# Infiltration Testing Report

## Washington State Fair Barn M Improvements

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March 11, 2025

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## PROJECT ENGINEER'S CERTIFICATION

I hereby certify that this Infiltration Testing Report for Puyallup State Fair Barn M Improvements has been prepared by me or under my supervision and meets minimum standards of the Department of Ecology Stormwater Management Manual for Western Washington.

____________________________________

Justin Jones, PE

01-30-2025

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## SUMMARY

This report details the results of infiltration testing for use in the stormwater system design of Puyallup State Fair Barn M Improvements located within Puyallup, WA. Two Small-Scale Pilot Infiltration Test (PIT) were conducted on site to determine the onsite stormwater infiltration rates. The test hole was excavated and backfilled by a licensed contractor and the PIT was completed in accordance with the Department of Ecology (ECY) Stormwater Management Manual for Western Washington (Stormwater Manual).

The PIT process evaluates the infiltration within a 12 SF area by first measuring the rate of water required to maintain a constant water elevation of approximately 12-inches in the test pit, and second by measuring the drawdown rate of the water within the test pit. The drawdown is done using a data logger.

The field data is then analyzed, and a factor of safety applied to determine the stormwater design infiltration rate. A design infiltration rate of 0.17 inches per hour was determined, which is below the 0.3 minimum required for onsite infiltration. Below is a summary of the results.

**Test Pit Location**

**Summary of Results**

Per the PIT, the site soil is suitable for stormwater infiltration. Soil evaluations were not taken as the designated stormwater BMP is not intended to treat pollution generating surfaces.

<table>
<tr><th>Testing</th><th>Test PIT</th><th>Results</th><th>ECY Threshold</th></tr>
<tr><td rowspan="2">Ground Water</td><td>Pit Depth</td><td>4.0-feet</td><td>N/A</td></tr>
<tr><td>Test Hole 1 Groundwater Level</td><td>Groundwater Observed at 48”</td><td>N/A</td></tr>
<tr><td rowspan="3">Infiltration Rate</td><td>Infiltration Rate Factor of Safety</td><td>0.45</td><td>N/A</td></tr>
<tr><td rowspan="2">Test Hole 1 Infiltration Rates</td><td>Uncorrected: 0.73 inches per hour</td><td rowspan="2">≥ 0.3 inches per hour</td></tr>
<tr><td>Design: 0.32 Inches per hour</td></tr>
</table>

## INFILTRATION TEST PROCEDURES

Below is the process taken for the Small-Scale PIT:

- ☐ Identify PIT locations based on the site survey of existing buildings and utilities as well as the potential locations of infiltration facilities based on the preliminary site plan.
- ☐ Obtain public and private utility locates. Prior to the PIT utility locates will be called to ensure there are no utilities present in the PIT locations.
- ☐ Excavation of PIT holes (approximately 3-feet x 4-feet 4-feet deep). A 3-feet x 4-feet x2-feet tall wood box is inserted into the test hole to ensures that the bottom surface area is exactly 12 SF. The box is backfilled to the top edge to ensure stability and infiltration only through the bottom of the test hole for the duration of the PIT.
- ☐ A soil sample is collected from the bottom of the hole to test treatment capability. A lab tests the cation exchange rate and organic matter content of soils. Lab results confirm if the soil is suitable for treatment based on Stormwater Manual criteria.
- ☐ A float system with a water hose connection is set into the center of the test hole. The float system is equipped with a leveling plate, a measuring ruler for visual inspection of water levels and a perforated pipe housing for the data collector.
- ☐ Using water transfer tanks or hose spigot as available, the test hole is filled to a 12-inch water depth that is maintained. The presoak period ensures that the soils have been fully saturated before conducting the PIT. A 1-hour stabilization test is performed after the presoak period to confirm soil stabilization. If the test yields 4 constant gallon per minute (GPM) readings that are conducted every 15-minutes, the stabilization of the soil is confirmed.
- ☐ A 1-hour GPM test is conducted per the Stormwater Manual. Using a water meter accurate to the nearest tenth of a gallon, a GPM flow rate is recorded every 15-minutes while the water level is maintained at a 12-inch depth. An infiltration rate (in/hr) can be determined using the GPM flow rate and the 12 SF bottom surface area of the hole.
- ☐ A drawdown test is performed per Stormwater Manual to determine the drawdown infiltration capability of the soil. A CRS451V (Pressure Transducer) is placed into the test hole and set to take pressure (PSI) readings every 10-minutes. The water source is shutoff, and the pressure transducer will measure water drawdown for a 2-hour period. At the end of the period the sensors are removed from the test hole, the data is collected using a PC interface module and the HydroSci program to communicate with the sensor to retrieve the data.
- ☐ The wood box and the float system are removed from the test hole.
- ☐ Over excavate test hole to confirm there is no ground water mounding.
- ☐ The test pit is then backfilled and restored to prior state of excavation.

