4/25/2018
Updated 12/20/18

The purpose of these provisional standards is to provide design guidance for new practices included in the update of Ohio's Construction General Permit on 4/23/18. These provisional standards are provided until a fully updated and edited version of the Rainwater and Land Development manual (http://epa.ohio.gov/dsw/storm/technical_guidance.aspx) can be published.

John Mathews,
Ohio EPA, Division of Surface Water

The following provisional standards are included in this document:

- Infiltration Estimates for Stormwater Practice Planning
- Infiltration Testing for Stormwater Practice Design

RAINWATER AND LAND DEVELOPMENT PROVISIONAL APPENDIX A-#

INFILTRATION ESTIMATES FOR STORM WATER PRACTICE PLANNING

DATE: 12/20/18

NOTE: These estimates should be used for initial project planning and conceptual layout only – that is, to assess feasibility and develop a ballpark estimate of the area allocated to infiltration practices. The estimates are not adequate for final sizing or design of BMPs. Sizing and design of infiltration practices requires appropriate field measurement of field saturated hydraulic conductivity at the development site, at the specific location of proposed practices and at the proposed depth of excavation for the practices (See Appendix XX: Soil Infiltration Testing).

NOTE: These estimates are intended for undisturbed sites and should not be used for sites where the soil previously was subjected to cutting, filling, or grading.

<u>Introduction</u>

This guidance provides subgrade infiltration rate estimates for development projects that include infiltrating stormwater practices such as bioretention, pervious pavement, infiltration trenches and underground infiltration systems. The method outlined below is appropriate only for initial project conceptualization and planning.

Subgrade infiltration rate estimates for your site requires, at minimum:

1) Estimating the excavated depth of proposed infiltration practice(s);
2) Identifying the (USDA) soil texture at the proposed depth of excavation.

We recommend reviewing properties of all soil layers to identify best opportunities for infiltration.

<u>1. Estimating the Depth of Excavation for the Proposed Infiltration BMP</u>

It is often challenging early in the site planning and development process to know exact grading, drainage patterns and BMP locations. Typically, a rough estimate of final surface grade and the required design excavation depth for proposed infiltration BMPs will give us enough information to identify the soil layers (typically B or C horizons) where the excavated bottom of the BMP is likely be located (Figure XX). Examples for developing rough, first estimates are presented here:

1) Bioretention - Total section depth (i.e., drainage layer, aggregate layer, soil media, and mulch layer) for bioretention is a minimum of 42" and often reaches 54" or more. By adding that depth to the typical 18” to 30” surface basin depth (ponding plus freeboard) results in estimated excavation depths between 60” and 84”. In the absence of more definitive design information, assuming a BMP excavation depth between 60" and 72" depth is a good place to start.

2) Permeable Pavement - Total section depth (i.e., the pavement surface and all underlying aggregate) for permeable is a minimum of 15" below finish grade, and may be 40" or more to account for frost

penetration depth, an infiltration sump, and/or detention of larger storm events for peak discharge control. In the absence of more definitive design information, assuming an BMP excavation depth between 24" and 30" depth is a good place to start.
3) Infiltration Trench – A typical section depth for an infiltration trench will be 48 inches.

4) Underground Detention with Infiltration - Total section depth (i.e., the pavement surface, underlying aggregate and storage units) can range from 4 ft to over 8 ft depending on a number of factors. Calculating the required storage volume and the available BMP footprint is necessary to determine excavated depth.

2. Identifying the Soil Texture at the Proposed Depth of Excavation

There are two approaches to identifying the soil texture at the proposed depth of excavation for planned BMPs: (1) collect soil samples at the proposed depth of excavation and send to a laboratory for soil textural analysis (soil particle size distribution); or (2) use the USDA-NRCS Web Soil Survey to identify the soil texture at the proposed excavation depth for the mapped soil(s) at the project site.

Collecting Field Samples for Soil Texture Analysis

NOTE: The soil texture used for estimating soil infiltration rate is based on the USDA soil texture classification system (represented by the USDA soil textural triangle) (reference) and not AASHTO or USCS Classification Systems in common use for soil engineering evaluations.

Samples for soil texture analysis can be collected using a truck-mounted soil probe or a handheld auger. It is recommended the entire soil profile from the surface to at least two feet below the expected depth of practice be described, noting layering (horizonation) of distinct soil layers with both physical and qualitative descriptors (texture, coloration, organic matter content, structure, density, depth of water table or bedrock, if present).

