APPENDIX C: INFILTRATION TESTING

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OVERVIEW OF INFILTRATION TESTING

Infiltration testing is used to determine the soil's infiltration rate. Performing infiltration testing allows BMPs to be adequately sized to drain within 30 hours and to not exceed the design ponding depth. Minimum infiltration rates are provided in **Chapter 4** "*Siting*" for each BMP. BMPs are sized for the either the water quality storm or the flow control design storm (See **Chapter 2**).

Sizing factors are provided for BMPs using the Simplified Sizing Approach. To size a BMP, infiltration testing must be performed as outlined in this Chapter at the location(s) of proposed BMPs. Refer to the "*LID Worksheets*" to determine what sizing factor is required for your BMP based on your design ponding depth and tested infiltration rate.

Infiltration based BMPs will have a larger footprint for soils with lower infiltration rates and will have smaller footprints for soils with higher infiltration rates. To minimize the size of a BMP, it is recommended to test multiple locations to find faster draining soils (See **Chapter 4**, "*Conserve fast(er) draining soils*"). If the Engineered Design Approach is used to size a BMP, infiltration testing must be performed by a qualified professional. Criteria for vertical separation must be met as specified in this Chapter and for the BMP requirements in **Chapter 4**.

APPLICABILITY

Infiltration Testing - Simplified Sizing Approach

Infiltration testing may be performed by the landowner or any other qualified licensed professional or contractor when using the Simplified Sizing Approach. All requirements for the Simplified Sizing Approach must be met as defined in **Chapter 2**. An **infiltration testing form** must be submitted to the City before constructing BMPs. When using the Simplified Sizing Approach to size a BMP, the following infiltration testing forms must be submitted to the City:

1. **Simplified Sizing Approach Infiltration Testing Form**
2. **Data entry form**
3. **Photo of infiltration testing setup**
    a. Include level indicator in photo

A copy of the Simplified Sizing Approach Infiltration Testing Form and an example Data Entry form are at the end of this chapter and available from the City website.

Infiltration Testing – Engineered Design Approach

Infiltration testing must be performed by a Professional Engineer, Registered Geologist, Soil Scientist or other professional testing service with equivalent training and experience in determining the permeability of soils when the Engineered Design Approach is used to size a BMP. All requirements for the Engineered Design Approach must be met as defined in **Chapter 2**.

Perform infiltration testing to implement the following BMPs:

Table C-1. List of BMPs requiring infiltration testing and sizing approaches applicable to each. BMPs sized with the Simplified Sizing Approach can be sized by the landowner or any other qualified licensed professional or contractor. BMPs sized with the Engineered Design Approach require a Professional Engineer, Registered Geologist, Soil Scientist or other professional testing service with equivalent training and experience in determining the permeability of soils.

Best Management Practice (BMP)	Simplified Sizing Approach†	Engineered Design Approach†	Is Infiltration Testing Required
Conserve fast(er) draining soils BMP			
Cluster Development BMP			
Tree Protection BMP			
Minimal Excavation Foundation BMP			
Construction Sequencing BMP			
Depave existing pavement BMP			
Restored Soil BMP			
Contained Planter BMP			
Tree Planting BMP			
Vegetated Roof (Green Roofs) BMP			
Porous Pavement BMP			
Rain Garden			
Stormwater Planter			
LID Swale BMP			
Soakage Trench BMP			
Drywell BMP			
Water Quality Conveyance Swale BMP			
Dispersion BMP			
Wet Pond			
Extended Wet Pond			
Dry Detention Ponds			
† Applies when meeting requirements in Chapter 2	=YES		=NO or N/A

TIMING

Tests should not be conducted:

- In the rain
- Within 24 hours of a storm greater than 1/2 inch, or
- When the ground is frozen.

Different protocol, as described below in "Test Infiltration", apply to wet-weather versus dry-weather testing.

LOCATION

The test measures infiltration of a very small and specific area.

In new developments and redevelopments with generous open space, infiltration tests should be performed across the proposed development area during the planning phase. Once the location of facilities is determined, additional design phase infiltration testing may be needed if the initial tests were not conducted within the footprint of the proposed facility.