## FINDINGS AND RECOMMENDATIONS

**Groundwater Conditions**

The Stormwater Manual specifies minimum separations between the seasonal high groundwater elevation and the bottom of the infiltration facility based on different best management practices (BMP):

- **Downspout Infiltration:** 1-foot
- **Permeable Pavement:** 1-foot
- **Infiltration Gallery:** 1-foot
- **Bioretention:** 3-foot

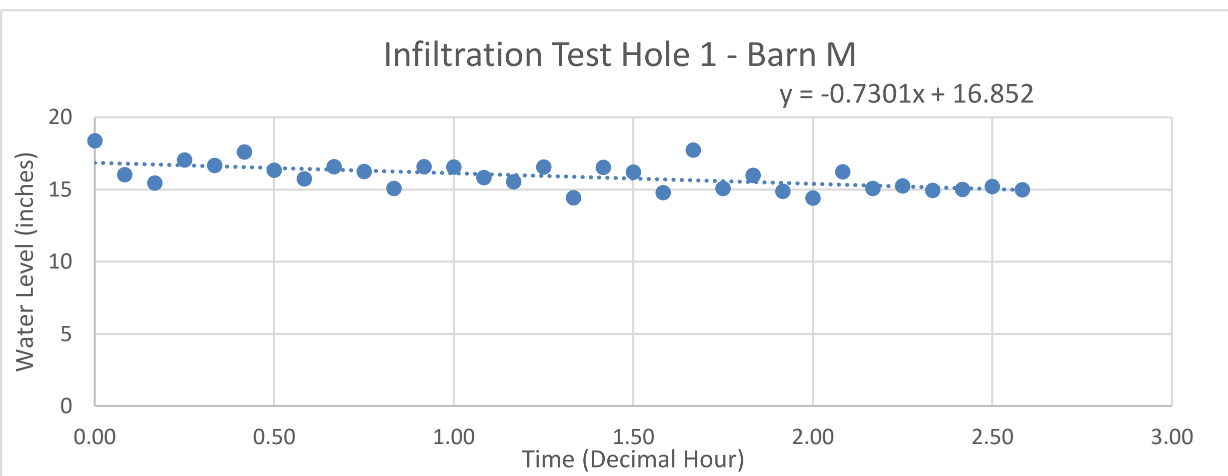
With known groundwater conditions for each test hole, there is adequate spacing between groundwater and BMPs. An overflow should be installed with BMP in case of large storm events.

**Field Measured Infiltration Rate**

The infiltration rate was collected using two methods during the PIT. The first method is to measure the gallons per minute flowrate required to maintain a constant water level in the test pit. The average of the flowrate measurements taken over an hour timeframe.

The second method is to measure the drawdown rate of the test pit. Measurements were taken both visually and with a data logger. The average of the drawdown measurements resulted in an infiltration rate of resulted in the following infiltration rates:

- Test Hole 1: 0.73 inches per hour



**Design Infiltration Rate**

Per the Stormwater Manual a minimum design infiltration rate of 0.3 inches per hour is required for onsite infiltration. The design infiltration rate takes the field measured infiltration rate and applies a factor of safety based on three correction factors. The three corrections are based on site variability, test method, and degree of influent control (See Appendix D).

| Issue | Partial Correction Factor |
|---|---|
| Site variability and number of locations tested | $CF_v$ = 0.33 to 1.0 |
| Test Method | |
| • Large-scale PIT | $CF_t$ = 0.75 |
| • Small-scale PIT | = 0.50 |
| • Other small-scale (e.g. Double ring, falling head) | = 0.40 |
| • Grain Size Method | = 0.40 |
| Degree of influent control to prevent siltation and bio-buildup | $CF_m$ = 0.9 |