Oftentimes geotechnical soil borings are used early in project development to evaluate site soils and/or geology for soil engineering properties and structural considerations. Soil samples at the depth(s) of interest are collected and submitted to a soils laboratory for USDA textural analysis. If soil boring samples are already being characterized for particle size distribution (PSD), the PSD can be used to establish USDA soil texture.
[See https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/home/?cid=nrcs142p2_054167]

Another option is to hire a professional soil scientist (https://www.ohiopedologist.com/consultant-list.html) to collect and submit samples at the proposed excavation depth(s).

Identifying Soil Texture through Web Soil Survey

1) Using your internet browser go to:
http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm

[Note: Web Soil Survey will not work under certain browser security settings. You may need to change the security settings on your browser to use Web Soil Survey.]

2) Click on the Green “Start WSS” button. This activates the Web Soil Survey (WSS).

3) Navigate to your Area of Interest (AOI). [There are several ways to navigate to your AOI - feel free to explore WSS to find which works best for your situation. One method is presented here.] Click on the “State and County” line left of the U.S. map. Enter “Ohio” and your county of interest, then click “View”. Your county of interest should appear.

Using the zoom tool (magnifying glass with +), progressively zoom in until your site is visible on the viewer. This may take a couple zooms.

Once your site can be clearly identified in the viewer, outline your site using one of the two Area of Interest (AOI) buttons at the top of the viewer. If your site fits neatly into a rectangle, use the left AOI button. If your site has an irregular shape, use the right AOI button.

Click on the appropriate AOI button, then select the first corner of your AOI. Use successive clicks until you have outlined the area, then double click to “set” or complete the Area of Interest. At this point you can save your AOI if you like (Recommended).

4) Click on the Soil Map tab. The Map showing all Map Unit Symbols within your area of interest will be generated. In addition, a Map Unit Legend table will be shown to the left of the map with Map Unit Symbols, Map Unit Names, Acreages within your AOI, and Percentage of AOI.

5) Within the Map Unit Legend table, click on the Map Unit Name for a soil of interest. A Map Unit Description will pop-up. In the lower half of the Map Unit Description will be a “Typical Profile” that will list depth and texture of typical soil layers for this soil. Record the soil texture at the depth(s) of interest.

[Note: Through the Soil Data Explorer tab, all of the available soil survey data for the mapped soils can be accessed and reports generated.]

6) Using the texture(s) identified, select the most limiting (lowest) infiltration rate from Table XXX.

<u>Estimated Infiltration Rate by Texture</u>

The following chart provides good estimates of subgrade infiltration rate based on texture.

Subgrade USDA Soil Texture	Clay Content %	Infiltration Rate (in/hr)
Sand	< 8	2.8
Loamy Sand	< 15	2.0
Sandy Loam	< 20	0.80

Loam	< 20	0.25
Loam	20 - 27	0.06
Silt Loam	< 20	0.10
Silt Loam	20 - 27	0.03
Silt	< 12	0.05
Sandy Clay Loam	20 - 35	0.07
Clay Loam	27 - 40	0.02
Silty Clay Loam	27 - 40	0.02
Silty Clay	40 - 50	0.01
Sandy Clay	35 - 50	< 0.005
Clay	> 40	< 0.005

How the Infiltration Rate Estimates Were Generated

Subgrade infiltration rate estimates were generated using a tool called the Soil Water Characteristic Calculator (Saxton and Rawls; http://hydrolab.arsusda.gov/soilwater/Index.htm) through the following steps:

(1) Organic matter was set to 0.5% to account for lower organic matter content in subsurface horizons.
(2) Compaction was set to 1.10 (Dense) to account for higher bulk density in subsurface horizon.
(3) Except for Loam and Silt Loam, the sand, silt and clay content was set by selecting the soil Texture Class from the pulldown menu. For Loam and Silt Loam, sand, silt and clay contents were selected by eye-balling a somewhat centrally located texture for the area below 20% clay and for the area between 20% and 27% clay content.
(4) Infiltration rate estimate was the resulting Saturated Hydraulic Conductivity generated by the Calculator.

RAINWATER AND LAND DEVELOPMENT PROVISIONAL APPENDIX A-#

INFILTRATION TESTING FOR STORM WATER PRACTICE DESIGN

DATE: 12/20/18

Introduction

This guidance provides procedures for field determination of subgrade infiltration rates that can be used for the design of infiltrating stormwater practices such as bioretention, pervious pavement, infiltration trenches, infiltration basins and underground infiltration systems. Subgrade infiltration tests often are part of a broader geotechnical investigation to evaluate soil characteristics and soil layering at locations proposed for infiltrating stormwater practices that will help the designer understand site and soil suitability or limitations.

