CHAPTER 4 – GEOTECHNICAL SITE CHARACTERIZATION

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4.1 INTRODUCTION

The intent of this chapter is to outline the minimum requirements for a Geotechnical Site Characterization (GSC). The GSC is necessary to provide recommendations for stormwater disposal and to determine sub-level structure construction feasibility, when required. A qualified Engineer is required to perform the GSC. The following geotechnical studies, if required, can be performed at the same time as the GSC:

- Geohazard analysis,
- Pavement subgrade evaluation,
- Down-gradient analysis (reference Section 3.4.5 Downstream/Down-Gradient Analysis),
- UIC Rule Authorization information, if applicable,
- Impacts on structural integrity of irrigation canals, if applicable,
- Groundwater effects on impervious pond liners for evaporative or detention ponds,
- Irrigation canal seepage effects on proposed stormwater facilities,
- Embankment recommendations for disposal facilities which propose to impound stormwater (reference Chapter 7 for embankment criteria), and,
- Comprehensive geotechnical evaluation of site conditions.

See the local jurisdiction standards for geohazardous areas and road surfacing requirements.

In areas other than *Special Drainage Areas* (SDAs) and known drainage problem areas identified by the local jurisdiction, the qualified Engineer may at his/her discretion, make recommendations regarding sub-level structure feasibility from the information available from the initial site investigation.

4.2 APPLICABILITY

A GSC will be required for most projects, however, the scope and geographic extent of the investigation may vary depending upon the general location and setting of the site, the characteristics of the target soil deposits, and whether there are known or anticipated drainage problems within the vicinity of the site.

A geotechnical site characterization shall be submitted for:

- Projects proposing infiltration (drywells, drill holes, detention facilities receiving credit for pond bottom infiltration, etc.) or non-standard drainage systems;
- Projects located in a SDA as identified by the local jurisdiction. (Note: Not all jurisdictions have defined SDAs.);

- Projects located within or draining to a drainage problem or study area as recognized by the local jurisdiction; or,
- Projects with administrative conditions requiring a GSC.

The local jurisdiction may reduce or waive the GSC requirements where sufficient geotechnical data is already available for a project site.

4.3 MINIMIMUM REQUIREMENTS

A GSC study shall consist of, at a minimum, the following items:

- Submittal of a written report (See Section 4.3.1);
- Review of available geologic, topographic, and soils maps and ground water condition information (well logs, hydrogeologic maps, documented local project experience) for the site area to identify any site conditions, including irrigation canals, that could impact the use of storm drainage systems and/or the construction of sub-level structures (i.e. basements or underground parking structures);
- Review of locations of nearby public and private wells, clean-up sites shown in Oregon DEQ's online facility profiles, as well as any existing geotechnical engineering reports or studies for sites within the vicinity;
- An evaluation, made by the qualified Engineer, of the potential impacts from groundwater and canal seepage on the existing and proposed storm drainage facilities, roadways, and public infrastructure, including consideration of indications that a seasonally high groundwater table may occur,
- An evaluation, made by the qualified Engineer, of the potential for a stormwater facility to compromise the structural integrity of any irrigation canal in the vicinity of the proposed facility.
- Surface reconnaissance of the site and adjacent properties to assess potential impacts from the stormwater system and to verify that the conditions are consistent with the mapped information;
    - Where access to adjacent properties is unavailable, the project proponent shall rely upon the best known information of the area, supplemented as is available from the local jurisdiction, including review of any existing geotechnical engineering reports or studies for sites within the vicinity; and,
- Field exploration and, in some cases, laboratory testing (See Section 4.3.2), when infiltration is proposed;
- A sub-level structure feasibility study (See Section 4.3.3), when the project is located in a SDA or in a known problem drainage area, as determined by the local jurisdiction.

If an infiltration facility is being considered for the project, the GSC is also the appropriate time to obtain information for the potential UIC application. Pertinent information may include a description of subsurface geology, regional and site-specific hydrogeology such as depth to groundwater, and any geologic information that would help determine if any additional subsurface treatment of stormwater will occur in the unsaturated zone. Obtaining such UIC information at this point can provide significant cost savings to the site development.

