountered, continue excavation to 5 feet below the native soil interface even if perched conditions are encountered.

For example, the native soil interface of an infiltration device, such as a bioretention device, is commonly 8 feet below the existing grade. Therefore, a device 8 feet deep to the proposed native soil interface would require a minimum soil investigation depth of 13 feet (8 feet plus 5 feet).

(3) In the event that a permeable layer is not found, additional depth can be investigated to determine if a permeable strata is at a feasible depth. Construct pits of adequate size, depth and construction to allow a complete morphological soil profile description using the NRCS Field Book for Describing and Sampling Soils, (latest edition). Soil profile descriptions are to be made by a State of Wisconsin Licensed Professional Soil Scientist. Refer to OSHA for excavation safety recommendations.

(4) Document the pits using the Soil Pit Evaluation form in Attachment 1.

Table 1. Evaluation Requirements to Proposed Infiltration Devices

<table>
<thead>
<tr>
<th>Infiltration Device (Technical Standard Code)</th>
<th>Tests Required</th>
<th>Minimum Number of Pits Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rain Garden</td>
<td>Soil texture evaluation or infiltration test</td>
<td>N/A</td>
</tr>
<tr>
<td>Infiltration Trenches (1007)</td>
<td>Pits</td>
<td>1 pit/100 linear feet of trench with a minimum of 2 pits</td>
</tr>
<tr>
<td>Vegetated Swale (1005)</td>
<td>Pits</td>
<td>1 pit/ 500 linear feet of swale with a minimum of 2 pits</td>
</tr>
<tr>
<td>Bioretention Systems (1004)</td>
<td>Pits</td>
<td>1 pit/1000 square feet of device, with a minimum of 2 pits</td>
</tr>
<tr>
<td>Surface Infiltration Basins (1003)</td>
<td>Pits</td>
<td>1 pit/ 5000 square feet of device with a minimum of 3 pits</td>
</tr>
<tr>
<td>Subsurface Dispersal Systems (N/A) greater than 15 feet in width. (1008)</td>
<td>Pits</td>
<td>1 pit/10,000 square feet of device, with a minimum of 2 pits</td>
</tr>
</tbody>
</table>

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1The infiltration rates in this table assume separation from a limiting layer below the device such that mounding of water will not reach the native soil interface. A regulatory authority may require a mounding analysis when concerned that mounding may approach the native soil interface or have an adverse impact to property. See Considerations section for more information.

2Technical standard codes refer to the corresponding WDNR design technical standard containing design criteria for this practice.
Step C.2. Infiltration Rate Determination.

The purpose of this step is to determine a design infiltration rate (Infiltration Options 1-3), or to measure the infiltration rate of existing vegetated swales (Infiltration Option 4).

To determine if a site is eligible for exemption from infiltration under s. NR 151.124(4)(c), Wis. Adm. Code, use a scientifically credible field test method unless the least permeable soil horizon within five feet below the native soil interface is one of the following: sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, or clay.

Base the infiltration rate used to request the exemption on the actual field-measured rate without the use of correction factors in Tables 3, 4, or 5.

Take at least three infiltration tests at the potential infiltration location within the native soil layer being evaluated for exemption. Distribute tests so that they best represent the area being tested. At least two-thirds of tests shall have a measured infiltration rate of less than 0.6 in/hr for the field site to be eligible for an exemption from infiltration requirements.

The geometric mean of infiltration test results should be used. However, it may be appropriate to group certain test results where an infiltration trend is apparent and assign different geometric mean rates accordingly. Grouping of results may be done based on soil type or spatial reasons to provide representative results. Where an infiltration rate is too low to measure, a rate of 0.03 in/hr may be used to calculate a geometric mean of the dataset (the dataset’s values must be greater than zero to calculate a geometric mean).

Use one of the following methods (Infiltration Options 1 – 4) to determine the design infiltration rate.

Examples within Infiltration Options 1-3 calculate the static infiltration rate. Option 4 outlines the dynamic infiltration rate used to model a flowing water condition.

Note that soil compaction mitigation reduces the soil density and promotes infiltration.

Infiltration Option 1 – Infiltration Rate Not Measured, Soil Compaction Mitigated

Using information from soil pits, select the design static infiltration rate from Table 2 based on soil texture of the least permeable soil horizon within 5 feet below the native soil interface. See Example 1.

Table 2. Design Static Infiltration Rates for Soil Textures Receiving Storm water

<table>
<thead>
<tr>
<th>Soil Texture</th>
<th>Design Static Infiltration Rate Without Measurement (Inches/hour)¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse sand or coarser</td>
<td>3.60</td>
</tr>
<tr>
<td>Loamy coarse sand</td>
<td>3.60</td>
</tr>
<tr>
<td>Sand</td>
<td>3.60</td>
</tr>
<tr>
<td>Loamy sand</td>
<td>1.63</td>
</tr>
<tr>
<td>sandy loam, fine sand, loamy sand, very fine sand, and loamy fine sand</td>
<td>0.50</td>
</tr>
<tr>
<td>Loam</td>
<td>0.24</td>
</tr>
<tr>
<td>Silt loam</td>
<td>0.13</td>
</tr>
<tr>
<td>Sandy clay loam</td>
<td>0.11</td>
</tr>
<tr>
<td>Clay loam</td>
<td>0.03</td>
</tr>
<tr>
<td>Silty Clay loam</td>
<td>0.04²</td>
</tr>
<tr>
<td>Sandy clay</td>
<td>0.04</td>
</tr>
<tr>
<td>Silty clay</td>
<td>0.07</td>
</tr>
<tr>
<td>Clay</td>
<td>0.07</td>
</tr>
</tbody>
</table>

¹Infiltration rates represent the lowest value for each textural class presented in Table 2 of Rawls, 1998.

