

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 rate* is used.

III. Conditions where Practice Applies

This standard is intended for development sites being considered for stormwater infiltration devices. Additional site location requirements may be imposed by other stormwater infiltration device technical standards.

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 infiltration devices. This standard does not contain the text of federal, state or local laws.

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 screening is to determine if installation is limited by ss. NR 151.12(5)(c)5. or NR 151.12(5)(c)6., and to determine where field work is needed for Step B. Optimal locations for infiltration are verified in Step B.

Information collected in Step A will be used to explore the potential for multiple infiltration areas versus relying on a regional infiltration device. Smaller infiltration devices dispersed around a development are usually more sustainable than a single *regional device* that is more likely to have maintenance and groundwater mounding problems.

The initial screening shall determine the following:
Note: Useful references for the existing resource maps and information are listed in Considerations VI.I and J.

1. Site topography and slopes greater than 20%.
2. Site soil infiltration capacity characteristics as defined in NRCS County soil surveys.
3. *Soil parent material*.
4. Regional or local depth to groundwater and bedrock. Use seasonally *high groundwater* information where available.

¹ Words in the standard that are shown in italics are described in VIII. Definitions. The words are italicized the first time they are used in the text.

5. Distance to sites listed on the GIS Registry of Closed Remediation sites within 500 feet from the perimeter of the development site.
6. Distance to sites listed on the Bureau of Remediation and *Redevelopment* Tracking System within 500 feet from the perimeter of the development site.
7. Presence of endangered species habitat.
8. Presence of flood plains and flood fringes.
9. Location of hydric soils based on the USDA County Soil Survey and wetlands from the WDNR Wisconsin Wetland Inventory map.
10. Sites where the installation of stormwater infiltration devices is excluded, due to the potential for groundwater contamination, by chapter NR 151 Wis. Adm. Code.
11. Sites exempted by chapter NR 151 Wis. Adm. Code from the requirement to install infiltration devices.
12. Potential impact to adjacent property.

Step B. Field Verification of the Initial Screening

- A. Field verification is required for areas of the development site considered suitable for infiltration. This includes verification of Step A.1, 2, 3, 4, 9, 10 and 11.
- B. Sites shall be tested for depth to groundwater, depth to bedrock and *percent fines* information to verify any exemption and exclusion found in Step A.10 and 11. The following is a description of the percent fines expected for each type of soil textural classification.
 1. Several textural classes are assumed to meet the percent fines limitations of Ch. NR 151.12(5)(c)5.i. for both 3 and 5 foot soil layers. These classifications include the sandy loams, loams, silt loams and all the clay textural classifications. *Coarse sand* is the only soil texture that by definition will not meet NR 151.12(5)(c)5.i. limitations for a 3 foot soil layer consisting of 20% fines. Other sand textures and loamy sands may need the percent fines level verified with a laboratory analysis.
 2. Borings and pits shall be dug to verify soil infiltration capacity characteristics and to determine depth to groundwater and bedrock.
- C. The following information shall be recorded for Step B:
 1. The date or dates the data 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 or fully dimensional.
 - b. Illustrates the entire development site.
 - c. Shows all areas of planned filling and/or cutting.
 - d. Includes a permanent vertical and horizontal reference point.
 - e. Shows the percent and direction of land slope for the site or contour lines. Highlight areas with slopes over 20%.
 - f. Shows all flood plain information that is pertinent to the site.
 - g. Shows the location of all pits/borings included in the report.
 - h. Location of wetlands as field delineated and surveyed.
 - i. Location of karst features, private wells within 100 feet of the development site, and public wells within 400 feet of the development site.
3. 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. Frozen soil material must be thawed prior to conducting evaluations for soil color, texture, structure and consistency. In addition to the data determined in Step B, soil profiles must include the following information for each soil horizon or layer:
 - a. Thickness, in inches or decimal feet.
 - b. Munsell soil color notation.
 - c. Soil mottle or redoximorphic feature color, abundance, size and contrast.
 - d. USDA soil textural class with rock fragment modifiers.
 - e. Soil structure, grade size and shape.
 - f. Soil consistence, root abundance and size.
 - g. Soil boundary.
 - h. Occurrence of saturated soil, groundwater, bedrock or disturbed soil.