In those areas where there has been a long standing record of satisfactory performance of standard subsurface disposal facilities, and no drainage problems are known to exist in the vicinity, the above minimum requirements may be reduced or waived after a formal written request from the project proponent's Engineer has been received, reviewed, and accepted by the local jurisdiction.

4.3.1 GEOTECHNICAL SITE CHARACTERIZATION REPORT

The resulting site characterization report shall be submitted to the local jurisdiction for review and acceptance. The report shall include, at a minimum:

- A vicinity map;
- Site layout map which includes:
    - Project boundaries (include lot lines, if applicable);
    - Labeled topographic contours which extend beyond the project or drainage basin far enough to define drainage boundaries. Projects within an urban area shall utilize a maximum contour interval of 2 feet. At the discretion of the local jurisdiction, projects outside an urban area, such as a large lot subdivision, may utilize the best available topographic information; this may involve contours on a scale larger than the 2 foot minimum required. In either case, the Engineer shall field verify the basin limits;
    - Location of the soil units identified;
    - Significant structures (including irrigation canals), properties, or geologic conditions (such as springs or steep slopes) onsite and within the project vicinity;
    - Existing natural or constructed drainage related features onsite and within the project vicinity;
    - Exploratory borings or test pits, and in-place field tests (if performed); and,
    - Proposed site infrastructure including roadways and drainage features such as ponds, drywells, etc.
- Descriptions of soil units within the vicinity of the site;
- A description of the site, surface conditions, slopes, soil conditions, groundwater conditions, etc;

- Logs of borings and/or test pits (including groundwater elevation, if encountered);
- Results of field and or laboratory testing conducted including raw data, assumptions, and calculations;
- Results of the sub-level structure feasibility study and downstream/down-gradient analysis, as applicable;
- A finding that proposed stormwater facilities will neither adversely affect the structural integrity of any irrigation canal or be adversely affected by seepage from an irrigation canal; and,
- Conclusions and recommendations.

4.3.2 FIELD AND LABORATORY TESTING

The exploration, testing, and associated engineering evaluations are critical not only for identifying permeable soils, but to determine the thickness, extent, and variability of said soils. This information is necessary for proper function of stormwater facilities.

Test Methods

Infiltration rates shall be determined using one or more of the following methods:

- The grain size distribution method (Appendix 4A) can be used to estimate soil permeability in uniform deep soils. The estimation method is well documented and supported by standard geotechnical engineering principals. This approach is only allowed to initially assess the suitability of onsite soils for subsurface stormwater disposal and to estimate infiltration rates for design purposes. Engineers shall apply a safety factor to the estimated infiltration rates to account for long term plugging of the system by sediments and debris. For newly constructed drywells, a full-scale drywell test is required prior to construction certification in order to verify the infiltration rates utilized in the design, unless waived by the local jurisdiction;
- The full-scale drywell or drill hole test (See Appendix 4B) utilizes field data to determine actual infiltration rates of a drywell or drill hole. This test method is required for all existing drywells and drill holes to verify the condition and capacity of the structure. For newly constructed drywells or drill holes, a full-scale test is required prior to construction certification in order to verify the infiltration rates utilized in the drainage design, unless waived by the local jurisdiction (Note that testing beyond the capacity used in the system design is not required.);
- The test pit method (See Appendix 4C) utilizes field data to estimate the infiltration rates of drywells and determine infiltration rates of other subsurface disposal facilities. This test is not suitable for drill holes. A qualified Engineer may elect to use this test method to further verify the design infiltration rates utilized in the drainage design when soil gradations indicate marginal infiltration rates. Also, this test method may be used for analyzing non-standard subsurface

disposal systems (infiltration galleries, under-drain systems, etc). For newly constructed drywells or drill holes, a full-scale drywell or drill hole test is required prior to construction certification to verify the infiltration rates utilized in the design, unless waived by the local jurisdiction;

- The single-ring infiltrometer test (See Appendix 4D) or pond flood test (See Appendix 4F) can be used to verify the pond drawdown times as required in Chapter 7 and the infiltration rates of the subgrade and treatment zone of a water quality facility as discussed in Chapter 6; the single-ring infiltrometer test utilizes field data to determine the hydraulic conductivity of surficial soils. One of these tests is required prior to construction certification of infiltration ponds, unless waived by the local jurisdiction. This test is not suitable for drill holes;
- Swale flood test (Appendix 4E) utilizes field data to verify swale drawdown times and functionality, as discussed in Chapter 6, and is required prior to release of bond or other surety, if required by the local jurisdiction; and,
- Additional or alternate test methods, upon approval from the local jurisdiction.