²Infiltration rate is an average based on Rawls, 1982 and Clapp & Hornberger, 1978.
Where adverse soil structure is present, such as moderate to strong platy soil structure, compacted or cemented soil horizons, or massive soil conditions with high bulk density reduce the design static infiltration rates per judgment of a qualified licensed individual (see Required Qualifications).

**Example 1.**

1. Calculate the design static infiltration rate ($K_{\text{static}}$) where the native soil interface is 4 feet below existing grade (Table E1).

<table>
<thead>
<tr>
<th>Soil Depth Below Existing Grade (Inches)</th>
<th>Soil Texture</th>
<th>Infiltration Rate$^1$ (Inches/Hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-12</td>
<td>Silt Loam</td>
<td>0.13</td>
</tr>
<tr>
<td>12-24</td>
<td>Sandy Loam</td>
<td>0.50</td>
</tr>
<tr>
<td>24-72</td>
<td>Loam</td>
<td>0.24</td>
</tr>
<tr>
<td>72 – 130</td>
<td>Silt Loam</td>
<td>0.13</td>
</tr>
<tr>
<td>130 – 180</td>
<td>Loam</td>
<td>0.24</td>
</tr>
</tbody>
</table>

$^1$Infiltration rates are from Table 2.

**Solution 1.**

1. $K_{\text{static}} =$ the soil texture with the lowest infiltration rate within 5 feet below the native soil interface
2. Solve for $K_{\text{static}}$: Add 5 feet to the depth of the native soil interface (4 feet) for a total of 9 feet of depth. The soil texture with the lowest infiltration rate from 4 feet to 9 feet (48 to 108 inches) below existing grade is silt loam, for which Table E1 shows an infiltration rate of 0.13 in/hr.
3. $K_{\text{static}} =$ 0.13 in/hr.

**Infiltration Option 2 – Infiltration Rate Measured with In-Field Device, Soil Compaction Mitigated**

Conduct two field infiltration tests within each soil pit at the native soil interface as required in Table 1 and calculate a geometric mean infiltration rate.

Select infiltration measurement location(s) representative of the device being tested. Conduct the infiltration tests at the native soil interface elevation of the proposed infiltration device. If the infiltration rate is measured with a *Double-Ring Infiltrometer*, use the requirements of ASTM D3385 for the field test, except that the test period may be reduced to 2 hours, in which case the test will be a falling-head test instead of the constant-head test described in the ASTM standard. If using the 2 hour test period, include at least 5 water depth measurements within the test period to determine the lowest infiltration rate that occurs during the test. An infiltration test may be conducted over a period of less than 2 hours only if water is depleted during testing due to a high infiltration rate (e.g., > 10 in/hr). In this case, graph the infiltration rate change with respect to time using the measured data points to project the infiltration rate out to 2 hours.

Alternative infiltration test methods (e.g., Modified Philip Dunne, TurfTech) may be used to measure infiltration rates of existing devices; discuss the method and purpose with the jurisdictional authority to obtain approval. The Modified Philip-Dunne is a falling head device suitable for existing infiltration practices because it can be performed relatively quickly. However, it can only measure the hydraulic conductivity of the top 50 cm of media and does not detect a confining layer below.

Infiltration testing is used to determine the lowest infiltration rate under a saturated soil condition and shall be conducted during **non-frozen soil conditions**. Infiltration test results may not be representative due to macro pores (e.g., soil cracks, worm holes); therefore, avoid areas with macro pores. If cracks in soil are due to dry soil, do not conduct testing until soil has been able to take on adequate moisture to eliminate the soil cracks.
The geometric mean of infiltration test results should be used. However, it may be appropriate to group certain test results where an infiltration trend is apparent and assign different geometric mean rates accordingly. Grouping of results may be done based on soil type or spatial reasons to provide representative results. Where an infiltration rate is too low to measure, a rate of 0.03 in/hr may be used to calculate a geometric mean of the dataset (the dataset’s values must be greater than zero to calculate a geometric mean).

To calculate the static infiltration rate,

1. Determine the ratio of textural infiltration rates by dividing the textural infiltration rate (Table 2) at the native soil interface (Figures 2-4) by the lowest textural infiltration rate (Table 2) within 5 feet below the native soil interface.

2. With this ratio, select the appropriate correction factor (A) from Table 3.

3. Next, divide the geometric mean of the measured infiltration rates by the correction factor (A) to obtain the static infiltration rate. The correction factor adjusts the measured infiltration rates for the occurrence of less permeable soil horizons below the surface and the potential variability in the subsurface soil horizons throughout the infiltration site.