In retrofits with limited areas to choose from, infiltration testing in the planning phase isn't needed. Simply test directly over the proposed facility location.

Never test under the canopy of a tree, since this could damage the tree. Healthy trees are critical to watershed health and should be protected, not damaged and removed to locate another stormwater management BMP (see **Chapter 4** "*Tree Protection BMP*"). Healthy trees provide "enhanced infiltration" (see **Chapter 5**) and can be assumed to be faster draining soils. Unhealthy trees should probably be removed from a development site, based on an arborist's report (see **Appendix A**), but if the health of a tree is unknown at the time of infiltration testing, test outside the canopy.

NUMBER OF TESTS

The number of infiltration tests for large sites varies widely. More tests are needed for sites with variable soil conditions than for sites that are uniform. In urban sites, where soils may have been disturbed a number of times over many years, soil conditions may vary greatly over small distances, so more tests may be needed. If the proposed facility has a large area, 1 test per 10,000 square feet within the area is recommended. A licensed engineer can assist with identifying soil uniformity and identifying the appropriate number of tests.

SAFETY

Always call 811 to locate utilities before testing begins[1]. Infiltration tests may require extensive excavation and can be potentially dangerous. Observe relevant Occupational Safety and Health Administration (OSHA) regulations.

EQUIPMENT NEEDED

To perform an infiltration test, you will need:

- Shovel and/or post-hole digger
- Yardstick or ruler
- Water source
- Some clean gravel (in clay soils)
- Pencil
- Paper
- Watch or timer
- Watering can (optional)

[1] *Oregon 811, Utility Notification Center. Retrieved from: http://digsafelyoregon.com/*

Figure C-1. Anyone fit enough to dig can perform an infiltration test with commonplace tools.

TESTING DEPTH

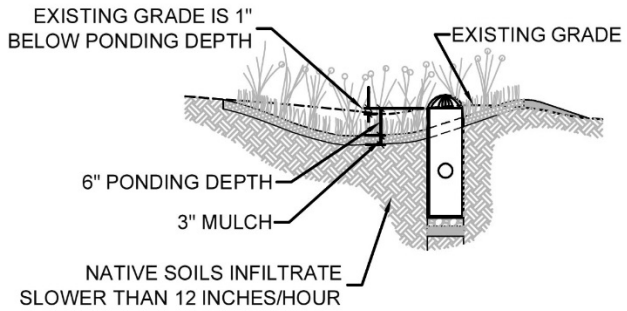
Testing depth varies with existing and final conditions, testing goals, and BMP choices. For testing depth of drywells, see **Chapter 4** "*Drywell BMP*" "*Infiltration Testing*".

Runoff prevention. If fast(er) draining soils will simply be conserved, an infiltration test depth of 6 inches to 12 inches into the soil just below the ground cover vegetation and topsoil, is sufficient depth.

Runoff reduction. Infiltration testing should be performed at the expected depth of the bottom of the facility; however, infiltration testing may also determine the depth of the facility, as well as the location. For example, soils just 6" below existing grade may be suitable for infiltration and have enough nutrients to support plant growth in a rain garden. Evaluate a very simple rain garden that doesn't replace or amend the native soils by testing the soils shallowly. Since the suitability at this shallow depth cannot be known until the test is completed, dig a few test holes at different elevations a few feet apart and test them simultaneously.

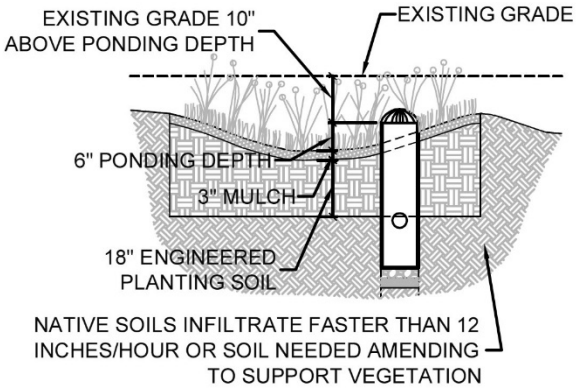
Existing and proposed finish grades should be used to determine appropriate testing depths for all applicable BMPs, similar to the examples below.