Test Locations

The following guidelines are recommended for determining the locations, depths, and frequencies of field explorations:

- Test borings and/or test pits should be located within the footprint of proposed stormwater disposal facilities;
- At least one subsurface exploration should be performed for each proposed drywell or drill hole and for every 1,200 square feet of disposal area (infiltration pond bottom, infiltration trench side walls and bottom). For a linear swale, one subsurface exploration should be performed every 300 feet. Subsurface explorations and sampling should be conducted according to applicable ASTM standards. In areas with known horizontal and vertical uniformity of soils, the local jurisdiction may reduce the recommended number of subsurface explorations;
- Unless otherwise recommended by the qualified Engineer, subsurface explorations should extend to a depth 5 feet below the bottom of the stormwater facility. Local jurisdictions may increase the subsurface exploration depth at their discretion..
- When Grain Size Distribution Methods are used to estimate hydraulic conductivity, a minimum of two laboratory gradation tests should be performed per subsurface exploration. Gradations should be performed on samples taken at varying depths below the ground surface, within the target soil deposit, in order to adequately characterize the proposed disposal site soils. Laboratory testing should be conducted according to applicable ASTM standards; and,
- Field explorations and laboratory testing should be conducted under the direct supervision of a qualified Engineer.

The above field and laboratory tests alone do not constitute a site characterization. It is important to consider all the factors present at a site when determining the feasibility of stormwater disposal. In addition, the suitability of the above methods for use on a particular site will vary significantly across Central Oregon as projects encounter soil types ranging from silts and fine volcanic ash to fractured basalt.

4.3.3 SUB-LEVEL STRUCTURE FEASIBILITY

If sub-level structure construction (i.e. basements, or underground parking structures) is being considered in a SDA, a known or suspected high groundwater area, and/or within a drainage problem or study area, as defined by the local jurisdiction, a sub-level structure feasibility study is required.

The sub-level structure feasibility study may be performed in conjunction with the site characterization but shall be submitted as a separate document and shall include the following minimum elements:

- Layout of the site showing lot lines and lot and block numbers;
- Identify lots where sub-level structure construction is feasible. Provide recommendations with details of construction (i.e. minimum below grade floor elevations, minimum drainage system requirements, flood-proofing or waterproofing requirements as per the International Building Code, and any site specific recommendations). Discuss the effects of hydrostatic pressure that may lead to basement flooding;
- Adverse impacts to groundwater including, but not limited to, changes to the groundwater characteristics in the area whereby sub-level structures, foundations, or surface areas have increased amount or frequency of groundwater intrusion; and,
- Identify where sub-level structure construction is not feasible.

In-lieu of conducting a sub-level structure feasibility study, the owner may elect to prohibit sub-level structure construction throughout the entire plat. If a potential buyer would like to construct a sub-level structure, then a site specific geotechnical evaluation shall be performed by a qualified Engineer, for the individual lot, prior to a building permit being issued.

Language regarding sub-level structure restrictions, as provided by the local jurisdiction, shall be placed on the face of the plat and on all engineering plans for private or public improvements. Also, title notices shall be recorded for all restricted lots with language regarding sub-level structure feasibility. Building permits will not be issued until the geotechnical recommendations have been prepared and met.

APPENDIX 4A – GRAIN SIZE DISTRIBUTION METHOD

PURPOSE AND APPLICABILITY

The Grain Size Distribution Method allows an Engineer to estimate the permeability of a soil and normalized infiltration rates for designing drywells, infiltration ponds, and infiltration trenches using the results of laboratory soil gradation tests. Note that laboratory tests can also be performed to measure the saturated hydraulic conductivity of the soil sample. The method described below is generally acceptable for soils down to a particle size of very fine sands, including degraded pumice soils. Soils finer than very fine sand, such as silts, tills, and ash, should have direct measurement of the saturated hydraulic conductivity done in the lab or field.