<table>
<thead>
<tr>
<th>Ratio of Textural Infiltration Rates</th>
<th>Correction Factor (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.5</td>
</tr>
<tr>
<td>1.1 to 4.0</td>
<td>3.5</td>
</tr>
<tr>
<td>4.1 to 8.0</td>
<td>4.5</td>
</tr>
<tr>
<td>8.1 to 16.0</td>
<td>6.5</td>
</tr>
<tr>
<td>16.1 or greater</td>
<td>8.5</td>
</tr>
</tbody>
</table>

Table 3. Correction Factors for Measured Infiltration Rates at Infiltration Devices

Example 2.

1. Calculate the static design infiltration rate ($K_{\text{static}}$) for an infiltration device having Double-Ring Infiltrometer measurements with a geometric mean infiltration rate of 2.4 in/hr.

2. The infiltration device native soil interface is 4 feet below existing grade. No groundwater or redoximorphic features were encountered.

<table>
<thead>
<tr>
<th>Soil Depth Below Existing Grade (Inches)</th>
<th>Soil Texture</th>
<th>Infiltration Rate (Inches/ Hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-12</td>
<td>Silt Loam</td>
<td>0.13</td>
</tr>
<tr>
<td>12-84</td>
<td>Sandy Loam</td>
<td>0.50</td>
</tr>
<tr>
<td>84-180</td>
<td>Loam</td>
<td>0.24</td>
</tr>
</tbody>
</table>

Table E2. Observed Soil Conditions for Example 2

Infiltration rates are from Table 2.
**Solution 2.**

(1) Calculate $R$, the ratio of textural infiltration rates = $T_N / T_L$

Where:

$T_N$ = Textural infiltration rate (Table 2, sandy loam) at the native soil interface

$T_L$ = Lowest textural infiltration rate (Table 2, loam) within 5 feet below the native soil interface

(2) $R = 0.50$ in/hr (sandy loam) / $0.24$ in/hr (loam) = 2.1

(3) From Table 3, the correction factor ($A$) for 2.1 is 3.5.

(4) Calculate $K_{\text{static}}$, the static infiltration rate = $G / A$

Where:

$G$ = the geometric mean of the measured infiltration rate = 2.4 in/hr

$A$ = the correction factor from Table 3 based on $R$.

(5) $K_{\text{static}} = 2.4$ in/hr / 3.5 = 0.69 in/hr

**Infiltration Option 3 – Infiltration Rate Not Measured, Soil Compaction Not Mitigated**

**Notice:** This section is not applicable where soil compaction mitigation actions will be implemented at an infiltration device (see Definitions).

Mitigating soil compaction is important, as both topsoil and subsoils can become compacted during construction. It is best to avoid compacting areas, primarily during construction, in the first place, especially areas where infiltration devices will be located. However, construction of an infiltration device can lead to soil compaction, so appropriate actions should be taken to mitigate potential compaction. Soil compaction mitigation actions will vary based on the site and type of infiltration device. Individual infiltration design standards include actions to avoid and mitigate soil compaction. Where actions are not taken to mitigate soil compaction, apply the correction factor ($B$) from Table 4 in this section to further reduce the design infiltration rate of the infiltration device.

**Table 4. Static Infiltration Rate\(^1\) Multiplier for Incidental Soil Compaction**

<table>
<thead>
<tr>
<th>Compacted Soil Type</th>
<th>Correction Factor ($B$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td></td>
</tr>
<tr>
<td>Coarse Sand or Coarser</td>
<td></td>
</tr>
<tr>
<td>Loamy Coarse Sand</td>
<td></td>
</tr>
<tr>
<td>Sand</td>
<td>0.9</td>
</tr>
<tr>
<td>Loamy Sand</td>
<td></td>
</tr>
<tr>
<td>Loam</td>
<td></td>
</tr>
<tr>
<td>Sandy Loam</td>
<td>0.4</td>
</tr>
<tr>
<td>Silt Loam</td>
<td></td>
</tr>
<tr>
<td>Sandy Clay Loam</td>
<td></td>
</tr>
<tr>
<td>Clay</td>
<td></td>
</tr>
<tr>
<td>Clay Loam</td>
<td></td>
</tr>
<tr>
<td>Silty Clay Loam</td>
<td></td>
</tr>
<tr>
<td>Sandy Clay</td>
<td>0.2</td>
</tr>
<tr>
<td>Silty Clay</td>
<td></td>
</tr>
<tr>
<td>Clay</td>
<td></td>
</tr>
</tbody>
</table>

\(^1\) Refer to Attachment 2 for background information
Example 3.

(1) Calculate the static infiltration rate ($K_{\text{static}}$) where soil compaction mitigation is not performed.

Observations from the pit indicate that the soil texture with the lowest permeability within 5 feet below the native soil interface is sandy loam.

Solution 3:

(1) $K_{\text{static}} = T_L \times B$

Where:

$T_L =$ Lowest textural infiltration rate (Table 2) within 5 feet below the native soil interface

$B =$ the correction factor from Table 4

(2) $= 0.5 \text{ in/hr (Table 2 with sandy loam)} \times 0.4 \text{ (Table 4 correction factor for sandy loam)}$

$= 0.2 \text{ in/hr}$

Infiltration Option 4 – Infiltration Rate of Existing Vegetated Swales.