Step C. Evaluation of Specific Infiltration Areas

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.

A minimum number of borings or pits shall be constructed for each infiltration device (Table 1). The following information shall be recorded for Step C:

1. All the information under Step B.C.3.
2. A legible site plan/map that is presented on paper no less than 8 1/2 X 11 inches in size and:
 - a. Is drawn to scale or fully dimensional.
 - b. Illustrates the location of the infiltration devices.
 - c. Shows the location of all pits and borings.
 - d. Shows distance from device to wetlands.
3. An analysis of groundwater mounding potential is required as per Table 1. The altered groundwater level, based on mounding calculations, must be considered in determining the vertical separation distance from the infiltration surface to the *highest anticipated groundwater elevation* as specified in NR 151. References include but are not limited to Finnemore 1993 and 1995, and Hantush 1967.
4. One of the following methods shall be used to determine the design infiltration rate:
 - a. Infiltration Rate Not Measured - Table 2 shall be used if the infiltration rate is not measured. Select the design infiltration rate from Table 2 based on the least permeable soil horizon five feet below the bottom elevation of the infiltration system.
 - b. Measured Infiltration Rate - The tests shall be conducted at the proposed bottom elevation of the infiltration device. If the infiltration rate is measured with a *Double-Ring Infiltrometer* the requirements of ASTM D3385 shall be used for the field test.

The measured infiltration rate shall be divided by a correction factor selected from Table 3. 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.

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.

To select the correction factor from Table 3, the ratio of design infiltration rates must be determined for each place an infiltration measurement is taken. The design infiltration rates from Table 2 are used to calculate the ratio. To determine the ratio, the design infiltration rate for the surface textural classification is divided by the design infiltration rate for the least permeable soil horizon. For example, a device with a loamy sand at the surface and a least permeable layer of loam will have a design infiltration rate ratio of about 6.8 and a correction factor of 4.5. The depth of the least permeable soil horizon should be within five feet of the proposed bottom of the device or to the depth of a limiting layer.

5. To determine if infiltration is not required under NR 151.12(5)(c)6.a., a scientifically credible field test method is required unless the least permeable soil horizon five feet below the bottom of infiltration system is one of the following: sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, or clay. The infiltration rate used to claim the exemption shall be the actual field measurement and shall be used without the correction factors found in Table 3.

Step D. Soil and Site Evaluation Report Contents

The site's legal description and all information required in Steps B and C shall be included in the Soil and Site Evaluation Report. These reports shall be completed prior to the *construction plan* submittal.

Table 1: Evaluation Requirements Specific to Proposed Infiltration Devices

Infiltration Device	Tests Required¹	Minimum Number of Borings/Pits Required	Minimum Drill/Test Depth Required Below the Bottom of the Infiltration System
<i>Irrigation Systems</i> ²	Pits or borings	NA ²	5 feet or depth to <i>limiting layer</i> , whichever is less.
<i>Rain Garden</i> ²	Pits or Borings	NA ²	5 feet or depth to limiting layer, whichever is less.
<i>Infiltration Trenches</i> (≤ 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.
<i>Infiltration Trenches</i> (> 2000 sq ft of impervious drainage area)	<ul style="list-style-type: none"> • 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
<i>Bioretention Systems</i>	<ul style="list-style-type: none"> • 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
<i>Infiltration Grassed Swales</i>	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
<i>Surface Infiltration Basins</i>	<ul style="list-style-type: none"> • Pits or borings • Mounding potential 	2 pits required per infiltration area with an additional 1 pit or boring for every 10,000 square feet of infiltration area, and sufficient to determine variability	Pits to 10 feet or depth to limiting layer Borings to 20 feet or depth to limiting layer
<i>Subsurface Dispersal Systems</i> greater than 15 feet in width.	<ul style="list-style-type: none"> • Pits or borings • Mounding potential 	2 pits required per infiltration area with an additional 1 pit or boring for every 10,000 square feet of infiltration area, and sufficient to determine variability	Pits to 10 feet or depth to limiting layer Borings to 20 feet or depth to limiting layer
<i>Permeable Pavement Systems</i>	<ul style="list-style-type: none"> • Pits or borings • Mounding potential 	2 pits required per infiltration area with an additional 1 pit or boring for every 10,000 square feet of infiltration area, and sufficient to determine variability	Pits to 10 feet or depth to limiting layer Borings to 20 feet or depth to limiting layer