Where soils are known to be uniform and deep, a qualified Engineer may elect to utilize this method as an alternative to any type of field infiltration test to initially assess the suitability of site soils for stormwater disposal. An appropriate Geotechnical Site Characterization, as discussed in Chapter 4, shall be conducted in conjunction with the laboratory testing. For newly constructed drywells and drill holes, a full-scale drywell or drill hole test is required prior to final construction acceptance in order to verify design infiltration rates, unless waived by the local jurisdiction.

PROCEDURE

1. Perform the field and laboratory testing as detailed in the minimum requirements found in Section 4.3.2
2. Determine the subsurface conditions (i.e. thickness of target soil layer or approximate location of groundwater, impervious soil layer and/or limiting layer) to verify that the minimum requirements for the proposed facilities are met (See Section 7.4).
3. Analyze the gradation data and determine the percentage of fines (percent passing the number 200 sieve) for the target soil deposit. Soils with greater than 12 percent fines are not suitable for drywell disposal but may be suitable for properly sized infiltration ponds, swales, or trenches.
4. Determine the effective Grain Size Diameter, D_{10}, which is the grain diameter in mm corresponding to 10 percent passing by weight (10 percent of the sample by weight is smaller than D_{10}).
5. Calculate an estimate of the hydraulic conductivity using the Hazen Formula:

$$k = C\,(D_{10})^2,$$

Where: k = hydraulic conductivity (cm/sec)

C = a constant and unit conversion factor equal to 0.7

D_{10} = effective Grain Size Diameter (mm).

6. Calculate the approximate maximum drywell, infiltration trench, infiltration swale, or infiltration pond infiltration rate, q_A, using the following equation:

   $q_A = (k)(A)$ (make proper unit conversions to cfs)

   Where: q_A = infiltration rate

   A = the total infiltration area of the soil interface

The total infiltration area of the soil interface can be: (1) the walls and bottom area of the pit that the granular drywell bedding will be placed within; (2) the sidewall and bottom areas of infiltration trenches; (3) the infiltration area of a swale or pond. Note that this equation is generally acceptable for estimation purposes since studies have shown that, under ponding, the long term vertical infiltration rate of a soil usually approaches a steady value equal to the saturated hydraulic conductivity.

7. Determine the allowable design infiltration rates (q_D) by applying the appropriate factor of safety (FS) for the type of soil involved.

$$q_D = \frac{q_A}{FS} \quad \text{(cfs)}$$

TABLE 4A-1
REQUIRED SAFETY FACTORS[1]

GENERAL SOIL TYPE	SAFETY FACTOR
Clean Medium to Coarse Gravel or Equivalent, such as Large Granular Volcanic Pumice; Fractured Basalt	2.5 (With Woven Geotextiles) 5 (With Non-Woven Geotextiles)
Sandy Gravels or Mixed Granular Pumice and Coarse Degraded Pumice	3.3
Medium to Coarse Sands or Coarse Loose Sandy Pumice	3.3
Fine Sands and Finely Degraded Pumice	1.7
Silts, Glacial Till, Volcanic Ash, Consolidated Fine Pumice	1.25

[1]The safety factors noted in Table 4A-1 account for plugging of the infiltration system over time by sediments, debris, and slime. Sandy gravels, gravelly sands, medium sands, and coarse sands (and equivalent soils) have the highest safety factor because they are very susceptible to plugging by sediment in stormwater – a small amount of sediment will form a surface seal causing their permeability to drop greatly. Fine sands and equivalent soils have a fairly low permeability to begin with. Therefore, fine stormwater sediments do not reduce the permeability as much compared to their natural value, so the safety factor is not as great. Fine and consolidated soils such as silts, till, ash and consolidated (compacted) ash have a low natural permeability which is nearly the same as the permeability of fine stormwater sediments. Therefore, a lower safety factor can be used.