Example C-1 Simple infiltration rain garden (existing grade elevation similar to final grade)



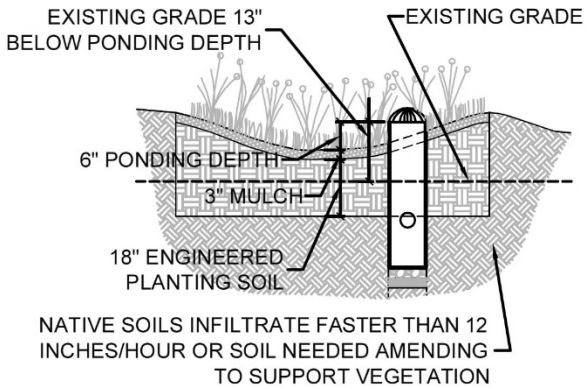
Infiltration testing depth = -1" (elevation difference) + 6" (ponding depth) + 3" (mulch) **= 8 inches below existing grade**

Example C-2 Infiltration rain garden with imported soil (existing grade elevation higher than final grade)



Infiltration testing depth = 10" (elevation difference) + 6" (ponding depth) + 3" (mulch) + 18" imported soil **= 37 inches below existing grade**

Example C-3 Infiltration rain garden with imported soil (existing grade elevation lower than final grade)



Infiltration testing depth = -13" (elevation difference) + 6" (ponding depth) + 3" (mulch) + 18" imported soil **= 14 inches below existing grade**

FALLING HEAD TEST

The falling head test is one of the oldest and simplest methods, commonly used for designing septic fields. It has been used successfully on LID projects for over 30 years by some professionals in the field and is the method recommended here. For testing method of drywells, see **Chapter 4** "*Drywell BMP*" "*Infiltration Testing*".

Perform a falling head test as follows:

1. Dig a test hole with a post-hole digger or a larger area with a shovel. The area of the hole doesn't matter. Dig a hole to the appropriate depth as discussed above.
2. If soils are clayey, scrape the sides of the hole a little (i.e. scarify). Remove the scraped material from the bottom of the hole and place an inch or so of clean gravel at the bottom; otherwise, the tiny clay particles will be suspended in the water to follow and form an impermeable barrier (appearing as a sheen) around the sides and bottom of the hole.
3. Push a pencil or nail into the side of the hole from which to measure the water level drop over time. The height above the bottom of the hole (or gravel if included) will determine the water

level depth. Because water is so heavy, deeper water will result in faster overall infiltration rates, so this is accounted for in the following:

- **Runoff Prevention.** Place the pencil or nail 6 inches above the bottom of the hole.
- **Runoff Reduction.** The depth of water should reflect the amount of water that might be ponded in a runoff reduction BMP. For instance, if the ponding depth will be 9 inches, then place the pencil or nail 9 inches above the bottom of the hole. If the ponding depth is unknown, 6 inches is conservative.

4. Fill the hole with water gently to the top of the pencil or nail. Record the exact time you stop filling the hole (if soils are fast draining, measure time down to the second) and the time it takes to drain completely.
5. If testing during the rainy season and soils are saturated, go on to step 6. If testing during the dry season and soils are dry, refill the hole again and repeat steps 2 to 4 **two more times**. The infiltration rate of the **third** test will give you the best measure of how quickly your soil absorbs water when it is fully saturated, as it would be during a rainy period of the year or during a series of storms that deliver a lot of rainfall in a short period of time. Occasionally, due to water changing the soil structure, infiltration rates can increase over short time periods during the test, but on average, the infiltration rate should generally decrease with each round.
6. To calculate the infiltration rate, divide the distance that the water dropped by the amount of time it took for it to drop. For example, if the water dropped 6 inches in 12 hours, then 6 divided by 12 equals 0.5 inches per hour.
7. If testing is for porous pavement managing direct rainfall only, skip to step 8. For rain gardens and stormwater planters and porous pavements managing runoff, if the slowest infiltration rate measured is less than 0.5 inches per hour, then dig another hole nearby, but 3 to 6 inches deeper, and repeat steps 1 to 4 to see if there's a faster draining soil that could be over excavated to. Repeat this process at various depths down to another 2 feet, or until you have at least 0.5 inches per hour infiltration. If you can't find a suitable area with an infiltration rate of at least 0.5 inches per hour, infiltration BMPs must be designed and modeled by a licensed engineer. Skip to step 9.
8. For porous pavements that infiltrate rainfall, if the slowest infiltration rate measured is less than 0.3 inches per hour, consider relocating the porous pavement to a faster draining soil.