Geotechnical Investigation

Information collected during geotechnical investigations is necessary to determine whether infiltration practices are a viable option. In addition to establishing infiltration rates for design, geotechnical investigations are used to evaluate slope stability, depth to bedrock or groundwater table, constructability and other site characteristics that affect infiltration practice suitability (WDOE, 2012).

Before - or in conjunction with - subgrade soil infiltration testing, soil borings or test pits should be used to evaluate the entire soil column from the soil surface to a depth (often 10-15 feet below original grade) that allows characterization all soil layers and identification of any impediments to infiltration including clay-dominated soil layers, compacted glacial till, water tables and/or bedrock. This investigation will also allow identification of more permeable sand or gravel layers, if present, that might be accessed to facilitate enhanced infiltration.

Infiltration Test Report

The infiltration test report should include (at minimum) (adapted from COIC, 2010):

- A map that identifies:
    - Project boundaries; [TOPO MAP??]
    - Surveyed soil map units;
    - General location(s)/outline(s) of proposed infiltration practices and outlets;
    - Location of infiltration tests;
    - Locations of soil borings or test pits;
    - Existing natural or constructed drainage features;
    - Proposed site structures and infrastructure including parking areas, roadways and drainage features;
- Logs of borings and/or test pits including groundwater elevation, if encountered);
- Results of infiltration tests including raw data, assumptions and calculations;
- Photograph(s) of the test pit and test set-up;

- Any pertinent field notes that help characterize the site and soil being tested;
- Conclusions and recommendations.

Infiltration Test Methods

Note: By law, everyone MUST contact the Ohio Utilities Protection Service (OUPS; http://www.oups.org/), 8-1-1 or 1 800 362 2764 to mark utilities at least 48 hours but no more than 10 working days (excluding weekends and legal holidays) before beginning ANY digging project.

Two infiltration methods are considered acceptable by Ohio EPA for determining design infiltration rate estimates for Table 4b post-construction stormwater practices (Ohio EPA, 2013):

(1) Single-ring Infiltrometer Method; or
(2) Pit Method.

Note: Bore hole infiltration tests and other similar small-diameter, 3-dimensional percolation methods are not acceptable methods for determining design infiltration rates for Table 4b Infiltration Practices (Ohio EPA, 2018). These methods overestimate subgrade infiltration rates by several orders of magnitude resulting in undersized infiltration bed areas that will not meet design drawdown requirements.

Single-Ring Infiltrometer Method

The Single-Ring Infiltrometer Method ponds water at a constant head in a ring (typically a section of steel pipe with a beveled edge) driven into the ground at the excavated depth for the proposed infiltration practice.[2]

Procedure (following Reynolds, 2008; Reynolds et al., 2002; and COIC, 2010)

1. Excavate a pit to the depth of excavation for the proposed infiltration practice. The pit must be large enough to conduct multiple tests in without disturbing the subgrade soil to be tested – a 4-foot wide by 6-foot long test pit bottom typically is sufficient for this purpose. The sides of the pit can be laid back or stepped as needed to facilitate entry/exit.
2. In the bottom of the test pit, use a hoe or other square-edged scraping tool to create a level soil test surface larger than the diameter of the infiltrometer ring. Make note of rocks, roots, macropores, smearing or any other conditions that might affect the test or intake rate. Photograph the test pit and area to be tested before the ring is placed.
3. Place the infiltration ring having a minimum inside diameter of 12 inches and a beveled leading edge [typically manufactured from a short (12” to 18” length recommended) section of steel

[2] Constant-head ring infiltrometer tests can be conducted using a single ring (Single-ring Infiltrometer) or two concentric rings (Double-ring Infiltrometer). It is recommended the tester utilize the Single-ring Infiltrometer Method with corrections for flow divergence and soil sorptivity. If a double-ring test is conducted: (1) the test must comply with ASTM D3385 (ASTM, 2009); (2) the inner ring must be a minimum 8-inch diameter and the outer ring a minimum 15-inch diameter; and (3) the infiltration rate used for design should be the final (steady state) constant-head infiltration rate divided by 2 to account for the effects of flow divergence and sorptivity.

pipe] on the level testing area and drive the ring into the subgrade soil surface a minimum 3 inch depth, leaving approximately 9" to 12" of pipe exposed above the soil surface (FIGURE XX). Check the surface of the soil inside and outside of the ring, especially near the wall of the ring, for cracking or separation of the soil from the ring wall. If there are signs of excessive cracking or disturbance, move and re-install the ring at another location. If the surface of the soil is only slightly disturbed along the ring, lightly tamp the soil inside and outside the wall to close the gap against the ring wall.