Two safety factors are provided for gravels to reflect the influence that geotextile selection can have on long term performance. It is common practice to use a geotextile liner between the native soil and the gravel bedding used for drywells and infiltration trenches. Drainage theory indicates that needle punched non-woven geotextiles (probably the most commonly used), should not be used in subsurface drainage applications where "dirty" water is involved (such as stormwater) due to their propensity to be quickly plugged with sediment, after which the plugged geotextile will control the infiltration rate. Generally it is advised that a woven geotextile with a high percent open area and relatively small opening size be used.

REPORT

1. Provide subsurface soil logs. Include photographs showing soil types encountered and the surrounding areas.
2. Report laboratory test data in a format that includes the sieve analysis graphically and in a tabular format.
3. Report the actual infiltration rates, design infiltration rates, and factors of safety. Include the equations, calculations, and assumptions used to compute the infiltration rates.
4. Provide name, title, and qualifications of person directing the test and providing the report.

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APPENDIX 4B – FULL-SCALE DRYWELL/DRILL HOLE TEST

PURPOSE AND APPLICABILITY

The full-scale drywell drill hole test method determines the normalized infiltration rates for drywells and drill holes. This testing is required for all existing and newly constructed drywells or drill holes prior to construction certification, unless specifically waived by the local jurisdiction.

PROCEDURE

1. Install the drywell or drill hole as per the local jurisdiction's standard plans, specifications and applicable construction guidelines.
2. Inspect the drywell or drill hole and take photographs.
3. Before beginning the test, field check the accuracy of the flow meter by filling up a suitable container of known volume; for example, a calibrated 55-gallon barrel.
4. Introduce clean water into the drywell or drill hole. Monitor flow using an in-line flow meter.
5. If possible, raise the water level in the structure until it reaches the top of the active barrel section. In the case of structures interconnected by pipes, raise the water level to the invert elevation of the connecting pipe, or use an expandable pipe plug to seal the connecting pipe.
6. Monitor and record the flow rate required to maintain the constant head level in the drywell or drill hole at appropriate intervals. In no case shall the interval exceed 10 minutes in length.
7. Maintain the water level in the structure, by adjusting the flow rate, for a minimum of 2 (two) hours or until a stabilized flow rate has been achieved, whichever is longer. Test time begins after the water level in the structure has reached the top of the active barrel section, or the invert elevation of any interconnecting pipes. The flow rate is considered stable when the water level in the structure is maintained and the incremental flow rate does not vary by more than 10 percent. *(In any case, the total volume and rate injected into the drywell or drill hole does not need to exceed the design storm volume.)*
8. Upon completion of the constant head period, discontinue flow, monitor and record the water level in the drywell or drill hole at intervals no more than 5 minutes in length, for a 30-minute time period. This time may need to be extended depending upon the soil performance.

CALCULATIONS

1. Calculate the actual potential maximum infiltration rate (q_A)

$$q_A = \left(\frac{Q}{H}\right) * H_D \quad \text{(cfs)}$$

Where: Q = stabilized flow rate observed near the end of the constant-head portion of the test (cfs);

H = level of water within the drywell or drill hole (ft); and,

H_D = maximum design drywell or drill hole head

2. Determine the design infiltration rates for a drywell or drill hole (q_D). Apply the appropriate factor of safety (FS), see Table 4B-1.

$$q_D = \frac{q_A}{FS} \quad \text{(cfs)}$$

TABLE 4B-1
REQUIRED SAFETY FACTORS[1]

GENERAL SOIL TYPE	SAFETY FACTOR
Clean Medium to Coarse Gravel or Equivalent, such as Large Granular Volcanic Pumice	2.5 (With Woven Geotextiles) 5 (With Non-Woven Geotextiles)
Fractured Rock	2.5
Sandy Gravels or Mixed Granular Pumice and Coarse Degraded Pumice	3.3
Medium to Coarse Sands or Coarse Loose Sandy Pumice	3.3
Fine Sands and Finely Degraded Pumice	1.7
Silts, Glacial Till, Volcanic Ash, Consolidated Fine Pumice	1.25

[1]See Table 4A-1 for notes on the development of safety factors.