¹Continuous soil borings shall be taken using a bucket auger, probe, split-spoon sampler, or shelby tube. Samples shall have a minimum 2-inch diameter. Soil pits must be of adequate size, depth and construction to allow a person to enter and exit the pit and complete a morphological soil profile description.

²Information from Step B is adequate to design rain gardens and irrigation systems.

Table 2: Design Infiltration Rates for Soil Textures Receiving Stormwater

Soil Texture ¹	Design Infiltration Rate Without Measurement inches/hour ²
Coarse sand or coarser	3.60
Loamy coarse sand	3.60
Sand	3.60
Loamy sand	1.63
Sandy loam	0.50
Loam	0.24
Silt loam	0.13
Sandy clay loam	0.11
Clay loam	0.03
Silty Clay loam	0.04 ³
Sandy clay	0.04
Silty clay	0.07
Clay	0.07

¹Use sandy loam design infiltration rates for fine sand, loamy fine sand, very fine sand, and loamy fine sand soil textures.

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

³ Infiltration rate is an average based on Rawls, 1982 and Clapp & Hornberger, 1978.

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

¹Ratio 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.

Required Qualifications

- A. Site Evaluations - Individuals completing site evaluations shall be a licensed professional acceptable to the authority having jurisdiction and have experience in soil investigation, interpretation and classification.
- B. Soil Evaluations - Individuals completing the soils evaluation shall be a Soil Scientist licensed by the Department of Regulation and Licensing or other licensed professional acceptable to the authority having jurisdiction.

VI. 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:

- A. Groundwater monitoring wells, constructed as per chapter NR 141, Wis. Adm. Code, can be used to determine the seasonal *high groundwater level*. Large sites considered for infiltration basins may need to be evaluated for the direction of groundwater flow

- B. Karst Inventory Forms on file with the Wisconsin Geological and Natural History Survey should be filled out if a karst feature is located within the site.
- C. Cation Exchange Capacity (CEC) of the soil can indicate the number of available adsorption sites. Sandy soils have limited adsorption capacity and a CEC ranging from 1-10 meq/100g. Clay and organic soils have a CEC greater than 20 and have a high adsorption rate.
- D. Soil organic matter and pH can be used to determine adsorption of stormwater contaminants. A pH of 6.5 or greater is optimal. A soil organic content greater than 1 percent will enhance adsorption.
- E. NR 151 provides for a maximum area to be dedicated for infiltration depending upon land use. This cap can be voluntarily exceeded.
- F. 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 that receive runoff from one lot or a single source area within a lot, such as rooftop or parking lot.
- G. Stormwater infiltration devices may fail prematurely if there is:
 - 1. An inaccurate estimation of the Design Infiltration Rate;
 - 2. An inaccurate estimation of the seasonal high water table;
 - 3. Excessive compacting or sediment loading during construction;
 - 4. No pretreatment for post-development and lack of maintenance.
- H. No construction erosion should enter the infiltration device. This includes erosion from site grading as well as home building and construction. If possible, rope off areas selected for infiltration during grading and construction. This will preserve the infiltration rate and extend the life of the device.
- I. Resources available for completing Step A. Initial screening:
 - 1. Sites listed on the GIS Registry of Closed Remediation sites.
<http://gomapout.dnr.state.wi.us/org/at/et/geo/gwur/index.htm>
- 2. Sites listed in the Bureau of Remediation and Redevelopment Tracking System.
<http://dnr.wi.gov/org/aw/rr/brrts/index.htm>
- 3. Flood plain areas as regulated under s. 87.30, Wis. Stats. and NR 116, NR 30 and NR 31, Wis. Adm. Code.
- 4. Wetlands as defined in Ch. NR 103, Wis. Adm. Code.
- 5. Endangered species habitat as shown on National Heritage Inventory County maps
- 6. Access points and road setbacks as determined by county or municipal zoning plans.
- 7. Existing reports concerning the groundwater and bedrock. Examples include: Publications from USGS, NRCS, Regional Planning Commissions, DNR, DATCP, DOT, UW system or WGNHS.
- 8. The Drinking Water and Groundwater pages of the DNR
<http://dnr.wi.gov/org/water/dwg/>
- 9. The Wisconsin Grain Size Database
<http://www.geology.wisc.edu/~qlab/>
- J. 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.
- K. Slopes 20% or greater are inappropriate for some infiltration devices.
- L. Expect to complete the preliminary design work (Criteria Step A through Step C) before the approval process (platting). Once required information is compiled, the initial design work for an infiltration device can begin.
- M. The approval 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 might have to be adjusted for the type of approval process. The following is an example of when the steps might be completed for a typical development site requiring a plat. The sequence in the example would comply with the criteria for timing of Steps A, B, and C.

