Appendix B - Infiltration Testing Methodology

Appendix B: Infiltration Testing

Perform an infiltration test to determine the soil's capacity to absorb and percolate water down into the lower layers. The infiltration test establishes the measured infiltration rate. The Design infiltration rate is determined by applying a safety factor of 3 to the measured infiltration rate. If the overseeing professional would like to use a different methodology, they must receive approval from the approving jurisdiction.

Applicability

Simplified Design Approach: The Falling Head Infiltration Testing method described below may be used for projects developing or redeveloping less than 10,000 square feet. This testing can be performed by anyone, but the results of the test must be submitted on the provided data form.

Performance Design Approach: For projects developing or redeveloping 10,000 square feet or more, infiltration testing must be overseen by an engineer or Registered Geologist licensed in the state of Oregon. One of the following methodologies must be used:

- Open pit falling head
- Encased falling head
- Double-ring infiltrometer

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. Tests must be conducted within the footprint of the proposed facility. Thus, 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 within the proposed facility location.

Never test under the canopy of a tree, since this could damage the tree.

Number of Tests

When using the Simplified Design Approach, at least 1 test must be conducted for each proposed SW facility.

The number of infiltration tests for large sites varies widely. At least 1 test per 10,000 square feet of land to be developed or redeveloped is required. 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. A geotechnical engineer can assist with identifying soil uniformity and identifying the appropriate number of tests. The approving jurisdiction reserves the right to require additional infiltration testing.

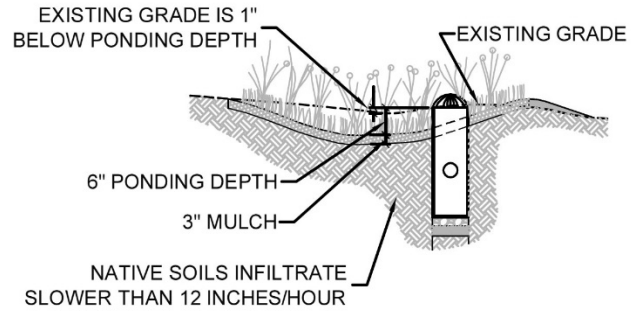
Testing depth

Testing depth varies with existing and final conditions, testing goals, and BMP choices.

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.

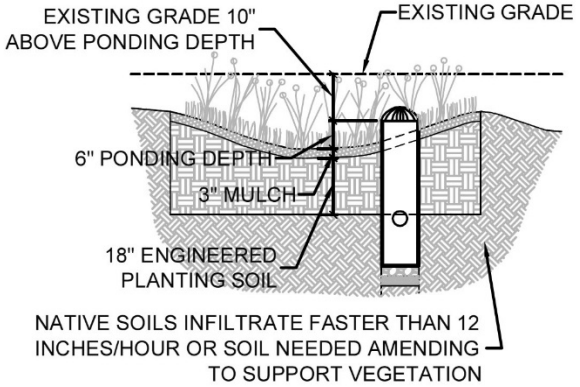
Runoff reduction. Infiltration testing should be performed at the expected depth of the bottom of the facility; however, infiltration testing may also determine the depth of the facility. Evaluate a very simple rain garden that doesn't replace or amend the native soils by testing the soils shallowly. 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 B-1 Simple infiltration rain garden (existing grade elevation similar to final grade)



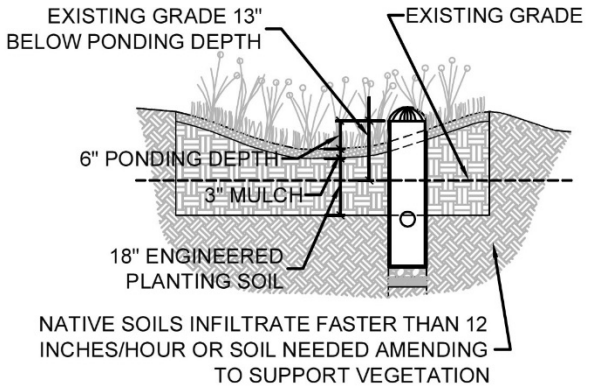
Infiltration testing depth = -1” (elevation difference) + 6” (ponding depth) + 3” (mulch) **= 8 inches below existing grade**

Example B-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 B-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 for the Simplified Design Approach

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.