REPORT

1. Report the condition of the drywell or drill hole. When applicable, include the following information:
   - General site,weather and drywell or drill hole conditions prior to the test;
   - Silt build-up;

- Water level in the drywell or drill hole;
- Connections to other structures;
- Overall depth of the drywell or drill hole from finished grate to bottom;
- Photographs taken of the drywell or drill hole during or after installation;
- Distance from finished grate to the invert elevation of any interconnecting pipes; and,
- The length of the active barrel section. (the vertical length of the drywell or drill hole in contact with water during the test)

2. Report test data in a format that includes time of day, flow meter readings, incremental flow rates, observed head levels and water depths in the structure, and total flow volumes.
3. Report the actual infiltration rates, design infiltration rates, and factors of safety.
4. Provide any conclusions or recommendations.
5. Provide name, title, and qualifications of person directing the test and providing the report.

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APPENDIX 4C – TEST PIT METHOD

PURPOSE AND APPLICABILITY

This test method is applicable for determining soil permeabilities for subsurface disposal systems incorporating such features as subsurface trenches, subsurface galleries, low-profile drywells, etc.

PROCEDURE

1. Perform the field and laboratory testing as detailed in the minimum requirements found in Section 4.3.2.
2. Determine the subsurface conditions (i.e. the thickness of target soil layer or approximate location of groundwater or impervious soil layer) to verify that the minimum requirements for the proposed facilities are met (See Section 7.4).
3. Excavate a rectangular test pit having approximate bottom dimensions of 2 feet in width and 4 feet in length. Extend the pit until its bottom elevation is approximately 2 feet to 5 feet below the bottom elevation of the proposed drainage structure. As much as is practical, excavate the pit to clean dimensions, and keep it free of surface slough, organics, and other deleterious material.
4. Measure and record the dimensions (length, width, depth) of the test pit. Include photographs of the test pit both before and after the test.
5. Line the walls and bottom of the pit with a highly porous, non-woven, geotextile fabric. Install a vertical, PVC observation pipe in the pit. Then backfill the pit with clean, uniform, pervious, fine gravel; or clean, uniform, pervious, open-graded coarse gravel. The omission of the PVC observation pipe and pervious gravel backfill is an allowable practice if the test pit walls will not slough when water is introduced.
6. Introduce clean water into the test pit using an in-line, commercially available, flow meter. Prior to the test, field check the accuracy of the flow meter using a suitable container of known volume (i.e., 5 gallon bucket, 55 gallon barrel, etc).
7. Raise the water level in the pit until a level consistent with the operating head anticipated in the proposed drainage structure is achieved. Based upon the soil permeability, the subsurface soil profile, and the water supply system available, head levels lower than those anticipated in the drainage structure are permitted.
8. Adjust the flow rate as needed to maintain the constant head level in the pit. Minimum required test time is 2 hours or the time needed to discharge the expected design storm volume into the facility, whichever is shorter. (Note: In highly permeable soils it is possible that no ponding in the test pit will occur even for high flows. In such a case, assume a constant-head depth of 0.5 feet for calculation purposes.)
9. Monitor and record the flow rate required to maintain the constant-head level at appropriate intervals. In no case shall the interval exceed 15 minutes in length.

10. Continue maintaining the constant head until a stabilized flow rate has been achieved. Consider the flow rate stable when the incremental flow rate required to maintain the head does not vary by more than about 5 percent between increments. The intent of this section is to achieve a relatively steady-state flow condition between the minimum 2 hour test time and a maximum test time of 2½ hours. At the discretion of the onsite Engineer or engineering technician, the test may be extended beyond the 2½ hour maximum.
11. Upon completion of the constant-head period, discontinue flow, and monitor the head level drop in the drill hole at appropriate intervals over at least a 30-minute falling-head period.
12. Compute the permeability for the constant-head portion of the test using the simplified approach below or the methods outlined in the following: United States Bureau of Reclamation (USBR) Procedure 73000-89: *Performing Field Permeability Testing by the Well Permeameter Method*. And USBR Procedure 7305-89: *Field Permeability Test (Shallow-Well Permeameter Method)*. Note: Utilize stabilized flow rates observed near the end of the constant-head period in the permeability calculations. See section 13.3 of USBR Procedure 7300-89 for test pit method.

CALCULATIONS

For ease of calculation purposes**,** a very simplified and conservative approach is allowed for estimating the maximum infiltration discharge (cfs) rate for dry wells, infiltration trenches, infiltration swales and infiltration ponds.