Step A should be completed before the preliminary plat and Step B should be completed before the final plat, or CSM is approved. For regional infiltration devices, and for devices constructed on public right-of-ways, public land or jointly owned land, Step C should be completed before the final plat or final CSM approval.

It can be difficult to select the final location and drainage area for an infiltration device before the use of the lot is known. Sometimes it is more desirable to design an infiltration device for an individual lot after the lot is purchased. For this situation Step C would be completed after the final plat is approved. The information for Step C would be collected when the lot is purchased. To give future devices credit towards achieving the infiltration performance standard, the final plat would contain approximate sizing information for each device. Information from Step A and B would be used to determine the approximate sizing information.

- N. The inner ring of the Double-Ring Infiltrometer should be at least 12 inches in diameter.
- O. Section NR 151.12(5)(c)5., is included in the administrative code as a means to discourage infiltration of runoff from or into the listed areas, due to potential concerns of groundwater contamination. Although it is not illegal to infiltrate storm water in areas with the listed limitations, DNR will not give credit for this infiltration towards meeting the infiltration requirements of ss. NR 151.12(5)(c)1. or NR 151.12(5)(c)2. Runoff that is infiltrated must be in compliance with s. NR 151.12(5)(c)8., which requires minimizing infiltration of pollutants so that groundwater quality standards are maintained.

VII. References

Armstrong, D.E. and R.L. Llena, 1992. Project Report on Stormwater Infiltration: Potential for Pollutant Removal, Water Chemistry Program University of Wisconsin-Madison to the U.S. EPA.

ASTM D 3385 – 88, 1988. Standard Test Method for Infiltration Rate of Soils in Field Using Double-Ring Infiltrometers.

Bachhuber, J., Bannerman, R.T., and Corsi, S., 2001. ETV Verification Protocol Stormwater Source Area Treatment Technologies, NSF International, Ann Arbor, Michigan.

Bouwer, H., 1978. Groundwater Hydrology, McGraw-Hill Book Company.

Clapp, R.W. and G.M., Hornberger. 1978. Empirical equations for some hydraulic properties. Water Resources Research 14:601-604.

Comm 83, Wis. Adm. Code

Comm 85, Wis. Adm. Code

Ferguson, B.K., 1994. Stormwater Infiltration, CRC Press Inc.

Freeze, R.A and J.A. Cherry, 1979. Groundwater, Prentice-Hall, Inc., 604 pgs.