Safety

Always call 811 (or visit http://digsafelyoregon.com/) to locate utilities before testing begins. Infiltration tests may require extensive excavation and can be potentially dangerous. Observe relevant Occupational Safety and Health Administration (OSHA) regulations. "Excavation should never be left unsecured and unmarked, and all applicable authorities should be notified prior to any work".

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
- Falling Head Soil Infiltration Testing Report Form
- Watch or timer
- Watering can (optional)

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

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. Perform a ribbon test as described below.
3. If soils are clayey, roughen 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 and will form an impermeable barrier (appearing as a sheen) around the sides and bottom of the hole.
4. 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.

5. 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). Measure and record the water level at regular intervals for a minimum of one hour, or until all the water has infiltrated. Record the distance between the water surface and the pencil at each time interval.
6. If testing during the rainy season and soils are saturated, go on to step 7. If testing during the dry season and soils are dry, refill the hole again and immediately repeat steps 2 to 5 two more times.
7. 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. The completed data sheet must be submitted to the approving jurisdiction with the Stormwater Management Report.
8. If testing is for porous pavement managing direct rainfall only, skip to step 9. 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 5 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, the Performance Design Approach must be used. Skip to step 10.
9. 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. If this is not possible and the infiltration rate below the porous pavement managing rainfall only is less than 0.3inches per hour, then the porous pavement must be designed using the Performance Approach.

Figure B-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:

10. 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, such as compacted ash, that may impede infiltration. If the soil is pretty consistent all the way down then one criteria for vertical separation is met.
11. If testing during the winter, 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 winter, hire a registered soil scientist, licensed geotechnical engineer, registered geologist, or other qualified licensed professional to assist with assessing the depth of the seasonal high groundwater table.
12. Fill the hole back up, and leave the site in a safe condition (*i.e. prevent a tripping hazard)*.

Ribbon Testing

As indicated above, to properly implement an infiltration facility, you need to approximately identify the soil texture of your existing native soils, which may range from more sandy to more clayey.
Determine soil texture:

1. Take a handful of the soil you have excavated from your infiltration test. Pulverize it in your hand and remove any bits of organic matter or obvious rocks.
2. Wet it with a small amount of water and rub it between your thumb and index finger. Don't saturate it until it is runny mud. You might feel stickiness, grittiness, or smoothness. The grittier the feel, the more sand is present in your soil. The slicker the soil, the more clay in it. Smooth soils are sometimes an indicator of a fine silt or loam. Discard the soil.
3. Next, take another sample in your hand. Wet it until it has the consistency of dough. You should be able to form a ball that holds together with the soil in your palm. If you cannot get the ball to form, then your soil is very sandy. In most soils, however, you should be able to create a rough ball.

Figure C-3. Step 3 of the ribbon test.

4. Knead the soil together between your thumb and fingers and attempt to form a ribbon. As you build the ribbon, it will either hold together or break off.

Figure C-4. Step 4 of the ribbon test.

Interpret Your Results. If the soil forms a ribbon:

- Less than 1 inch in length before it breaks, the soil is sandy or silty.
- 1 to 2 inches in length before it breaks, the soil is clayey (i.e. has some clay).
- Greater than 2 inches before it breaks, the soil is clay.

Performance Approach Methods

One of the following methodologies should be selected by the professional overseeing the test based on the site conditions and limitations of the method:

- Open pit falling head
- Encased falling head
- Double-ring infiltrometer

The City of Portland Stormwater Management Manual (2016) provides procedures for utilizing each method. Documentation of the method selected, the reason for selecting the method, a map of testing locations and results must be submitted with the stormwater management report.

References

City of Portland Stormwater Management Manual (2016). Chapter 2: Stormwater Facility and Conveyance Design, Submittal Requirements. Retrieved from: https://www.portlandoregon.gov/bes/index.cfm?&c=64040