1. Calculate the normalized infiltration rate of the test pit (q_N):

$$q_N = \frac{Q/A}{H/2} \quad \text{(cfs per ft}^2\text{ per ft of head)}$$

Where: Q = stabilized flow rate observed near the end of the constant-head portion of the test (cfs);

A = wetted bottom and sidewall area of the flooded test pit (ft^2); and,

H = depth of water in the test pit.

2. Determine the approximate infiltration rate for the intended infiltration facility (q_f) using:

$$q_f = q_N A_f \frac{H_f}{2} \quad \text{(cfs)}$$

Where: A_f = wetted bottom and sidewall area of the intended facility (ft^2), some facilities may only have a bottom area; and,

H_f = maximum depth of water for the intended facility.

3. Calculate the design infiltration rate (q_D):

   Apply the appropriate factor of safety (FS), see Table 4C-1.

$$q_D = \frac{q_A}{FS} \quad \text{(cfs)}$$

4. Iterate through steps 2 and 3 until the facility infiltration area provides an allowable design infiltration rate that matches the design inflow rate calculated from the site hydrology.

TABLE 4C-1
REQUIRED SAFETY FACTORS

GENERAL SOIL TYPE	SAFETY FACTOR
Clean Medium to Coarse Gravel or Equivalent, such as Large Granular Volcanic Pumice	2.5 (With Woven Geotextiles) 5 (With Non-Woven Geotextiles)
Sandy Gravels or Mixed Granular Pumice and Coarse Degraded Pumice	3.3
Medium to Coarse Sands or Coarse Loose Sandy Pumice	3.3
Fine Sands and Finely Degraded Pumice	1.7
Silts, Glacial Till, Volcanic Ash, Consolidated Fine Pumice	1.25

[1]See Table 4A-1 for notes on the development of safety factors.

REPORT

1. Provide a description of the equipment used to perform the test (including the type of flow meter and the results of the onsite flow meter accuracy check). When applicable, describe the type of fabric lining and gravel backfill used.
2. Describe any difficulties encountered during excavation and testing, including any surface sloughing
3. Provide subsurface soil logs of the test pits and surrounding areas and test pit dimensions. Include photographs showing the test pit and soil types encountered.
4. Report test data for both constant and falling head periods in a format that includes time of day, flow meter readings, incremental flow rates, observed head levels and water depths in the test pit, and total flow volumes.
5. Report the actual infiltration rates, design infiltration rates, and factors of safety. Include the equations, calculations, and assumptions used to compute the infiltration rates.

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APPENDIX 4D – SINGLE-RING INFILTROMETER TEST

PURPOSE

The single-ring infiltrometer test method is applicable for estimating infiltration and permeability rates for surficial soils to verify drawdown times in bio-infiltration swales and detention ponds.

PROCEDURE

1. Drive, jack, or hand-advance a short section of steel or PVC pipe having a minimum inside diameter of 12 inches, and a beveled leading edge into the soil surface to a depth of about 8 inches, leaving approximately 12 inches of pipe exposed above the ground surface. If after installation the surface of the soil surrounding the wall of the ring shows signs of excessive disturbance such as extensive cracking or heaving, reset the ring at another location using methods that will minimize the disturbance. If the surface of the soil is only slightly disturbed, tamp the soil surrounding the inside and outside wall of the ring until it is as firm as it was prior to disturbance.
2. Before beginning the test, field check the accuracy of the flow meter by filling up a suitable container of known volume; for example, a 5-gallon bucket or a 55-gallon barrel.
3. Introduce clean water into the ring. Use some form of splash-guard or diffuser apparatus such as a highly porous, non-woven, geotextile fabric or a sheet of thin aluminum plate to prevent erosion of the surface of the soil during filling and testing. Monitor flow using an in-line flow meter.
4. Raise the water level in the ring until a head-level of at least 6 inches above the soil surface is achieved.
5. Monitor and record the flow rate required to maintain the constant head level at appropriate intervals. In no case shall the interval exceed 10 minutes in length.
6. Maintain the water level in the ring, by adjusting the flow rate, for a minimum of 2 (two) hours or until a stabilized flow rate has been achieved, whichever is longer. Test time begins after the water level in the ring has reached 6 inches above the soil surface. The flow rate is considered stable when the water level in the ring is maintained and the incremental flow rate does not vary by more than 5 percent.
7. Upon completion of the constant-head period, discontinue flow, monitor and record the water level in the ring at intervals, not more than 5 minutes in length, for a 30-minute period.
8. One single-ring infiltrometer shall be performed for every 1,200 square feet of bio-infiltration swale/pond bottom area or detention pond bottom area or every 300 feet of linear swale, with a minimum of one per swale/pond.