Finnemore, E. J., 1993. Estimation of Ground-Water Mounding Beneath Septic Drain Fields. Groundwater, Vol. 31 No. 6, pp. 884-889.

Finnemore, E.J., 1995. A program to calculate Ground-Water Mound Heights. Groundwater, Vol. 33, No. 1.

Hantush, M. S., 1967. Growth and Decay of Groundwater-Mounds in Response to Uniform Percolation. Water Resources Research, Vol. 3, No. 1, pp. 227-234.

Lowndes, M., 2000. "Infiltration Basins and Trenches" The Wisconsin Stormwater Manual, G3691-3.

McHenry County Soil and Water Conservation District USDA Natural Resources Conservation Service, 1991. Additional Requirements for subdivision to be served by septic systems.

NR 141, Wis. Adm. Code

NR 140, Wis. Adm. Code

Rawls, W.J., D.L. Brakensiek and K.E. Saxton, 1982. Estimation of Soil Water Properties, Transactions of the American Society of Agricultural Engineers Vol. 25, No. 5 pp. 1316 –1320 and 1328.

Rawls, W.J., Gimenez, and Grossman, R., 1998. Use of Soil Texture, Bulk Density and Slope of Water Retention Curve to Predict Saturated Hydraulic Conductivity, ASAE, Vol. 41(2), pp. 983-988.

Tyler, J.E. and Converse, J.C., 1994. Soil Acceptance of onsite wastewater as affected by soil morphology and wastewater quality. In: D. Sievers (ed.) On-site wastewater treatment. Proc. of the 8th International Symposium on Individual and Small Community Sewage Systems. ASAE. St. Joseph, MI.

Tyler, J.E. and Kuns, L. Kramer, Designing with Soil: Development and Use of a Wastewater Hydraulic Linear and Infiltration Loading Rate Table, unpublished.

U.S. EPA, February, 2002. Onsite Wastewater Treatment Systems Manual, EPA/625/R-00/008.

Washington State Department of Ecology, 2001. Stormwater Management Manual for Western Washington, Publication Numbers 99-11 through 99-15.

VIII. Definitions

Bioretention systems (Table 1): Bioretention is an infiltration device 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.

Construction Plan (V.Step D): A map and/or plan describing the built-out features of an individual lot.

Coarse sand (V.Step B.B.1): Soil material that contains 25% or more very coarse and coarse sand, and <50% any other one grade of sand.

Design infiltration rate (II.3): A velocity, 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 to be minimal rates for the different types of soils. Selection of minimal rates will provide a robust design and maximize the longevity of the device.

Development site (I.1): 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.

Double-ring infiltrometer (V.Step C.4.b): 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.

High groundwater level (V.Step A.4): 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 elevation (V.Step C.3): The sum of the calculated mounding effects of the discharge and the seasonal high groundwater level.

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

Infiltration basin (Table 1): 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 (II.2): 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 (Table 1): An excavated trench that is usually filled with coarse, granular material in which stormwater 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.

Irrigation system (Table 1): A system designed to disperse stored stormwater to lawns or other pervious areas.

Limiting layer (Table 1): A limiting layer can be bedrock, an aquatard, aquaclude or the seasonal high groundwater table.

Percent fines (V. Step B.B): the percentage of a given sample of soil, which passes through a # 200 sieve.

Permeable pavement systems (Table 1): A pavement system that allows movement of stormwater through the pavement surface and into a base/subbase reservoir designed to achieve water quality and quantity benefits.

Rain garden (Table 1): A shallow, vegetated depression that captures stormwater runoff and allows it to infiltrate.

Regional device (V.Step A): An infiltration system that receives and stores stormwater runoff from a large area. Infiltration basins are the most commonly used regional infiltration devices.

Redevelopment (V.Step A.6): Areas where new development is replacing older development.

Soil parent material (V.Step A.3): The unconsolidated material, mineral or organic, from which the solum develops.

Subsurface dispersal systems (Table 1): An exfiltration system that is designed to discharge stormwater through piping below the ground surface, but above the seasonal high groundwater table.