4. Place a double-layered section of plastic window screen inside the ring on the soil at the bottom of the ring to protect the soil from eroding when first introducing water into the ring. The screen should be slightly bigger than the ring area so that no soil is exposed to flowing water.
5. It is recommended for denser or tighter (clay loams or silt loams) that a Mariotte bottle be used to supply water and maintain a constant ponded head in the ring. In addition to maintaining a constant head, Mariotte bottles allow precise reading/recording of intake volume and intake rate. For coarser soils (sands, sandy loams and loams) with higher infiltration rates, a larger water reservoir (e.g., 5-gal bucket or 50-gal tank) with a spigot may be used to supply water – this water supply apparatus must be fitted with a flow meter or other precise method for measuring volume and rate of water supplied.
6. Ponding in the ring should be quickly brought up to a minimum of 6 inches (maximum 12 inches) and maintained at constant depth for the remainder of the constant head test. It typically will be most efficient to bring the ponding depth to within 1 inch of the target ponding depth by pouring water from a bucket rather than from a Mariotte bottle or other flow metering device, then using the metered water source to make fine adjustments to establish ponding at the target depth for the constant head test.
7. The time the constant ponding depth is reached should be noted, and this time denoted as "time zero" for purpose of the constant head test. The exact ponding depth to the nearest 0.1 inch should be noted and recorded at the first (time zero) and each subsequent reading to confirm consistent head is being maintained. Photograph the set-up during the test.
8. The volume of water supplied to the infiltrometer ring should be recorded at time increments sufficient to capture changes in the intake rate (i.e., the rate the water moves into the soil). Shorter time increments typically are necessary at the beginning of the test and can be extended as soil within the ring saturates and intake rate slows. For clayey soils (e.g., clay loam, silty clay loam) an initial time increment of 15 minutes may be sufficient, extending the time increment to 30 minutes between readings as intake rate slows. In contrast, sandy soils may require readings every minute or every 5 minutes throughout the test.
9. Water supply to the ring and readings recording the volume supplied should continue until a constant or steady state intake rate has clearly been established. A good rule of thumb is to discontinue the constant head test after one hour at constant intake rate (i.e., 3 consecutive readings of volume supplied with the readings taken at 30 minute increments) for tighter, clayey soils. This field saturated intake rate may take 3-4 hours (or more) to be reached. For sandier soils, a constant intake rate may be established within 1-2 hours.
10. Though not required, it is recommended once the constant head portion of the test is concluded, the water supply should be shut off and the depth of ponding recorded until the ponded water fully infiltrates into the ground or, if infiltration is slow, at 30 minute increments for two hours. This is an excellent check on intake rate.

11. To convert the final, steady state intake rate from (9) above into a field saturated infiltration rate to use in practice design, the field measured intake rate and test set-up (ring diameter, insertion depth, ponding depth) must be used to adjust the value to account for flow divergence and soil sorptivity. A spreadsheet is provided to make this conversion.

Pit Method

The PIT (Pilot Infiltration Test) method consists of excavating a large hole of known dimensions to, or just below, the depth of excavation for the proposed infiltration practice, inundating the resulting "pit" with water to simulate ponding within the proposed practice, and recording the volume and rate of water entering the soil. Henceforth, this test will be referred to as the Pit Method.

Procedure (adapted from COIC, 2010; WDOE, 2012, 2013)