CALCULATIONS

1. Calculate the surface infiltration rate (I)

$$I = \frac{Q}{A} \text{ (ft/sec)}$$

Where: Q = stabilized flow rate observed near the end of the constant-head portion of the test (cfs); and,

A = area of soil inside the ring (ft^2).

2. Compute the permeability rate (K)

$$K = \frac{(Q * L)}{(A * H)} \text{ (ft/sec)}$$

Where: L = depth of soil contained within the ring (in);

A = area of soil inside the ring (ft^2); and,

H = constant level of water within the ring, measured from the base of the ring to the free water surface (in).

REPORT

1. Provide a description of the equipment used to perform the test.
2. Describe any difficulties encountered during testing.
3. Provide subsurface soil logs of the test pits and surrounding areas, if available.
4. Report test data in a format that includes time of day, flow meter readings, incremental flow rates, observed head levels and water depths in the ring, and total flow volumes.
5. Provide name, title, and qualifications of person directing the test and providing the report.

REFERENCED DOCUMENTS

(United States Bureau of Reclamation (USBR) Drainage Manual: Section 3-8 Ring Permeameter Test)

APPENDIX 4E – SWALE FLOOD TEST

PURPOSE

The swale flood test verifies the path of flow into a swale and the drawdown time of the bio-infiltration swale. The flood test shall be conducted, when required, after the swale has been constructed and the vegetation has been established.

PROCEDURE

1. Introduce clean water into the swale by directing the water (via hose from a hydrant or other clean water source) along the curb and gutter upstream of the swale inlet.
2. Raise the water level in the swale until it reaches 6 inches in depth and note the time; this is the beginning of the flood test.
3. If the swale is draining rapidly, the progress is observed, and when the swale is empty, the time is documented, and the flood test has ended.
4. If the swale is not draining, measure the depth of water currently in the swale, documenting the time, and return to the swale site at a later time in order to verify that the swale has completely drained within 72 hours.

NOTE: Flood tests are performed by the project proponent in the presence of local jurisdiction staff. The project proponent will be notified should the swale fail to perform as designed (i.e. completely drain with 72 hours).

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APPENDIX 4F – POND FLOOD TEST

PURPOSE

The pond flood test method verifies drawdown time of a stormwater disposal facility, such as an infiltration pond. The pond flood test shall be conducted, when required, after the pond has been constructed, and preferably after vegetation has been established.

PROCEDURE

1. Introduce clean water into the pond. Use some form of splash-guard or diffuser device to prevent surface erosion of the pond.
2. Raise the water level in the pond until it reaches operational depth; i.e. to the invert elevation of first outlet device (culvert, orifice, weir, etc.).
3. Document the time and measure the depth of water in the pond; this is the beginning of the pond flood test.
4. The progress of the pond's ability to drain is observed. If the pond appears to be emptying rapidly, as soon as the pond is empty, the time is documented, and the flood test has ended.
5. If the pond is not draining, or is draining very slowly, measure the depth of water currently in the pond, documenting the time, and return to the pond site at a later time in order to verify that the pond has completely drained within 72 hours.

Flood tests are performed by the project proponent in the presence of local jurisdiction staff. The project proponent will be notified should the pond fail to perform as designed (i.e. completely drain with 72 hours).

Some ponds will be large enough that a pond flood test may not be the most efficient method of determining drawdown time or infiltrative ability. Consideration may need to be given to other types of infiltrative test methods, such as the single-ring infiltrometer test as described in Appendix 4D. If the pond flood test is pursued for larger ponds, the local water purveyor must be contacted so that water service is not disrupted.

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