Total Correction Factor, $CF_T = CF_v \times CF_t \times CF_m$

Per the Stormwater Manual, a site variability correction of 0.5 is used due to extensive amounts of clay found throughout the site. A correction of 0.5 for the small-scale PIT and 0.9 for the degree of influent are also used. A total correction factor of 0.225 is applied to the measured infiltration rate yielding a recommended design infiltration rates as follows:

- Test Hole 1: 0.17 inches per hour (Infiltration not feasible)

**Treatment Suitability**

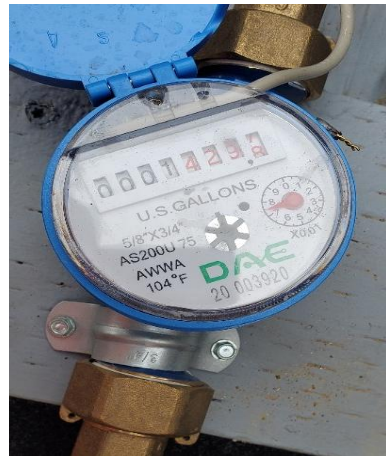
Per the Stormwater Manual the soils that stormwater is infiltrated into may be used for treatment of pollution generating surfaces if the soil meets specific requirements. Otherwise, a treatment layer is required to treat pollution generating surfaces. The treatment threshold of the infiltrated soil per the Stormwater Manual is a Cation Exchange Capacity greater than or equal to 5 milliequivalents CEC/100g and a minimum of 1.0% organic content.

This project does not propose to manage pollution generating hard surfaces runoff through an infiltration facility; therefore soil suitability was not evaluated.