Notice: This section is only applicable to measuring infiltration rates at vegetated swales. The dynamic infiltration rate is used to model a flowing water condition, and shall be calculated for vegetated swales by multiplying the static infiltration rate by 0.5.

Municipalities regulated under a municipal permit pursuant to subch. I of ch. NR 216, Wis. Adm. Code, may conduct infiltration rate testing of existing vegetated swale(s) as opposed to using infiltration rates based on soil texture that are developed from Table 2. Table 2 infiltration rates are static rates; model vegetated swales using a dynamic infiltration rate. A water quality model may be programmed to increase the effective infiltration rate within the model up to the full static rate when the swale slope is 0.5% or less.

Determine which vegetated swale sections qualify as water quality swales consistent with DNR’s Process to Assess and Model Grass Swales guidance. This guidance also modifies the ASTM D3385 Double-Ring Infiltrometer to a 2-hour test period. Refer to instructions under Infiltration Option 2, paragraphs 1 - 4, for the modified ASTM D3385 method and alternative infiltration testing methods.

Use either infiltration tests or hand-dug pits to assess the infiltration rate. If using infiltration tests, conduct at least five tests within the vegetated swale(s), equally spaced throughout the swale system to collect a representative dataset. Where an infiltration rate is too low to measure, a rate of 0.03 in/hr may be used to calculate a geometric mean of the dataset (the dataset’s values must be greater than zero to calculate a geometric mean).

If using hand-dug pits, dig one pit per 500 feet of swale, up to a maximum of 20 across the site, spatially distributed to capture site variation. For each pit, a State of Wisconsin Licensed Professional Soil Scientist must determine the static infiltration rate from Table 2 based on the soil texture of the least permeable soil horizon within 18 inches of the existing soil surface. See Consideration XX for potentially acceptable infiltration test methods.

The geometric mean of infiltration test or test pit results should be used. However, it may be appropriate to group certain test results where an infiltration trend is apparent and assign different geometric mean rates accordingly. Grouping of results may be done based on soil type or spatial reasons to provide representative results.

Apply a correction factor ($C$) based on the size of the dataset to the geometric mean of measured swale infiltration rates (Table 5). This correction factor accounts for the occurrence of less permeable soil horizons below the surface and the potential variability in the subsurface soil horizons throughout the water quality swale(s). A less permeable soil horizon below the location of the measurement increases the level of uncertainty in the measured value. Also, the uncertainty in a measurement is increased by the variability in the subsurface soil horizons throughout the proposed infiltration site.

Note that a larger data set will result in application of a lower correction factor to the geometric mean from the data set as shown in Table 5 below.
Table 5. Correction Factors for Measured Infiltration Rates in Water Quality Swales

<table>
<thead>
<tr>
<th>No. of Existing Swale Infiltration Tests</th>
<th>Correction Factor (C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-9</td>
<td>4</td>
</tr>
<tr>
<td>10-19</td>
<td>3</td>
</tr>
<tr>
<td>≥20</td>
<td>2</td>
</tr>
</tbody>
</table>


Example 4.
(1) Calculate the dynamic infiltration rate ($K_{\text{dynamic}}$) for 12 infiltration rate measurements that have a geometric mean infiltration rate ($G$) of 2.8 in/hr for a water quality swale system.

Solution 4.
(1) $K_{\text{static}} = \frac{G}{C}$
Where:
$G$ = the geometric mean of the measured (static) infiltration rates
$C$ = the correction factor from Table 5 based on the number of infiltration rate measurements taken

$= \frac{2.8 \text{ in/hr}}{3}$
$= 0.93 \text{ in/hr}$

(2) $K_{\text{dynamic}} = K_{\text{static}} \cdot 0.5$

$= 0.93 \text{ in/hr} \cdot 0.5$
$= 0.46 \text{ in/hr}$

Step D – Soil and Site Evaluation Report
Include the site information required in Steps B and C in the Soil and Site Evaluation Report. Complete the single report prior to the construction plan submittal. Include the following in the report:

(1) The date the information was collected.
(2) A legible site plan/map that is presented on paper that is no less than 8 ½ X 11 inches in size and:
(a) Is drawn to scale,
(b) Includes a site location map,
(c) Include a north arrow,
(d) Includes a permanent vertical and horizontal reference point,
(e) Illustrates the entire development site,
(f) Shows all areas of planned filling and/or cutting if known,
(g) Shows the percent and direction of land slope for the site or contour lines,
(h) Highlights areas with slopes over 20%,
(i) Shows all floodplain information (elevations and locations) that is pertinent to the site,
(j) Shows the locations of the soil pits,
(k) Shows the location by site grid and elevations of existing surface and bottom of all
pits/borings included in the report,

(l) Shows location of wetlands within the entire development site as field delineated and
surveyed,

(m) Shows location of private wells within 100 feet of the development site, and public wells
within 400 feet of the development site,

(n) Shows location of karst features within 1,000 feet downgradient and 100 feet upgradient
of the development site

Write soil profile descriptions in accordance with the descriptive procedures, terminology and
interpretations found in the Field Book for Describing and Sampling Soils, USDA, NRCS (latest edition).
Thaw frozen soil material prior to conducting evaluations for soil color, texture, structure and consistency.
In addition to the data determined in Steps B and C, include the following information for each soil horizon
or layer of the soil profiles:

(1) Thickness, in inches or decimal feet.
(2) Munsell soil color notation.
(3) Soil mottle or redoximorphic feature color, abundance, size and contrast.
(4) USDA soil textural class with rock fragment modifiers.
(5) Soil structure, grade size and shape.
(6) Soil consistence, root abundance and size.
(7) Soil horizon boundary, distinctness and topography.
(8) Occurrence of saturated soil, groundwater, bedrock or disturbed soil.
(9) Bedrock type, weather-fractured or unfractured, and elevation.
(10) Proposed native soil interface elevation.
(11) Seasonal and current groundwater elevations.