Figure C-2. A shovel was used to dig most of the way then a 6" diameter post hole digger was used to reach the proposed bottom elevation of a rain garden. Measure the drop in water from a known, stable marker.

Confirm Vertical Separation

Two conditions for vertical separation should be met:

9. After infiltration testing is complete, dig the hole another 2 feet of depth from the bottom of the BMP (*i.e.* the elevation where water will begin to pond) to uncover bedrock or other impermeable subsurface layers that may impede infiltration. If the soil is pretty consistent all the way down then one criteria for vertical separation is met.
10. If testing during the wet weather season (Nov. 1st to April 1st), dig the hole one foot deeper to discover groundwater. If water doesn't seep into the hole, then groundwater is sufficiently deep and the second vertical separation criteria is met. If not testing during the wet weather season, hire a registered soil scientist, licensed engineer, registered geologist, or other qualified licensed professional to assist with assessing the depth of the seasonal high groundwater table.
11. Fill the hole back up and leave the site in a safe condition (*i.e. prevent a tripping hazard)*.

OTHER TESTING METHODS

There are numerous other methods to test the rate at which water will pass through the soil. One method that may be suitable for larger scale infiltration BMPs is the Pilot Infiltration Test, developed and recommended by the Washington Department of Ecology[2].

[2] *Washington State Department of Ecology, Water Quality Program. Stormwater Management Manual for Western Washington. Volume V: Runoff Treatment BMPs. Page B-1. (Feb. 2005). Retrieved from: https://fortress.wa.gov/ecy/publications/publications/0510033.pdf*

SIMPLIFIED SIZING APPROACH INFILTRATION TESTING FORM

Owner's Name:	
Mailing Address:	
Site Address:	
Email:	**Phone:**
Signature:	**Date:**

Complete form for each BMP

Infiltration Testing Information		**Infiltration Testing Results**			
BMP type:			Test 1	Test 2	Test 3
BMP ID:		Start time (of day)			
Infiltration test ID:		Duration (hours) (1 hour minimum)			
Test method:		Initial water depth (inches)			
Date of test:		Final water depth (inches)			
Depth of excavation (inches):		**Infiltration rate*** (inches/hour)			

*Infiltration Rate = (Initial Depth (in.) - Final Depth (in.)) / Duration of Test (hours)

Infiltration Testing Conditions		
	YES	NO
Test conducted in the rain.		
Test conducted within 24 hours of a storm > 1/2 inch.		
Test conducted when ground is frozen.		
Data entry form attached		
Was the soil dry before testing?		

****Attach a photo of the infiltration testing setup with water elevation marker clearly visible.****

Confirm Vertical Separation		
	YES	NO
Was an impermeable layer found 2 feet below initial depth of hole?		
Was testing during wet weather months (Nov. 1st to April 1st)?		
Did groundwater seep into testing hole after digging a foot deeper than initial depth (within 2 hours)?		

Test pit location (site plan sketch)

Key information to include: 1) Site or parcel, 2) Adjacent road(s) or cross street(s), 3) Tests pit location with dimensions and ID, 4) BMP sketch with dimensions and ID.

N

DATA ENTRY FORM

Tester's Name:		
Company (if applicable):		
Contact Number:		
Location:	**Date:**	**BMP ID:** **Infiltration test ID:**
Depth to bottom of hole:	**Hole diameter (inch):**	**Test method:**

Depth (inch):	**Soil Texture:**

Dry weather test repetition #	Time	Time interval (minutes)	Measured drop in water elevation from marker (inch)	Infiltration rate (inch/hour)	Notes/Comments:
1					
2					
3					