1. Excavate a rectangular test pit with a bottom area between 25 and 40 ft^2 (e.g., 5 feet by 6 feet). The pit should be excavated such that the bottom of the test pit is located at the proposed excavated depth of the infiltration practice. Excavate the pit to as clean dimensions as possible, removing any sloughed soil, organics and other debris. The bottom 12" of the pit (minimum) should have vertical sidewalls, but above 12" the walls can be laid back (e.g., 1:1 slope) or stepped to facilitate entry.
2. Make note of rocks, roots, macropores, smearing or any other conditions that might affect the test or intake rate. Photograph the test pit.
3. Measure and record the dimensions (depth, length, width) of the test pit.
4. Taking care not to compact or smear the bottom of the pit, use a soil auger to "drill" a 2" diameter hole 6" below the bottom of the pit. Place a self-logging pressure transducer in the augered hole, recording at a 1 minute interval. Also place a vertical measuring stick (either a yardstick with markings at tenths and hundredths of a foot, or a metric yardstick with cm and mm markings, works well for this purpose) in the hole and note the height on the stick that coincides with the bottom of the test pit. [Note: If, because of soil type, the sidewalls of the pit are prone to sloughing when exposed to water, the sidewalls of the pit should be lined with porous, non-woven geotextile filter fabric (Spec??) and the pit backfilled with clean, uniform open-graded gravel (e.g., #57 or #4). If the pit is backfilled with gravel, it is recommended a 1-1/4 inch diameter PVC water level observation pipe be placed in the augered hole (with the vertical measuring stick) in which to place the recording pressure transducer. The PVC pipe should be capped at the bottom and have ¼-in holes drilled every 1-inch on center for the first 12 inches of pipe. Place the observation well and measuring stick first, then backfill the bottom of the pit around the observation well to a depth of 12 inches. The sidewalls of the pit should approximate vertical for the bottom of 12 inches of the pit but can be laid back (e.g., 1:1 sideslope) above 12 inch depth to facilitate placement of the filter fabric, if needed.]
5. Introduce clean water into the test pit using a hose connected to a rigid pipe with a splash plate on the bottom to discharge water into the pit without causing soil scouring or side-wall erosion. Excessive scouring or erosion will cause clogging of the infiltration bed, reducing measured infiltration rates.
6. Add enough water to the pit to bring the water level up to 12 inch (30 cm) depth, then shut off the water supply to pre-soak the infiltration bed. Pre-soaking is considered complete when the

water completely infiltrates into the ground or after 3 hours if water is still standing in the pit. [Depending on the soil, season and number of tests to be conducted, it may make sense to construct and pre-soak test pits one day then conduct infiltration measurements the following day.]

7. After completion of the pre-soaking, the tester should complete two falling head tests starting at 12 inch (30 cm) ponding depth. Raise the water level to a 12 inch (30 cm) depth. Record the volume of water needed to raise the water level to 12 inches. If there is still standing water (i.e., the pre-soak did not fully infiltrate), record water depth before filling begins. The time the 12 inch ponding depth is reached should be noted, and this time denoted as "time zero" for purpose of the infiltration test. Shut off the water supply and record the drop in water level at appropriate time increments for the rate of drawdown (this might be every minute for sandy soils or every half hour for clayey soils) until the water is fully infiltrated. The use of a self-logging pressure transducer as mentioned above will be taking this measurement, but such measurements should be taken with a stopwatch and readings from the measuring stick as well.
8. Photograph the set-up/conditions during the test.
9. After the water has completely infiltrated, repeat step 7.

Minimum Number of Pits and Infiltration Tests

Surface Area of Infiltration BMP (ft^2)	Number of Test Pits	Pit Tests	Single-ring Infiltrometer Tests (2 tests/pit)
<5000	2	2	4
5000-10000	3	3	6
>10000	4	4	8

References

ASTM. 2009. Standard Test Method for Infiltration Rate of Soils in Field Using Double Ring Infiltrometer. ASTM D3385 09. American Society for Testing and Materials. Philadelphia, PA.

COIC. 2010. Geotechnical Site Characterization. Chapter 4 in Central Oregon Stormwater Manual. Central Oregon Intergovernmental Council, Bend, OR.

Reynolds, W.D., D.E. Elrick, E.G. Youngs, and A. Amoozegar. 2002. Ring or Cylinder Infiltrometers (Vadose Zone). Section 3.4.3.2 in Dane, J.H. and G.C. Topp (Eds.), Methods of Soil Analysis - Part 4: Physical Methods. Soil Science Society of Agronomy. Madison, WI.

Reynolds, W.D. 2008. Saturated Hydraulic Properties: Ring Infiltrometer. Chapter 77 in Carter, M.R., and E.G. Gregorich (eds), Soil Sampling and Methods of Analysis, 2nd Ed. Canadian Society of Soil Science, CRC Press and Taylor & Francis Group. Boca Raton, FL.

WDOE. 2012. Stormwater Management Manual for Western Washington. Washington Department of Ecology, Olympia, WA.

WDOE. 2013. Methods for Evaluating Native Soil Infiltration Rates. Appendix B in Eastern Washington Low Impact Development Guidance Manual. Washington Department of Ecology, Olympia, WA.

===