REQUIRED QUALIFICATIONS
Soil and Site Evaluations shall be completed by a Wisconsin Department of Safety and Professional
Services Licensed Professional Soil Scientist, Licensed Professional Geologist, or Licensed Professional
Hydrogeologist.

CONSIDERATIONS
Additional recommendations relating to design that may enhance the use of, or avoid problems with this
practice but are not required to insure its function are as follows:

(1) The development site should be checked to determine the potential for archeological sites. This
search may be conducted by state staff for projects required or funded by the state. If cultural or
historical resources are known or suspected to be on site, contact the Wisconsin Historical
Society.

(2) If a site is suspected of having contaminated soil or other materials from its prior land use, historic
fill or other reason, then an evaluation to characterize the potential contamination may be
warranted (an Environmental Site Assessment may be justified). New fill should be evaluated for
contamination before it is brought to a new site. DNR guidance publications WA-1820 “Waste Soil
Determinations and Identifying Clean Soil” (http://dnr.wi.gov/news/input/Guidance.html) and RR-
060 “Management of Contaminated Soils and Other Solid Wastes” were developed to assist generators, regulators and property owners to manage waste properly.

(3) The permitting process requirements for development sites vary across the state and may also vary within a municipality depending on the number of lots being developed. The timing of Steps A, B, and C may need to be adjusted for the type of approval process. Be aware that any activity that will result in a discharge of fill material to a wetland will require a permit under s. 281.36 Wis. Stats. Wetlands are defined in s. 23.32 Wis. Stats and Ch. NR 103, Wis. Adm. Code.

(4) Resources available for completing Steps A and C:

(a) Sites listed in the Wisconsin Remediation and Redevelopment Database (WRRD), including GIS tool. http://dnr.wi.gov/topic/Brownfields/WRRD.html

(b) Floodplain areas as regulated under s. 87.30, Wis. Stats. and chs. NR 30, 31, and 116, Wis. Adm. Code.

(c) NRCS Climate Analysis for Wetlands Tables (WETS Tables). https://www.wcc.nrcs.usda.gov/climate/navigate_wets.html

(d) Endangered species habitat as shown on National Heritage Inventory County maps, http://dnr.wi.gov/topic/nhi.

(e) Access points and road setbacks as determined by county or municipal zoning plans.

(f) Existing reports concerning the groundwater and bedrock. Examples include: Publications from USGS, NRCS, Regional Planning Commissions, WDNR, DATCP, WisDOT, UW system or WGNHS.

(g) The Drinking Water and Groundwater pages of the WDNR http://dnr.wi.gov/topic/DrinkingWater/

(h) The Wisconsin Grain Size Database http://wgnhs.uwex.edu/maps/data

(i) WDNR Surface Water Data Viewer http://dnr.wi.gov/topic/surfacewater/swdv/


(5) If a karst feature is located within the site, a Karst Inventory Forms from the Wisconsin Geological and Natural History Survey should be filled out (https://wgnhs.uwex.edu/water-environment/karst-sinkholes/).

(6) Groundwater monitoring wells, constructed as per ch. NR 141, Wis. Adm. Code, can be used to determine the groundwater level. Large sites considered for infiltration basins may need to be evaluated for the direction of groundwater flow.

(7) Consider conducting a groundwater mounding analysis to verify that the highest anticipated groundwater level does not approach the native soil interface. The infiltration rate into saturated soil in this case may be at or near zero. This standard requires that limiting layers within 5 feet below the native soil interface of an infiltration device be considered in the design infiltration rate. It is also possible for a limiting layer more than 5 feet below the native soil interface to affect an infiltration device where lateral movement is limited. Increased mounding height, and therefore the potential for increased infiltration device drawdown time, are more likely to occur under the following conditions: shallow depth to groundwater or limiting layer, increased infiltration device size, decreased device length/width ratio, the presence of low-hydraulic conductivity material, thin aquifer thickness, and shallow water table gradient. It is also appropriate to conduct a mounding analysis in locations where mounding may impact basements or adjacent property. Refer to http://dnr.wi.gov/topic/stormwater/standards/gw_mounding.html for mounding calculation guidance.
(8) Ch. NR 151 Wis. Adm. Code provides for a maximum area to be dedicated for infiltration depending upon land use. This cap can be voluntarily exceeded.

(9) One or more areas within a development site may be selected for infiltration. A development site with many areas suitable for infiltration is a good candidate for a dispersed approach to infiltration. It may be beneficial to contrast regional devices with onsite devices for sites that receive runoff from one lot or a single source area within a lot, such as rooftop or parking lot.

(10) Consider conducting a soil investigation to a depth of 15 feet below the existing grade as standard protocol, unless bedrock or groundwater is reached, and deeper if this area will be 'cut,' or lowered, from existing grade.

(11) In some situations, adding fill to a location to increase the separation distance between the proposed bottom of an infiltration device and a limiting layer may make a location suitable for infiltration.

(12) The authority having jurisdiction will decide if a proposed alternative infiltration test method is acceptable. It is best to discuss the proposed plan with the authority before detail design.

(13) The Modified Philip Dunne infiltration test is suitable for assessment of required maintenance because accumulation of fine particles limit the infiltration rate in these practices.

(14) Devices located on or near final slopes of ≥20% may be unstable. Consider a slope stability calculation.

(15) No construction sediment should enter the infiltration device. This includes sediment from site grading as well as construction activities. If possible, delineate and protect from compaction areas selected for infiltration during grading and construction. This will help to preserve the infiltration rate and extend the life of the device.

(16) Class V injection wells are not addressed in this document.

(17) In projects which involve piping of storm water, consult plumbing code in ch. SPS 382 Wis. Adm. Code.

(18) Storm water infiltration devices may fail prematurely if there is:

(a) An inaccurate estimation of the Design Infiltration Rate;

(b) An inaccurate estimation of the seasonal high water table or bedrock;

(c) Excessive compacting or sediment loading during construction;

(d) No pretreatment for post-development and lack of maintenance.

REFERENCES


Ch. NR 30, Wis. Adm. Code
Ch. NR 31, Wis. Adm. Code
Ch. NR 116, Wis. Adm. Code
Ch. NR 103, Wis. Adm. Code
Ch. NR 141, Wis. Adm. Code
Ch. NR 151, Wis. Adm. Code
Ch. NR 811, Wis. Adm. Code (line 71)
DEFINITIONS

Aquiclude: A geological material through which zero water flow occurs.

Aquitard: Compacted layer of clay, silt or rock that attenuates water flow underground.

Bedrock: Bedrock is a consolidated rock, or weathered in place parent material larger than 2 mm in size and greater than 50 percent of the soil profile.

Bioretention systems: Bioretention is an infiltration device consisting of an excavated area that is back-filled with an engineered soil, covered with a mulch layer or erosion control mat and planted with a diversity of woody and herbaceous vegetation. Storm water directed to the device percolates through the engineered soil, where it is treated by a variety of physical, chemical and biological processes before infiltrating into the native soil and/or discharges through an underdrain.

Class V injection well: Any bored, drilled, or driven shaft, or dug hole that is deeper than its widest surface dimension, or an improved sinkhole, or a subsurface fluid distribution system. Any infiltration device that has a subsurface pipe distribution system is considered to be an injection well. See Chapter NR 815, Wis. Adm. Code and http://dnr.wi.gov/topic/Wells?UIW.html for compliance criteria.

Construction plan: A map and/or plan describing the built-out features of an individual lot.

Coarse sand: Soil material that contains 25% or more very coarse and coarse sand, and <50% any other one grade of sand.

Design infiltration rate: A velocity (in/hr), based on soil structure and texture, at which precipitation or
runoff enters and moves into or through soil. The design rate is used to size an infiltration device or system. Rates are selected based on soil texture or in-field infiltration rate measurements with appropriate correction factors. See also: static infiltration rate, dynamic infiltration rate.

Development site: The entire area planned for development, irrespective of how much of the site is disturbed at any one time or intended land use. It can be one lot or multiple lots.

Direct conduits to groundwater: Wells, 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.

Double-Ring Infiltrometer: A device that directly measures infiltration rates into a soil surface. The Double-Ring Infiltrometer requires a fairly large pit excavated to depth of the proposed infiltration device and preparation of a soil surface representative of the bottom of the infiltration area.

Dynamic infiltration rate: The infiltration rate accounting for flowing water conditions (multiply static infiltration rate by 0.5).

Existing grade: Slope of the site prior to modification.

Geometric mean: The $n$ root of the product of $n$ values. For example, the geometric mean of 0.5, 0.65, and 0.71 inches/hour is:

$$\sqrt[3]{0.5 \times 0.65 \times 0.71} = \sqrt[3]{0.23075} = 0.61338 \text{ inches/hr}$$

High groundwater level: The higher of either the elevation to which the soil is saturated as observed as a free water surface in an unlined hole, or the elevation to which the soil has been seasonally or periodically saturated as indicated by soil color patterns throughout the soil profile.

Highest anticipated groundwater level: The sum of the calculated mounding effects of the discharge and the seasonal high groundwater level.

Infiltration areas: Areas within a development site that are suitable for installation of an infiltration device.

Infiltration basin: An open impoundment created either by excavation or embankment with a flat densely vegetated floor. It is situated on permeable soils and temporarily stores and allows a designed runoff volume to infiltrate the soil.

Infiltration device: A structure or mechanism engineered to facilitate the entry and movement of precipitation or runoff into or through the soil. Examples of infiltration devices include irrigation systems, rain gardens, infiltration trenches, bioretention systems, infiltration grassed swales, infiltration basins, subsurface dispersal systems and infiltration trenches.

Infiltration trench: An excavated trench that is usually filled with coarse, granular material in which storm water runoff is collected for temporary storage and infiltration. Other materials such as metal pipes and plastic domes are used to maintain the integrity of the trench.

Karst feature: An area or surficial geologic feature subject to bedrock dissolution so that it is likely to provide a conduit to groundwater, and may include caves, enlarged fractures, mine features, exposed bedrock surfaces, sinkholes, springs, seeps, or swallets.

Licensed Professional Soil Scientist: A soil scientist licensed by the Wisconsin Department of Safety and Professional Services.

Limiting layer: A limiting layer can be bedrock, an aquitard, aquiclude or the seasonal high groundwater table, but it does not include a perched water layer (water above an aquitard) or soil with redoximorphic features. A clayey soil aquitard may exist within a few feet below grade, but still have a suitable layer for infiltration within 5 feet below the proposed grade.

Native soil interface: The surface at which stormwater runoff is proposed to infiltrate. This surface is below an engineered soil layer (see Figures 2-4).

OSHA: Occupational Safety and Health Administration, a government agency to assure safe and healthy working conditions for working men and women (www.osha.gov).
Percent fines: Percentage of given sample of soil which passes through a #200 sieve.

Perched conditions: A soil moisture regime where saturated soil (i.e., wet soil) is located above unsaturated soil (i.e., moist soil).

Permeable pavement system: A pavement system that allows movement of storm water through the pavement surface and into a base/subbase reservoir designed to achieve water quality and quantity benefits.

Proposed grade: The proposed final design elevation and grade of the development. This is the top of topsoil, walkways, planting beds, roads, and parking areas.

Rain garden: A shallow, vegetated depression that captures storm water runoff and allows it to infiltrate.

Regional device: An infiltration system that receives and stores storm water runoff from multiple structures. Infiltration basins are the most commonly used regional infiltration devices.

Soil borings: For the purposes of this standard, soil borings are drilled, bored, cored or dug holes in the ground to obtain data from an unmixed soil sample, such as from a hollow stem auger or split spoon sampler. Mixed soil samples, such as those from a power auger, are not acceptable.

Soil compaction: An increase in bulk density of the soil. The more pressure per unit area exerted on soil, the greater the increase in bulk density, which leads to a decrease in infiltration. Also known as “soil structure degradation.”

Soil compaction mitigation: Taking action to decrease bulk density of the soil, which might be accomplished by a combination of mechanical, vegetative and/or chemical means. Example of compaction mitigation include: deep tilling, deep ripping, soil amendment and establishment of deep-rooted vegetation.

Soil parent material: The un consolidated material, mineral or organic, from which the solum develops.

Solum: The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soils includes the A and B horizons.

Static infiltration rate: Infiltration rate as measured for standing water.

Subsurface dispersal system: An exfiltration system that is designed to discharge storm water through piping below the ground surface, but above the seasonal high groundwater table (subject to the applicable requirements of ch. NR 815, Wis Adm. Code).

Vegetated swale: A constructed stormwater conveyance system designed to achieve water quality and quantity benefits.
Figure 1:
Site Evaluation for Infiltration Flow Chart of Steps

Step A - Initial Site Screening
- Review existing information without field work

Step B - Preliminary Field verification of Initial Site Screening
- Field verify information from Step A
- Depth to bedrock and groundwater

Step C - Establishment of Design Infiltration Rate
- Determine if proposed infiltration sites are suitable

Step C.1 - Field Evaluation of Specific Infiltration Areas
- Soil evaluation with pits

Step C.2 - Infiltration Rate Determination
- Examine design infiltration rate using one of the following options

Step C.2 - Option 1 - Infiltration Rate Not Measured, Compaction Mitigated

Step C.2 - Option 2 - Infiltration Rate Measured With In-Field Device, Compaction Mitigated

Step C.2 - Option 3 - Infiltration Rate Not Measured, Compaction Not Mitigated

Step C.2 - Option 4 - Infiltration Rate of Existing Vegetated Swales

Step D - Soil and Site Evaluation Report
Figure 2:
Example Bioretention Basin Section

Notes

A NR 151 and SPS 382 require minimum separation distance from the native soil interface and seasonal high groundwater/bedrock
B Soil evaluation depth shall be at least 5 feet below the native soil interface, unless seasonal high groundwater/bedrock is reached
C Refer to Technical Standard 1004 Bioretention for Infiltration for additional design details
D Engineered soil is not used for estimating the *in situ* soil infiltration rate
E Engineered soil layer shall be above the seasonal high groundwater level
F Excavation sidewalls are not included in the infiltration surface
G Location of infiltration testing is at the native soil interface
Figure 3:  
Example Bioretention Basin with Underdrain Section

Notes
A NR 151 and SPS 382 require minimum separation distance from the native soil interface and seasonal high groundwater/bedrock
B Soil evaluation depth shall be at least 5 feet below the native soil interface, unless seasonal high groundwater/bedrock is reached
C Refer to Technical Standard 1004 Bioretention for Infiltration for additional design details
D Engineered soil is not used for estimating the *in situ* soil infiltration rate
E Engineered soil layer shall be above the seasonal high groundwater level
F Groundwater mounding may enter the filter layer
G Underdrain and rock storage is not part of filter layer
H Excavation sidewalls are not included in the infiltration surface
I Location of infiltration testing is at the native soil interface
Figure 4: Example Infiltration Basin Section

Notes

A NR 151 and SPS 382 require a minimum separation distance from the native soil interface and seasonal high groundwater/bedrock.

B Soil evaluation depth shall be at least 5 feet below the native soil interface, unless groundwater/bedrock is reached.

C Soil amendment, such as compost, may be tilled into the top 1-2 feet of soil.

D Excavation sidewalls are not included in the infiltration surface.

E Location of infiltration testing is at the native soil interface.
Attachment 1:

SOIL AND SITE EVALUATION – STORM

In accordance with SPS 382.365, 385, Wis. Adm. Code, and WDNR Standard 1002

Attach a complete site plan on paper not less than 8 1/2 x 11 inches in size. Plan must include, but not limited to: vertical and horizontal reference point (BM), direction and percent of slope, scale or dimensions, north arrow, and BM referenced to nearest road.

Please print all information

Personal information you provide may be used for secondary purposes [Privacy Law, s. 15.04(1)(m)].

<table>
<thead>
<tr>
<th>Property Owner</th>
<th>Property Location</th>
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<table>
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<tr>
<th>City</th>
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<thead>
<tr>
<th>Drainage area</th>
<th>sq. ft</th>
<th>acres</th>
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Test site suitable for (check all that apply):  
- Site not suitable:
- Bioretenchore
- Subsurface Dispersal System
- Reuse:
- Irrigation:
- Other:__________

Hydraulic Application Test Method

- Morphological Evaluation
- Double Ring Infiltrometer
- Other:__________

Soil Moisture Date of soil borings:__________

USDA NRCS WETS Value:
- Dry = 1;
- Normal = 2;
- Wet = 3;

<table>
<thead>
<tr>
<th>OBS.</th>
<th>Pit</th>
<th>Boring</th>
<th>Ground surface elevation</th>
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<th>Elevation of limiting factor</th>
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<td>Horizon</td>
<td>Depth In.</td>
<td>Dominant Color</td>
<td>Munsell</td>
<td>Redox Description</td>
<td>Gr. Sz. Cont. Color</td>
<td>Texture</td>
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Comments:__________

CST/PSS Name (Please Print)__________

Signature__________

CST/PSS Number__________

Address__________

Date Evaluation Conducted__________

Telephone Number__________

SBD-10793 (R01/17)
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### Comments:

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### Overall Site Comments:
Attachment 2:
Technical Note for Infiltration in Compacted Soils

The table below documents the approach used for developing multipliers for unmitigated incidental compaction in swales.

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Infiltration Rate, inches/hour</th>
<th>Ratio (B/A)</th>
<th>Compaction Multiplier$^4$</th>
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</thead>
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<tr>
<td></td>
<td>Table 2 Site Evaluation for Infiltration 1002$^3$</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(A)</td>
<td>(B)</td>
<td></td>
</tr>
<tr>
<td>Sand</td>
<td>Coarse Sand or Coarser</td>
<td>3.6</td>
<td>3.26$^3$</td>
</tr>
<tr>
<td>Loamy Coarse Sand</td>
<td>3.6</td>
<td>3.26$^3$</td>
<td>0.91</td>
</tr>
<tr>
<td>Sand</td>
<td>3.6</td>
<td>3.26$^3$</td>
<td>0.91</td>
</tr>
<tr>
<td>Loamy Sand</td>
<td>1.63</td>
<td>1.467</td>
<td>0.90</td>
</tr>
<tr>
<td>Loam</td>
<td>Sandy Loam, fine sand, loamy sand, very fine sand, and loamy fine sand</td>
<td>0.5</td>
<td>0.22$^3$</td>
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<tr>
<td>Loam</td>
<td>0.24</td>
<td>0.11</td>
<td>0.46</td>
</tr>
<tr>
<td>Silt Loam</td>
<td>0.13</td>
<td>0.014$^3$</td>
<td>0.11</td>
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<tr>
<td>Sandy Clay Loam</td>
<td>0.11</td>
<td>0.0242</td>
<td>0.22</td>
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<tr>
<td>Clay</td>
<td>Clay Loam</td>
<td>0.03</td>
<td>0.0066$^3$</td>
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<td>Silty Clay Loam</td>
<td>0.04$^5$</td>
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<td>0.23</td>
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<td>Sandy Clay</td>
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<td>0.25</td>
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<tr>
<td>Silty Clay</td>
<td>0.07</td>
<td>0.002</td>
<td>0.03</td>
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<tr>
<td>Clay</td>
<td>0.07</td>
<td>&lt;0.002$^3$</td>
<td>0.03</td>
</tr>
</tbody>
</table>

1 Infiltration rates represent the lowest value for each textural class presented in Table 2 of Rawls, 1998.
2 Compacted soils data from Table 8 (Standard Compaction) of Pitt, R., et al. 2003.
3 Extrapolated number
4 Multipliers were developed from a ratio of the compacted soil infiltration rates from the Pitt, R. et al. 2003 research and Table 2 Site Evaluation for Infiltration 1002 infiltration rates, then simplified into three categories.
5 Infiltration rate in Table 2 Site Evaluation for Infiltration 1002 is an average based on Rawls 1982 and Clapp and Hornberger, 1978.