## TEST PIT PHOTO DOCUMENTATION – TEST HOLE 1

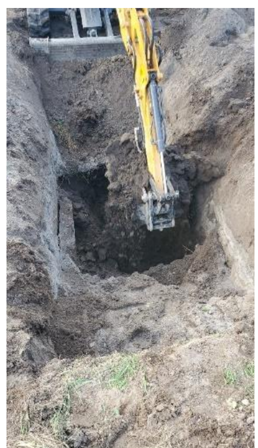
3-feet x 4-feet x 18-inches

Test Pit Pre-soak at 12-inches




1-hour GPM Test

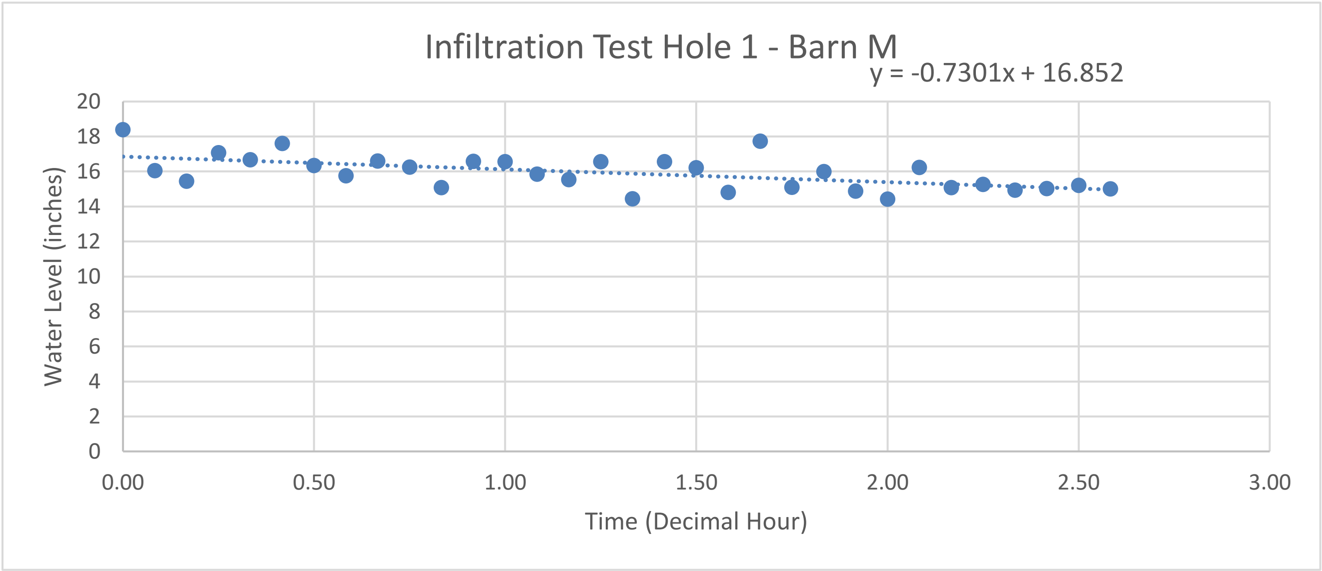
Pressure Transducer Drawdown Test



Over Excavation to observe if Groundwater is Mounding

Backfill Test Hole

# APPENDIX A


Infiltration Test Hole 1 - Barn M
y = -0.7301x + 16.852
Water Level (inches)
20
18
16
14
12
10
8
6
4
2
0
0.00
0.50
1.00
1.50
2.00
2.50
3.00
Time (Decimal Hour)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Project Location:** | Puyallup State Fair Barn M | | | | | | | |
| **Date of Test:** | | 2/19/2025 | Test start | | | | | |
| | | | | | | | | |
| **Test Pit Dimensions:** | | Width (feet) | 3 | Length (feet) | 4 | Depth (inches) | 24 | |
| | | | | | | | | |
| **Presoak:** | 12 hours at 12" | | | | | | | |
| | | | | | | | | |
| **Weather Conditions:** | Cloudy | 52° F | | | | | | |
| | | | | | | | | |
| **Infiltration Test:** | | | | | | | | |
| | | Water Column Maintained (inches): | 12 | | | | | |
| | | Gallons Per Inch: | 7.48 | | | | | |
| | | **Time(Minutes)** | **Volume (gallons)** | **Flow Rate (GPM)** | | | **Flow (Gallons)** | **Infiltration Rate (in/hr)** |
| | | | | Meter Start | Meter End | Flow (Gallons) | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| **Drawdown Test (Sensor):** | | | | | | | | |
| **Sensor Name:** | | JMJ 02 (**CRS451V Sensors from Campbell Scientic**) | | | | | | |
| | | | | | | | | |
| **Time (Decimal Hours)** | **Record Measurement Interval** | **Time Stamp** | **Record #** | **Reading (PSI)** | **Level (in)** | | | |
| 0.0000 | 0 | 4:05 PM | 0 | 0.6630507 | 18.3797654 | | | |
| 0.0833 | 5 | 4:15 PM | 1 | 0.5785586 | 16.03764439 | | | |
| 0.1667 | 10 | 4:25 PM | 2 | 0.5572405 | 15.44670666 | | | |
| 0.2500 | 15 | 4:35 PM | 3 | 0.6154814 | 17.06114441 | | | |
| 0.3333 | 20 | 4:45 PM | 4 | 0.6012944 | 16.66788077 | | | |
| 0.4167 | 25 | 4:55 PM | 5 | 0.6347529 | 17.59535039 | | | |
| 0.5000 | 30 | 5:05 PM | 6 | 0.5894251 | 16.33886377 | | | |
| 0.5833 | 35 | 5:15 PM | 7 | 0.5681682 | 15.7496225 | | | |
| 0.6667 | 40 | 5:25 PM | 8 | 0.5984511 | 16.58906449 | | | |
| 0.7500 | 45 | 5:35 PM | 9 | 0.5864033 | 16.25509948 | | | |
| 0.8333 | 50 | 5:45 PM | 10 | 0.5437605 | 15.07304106 | | | |
| 0.9167 | 55 | 5:55 PM | 11 | 0.598312 | 16.58520864 | | | |
| 1.0000 | 60 | 6:05 PM | 12 | 0.5974992 | 16.56267782 | | | |
| 1.0833 | 65 | 6:15 PM | 13 | 0.5714533 | 15.84068548 | | | |
| 1.1667 | 70 | 6:25 PM | 14 | 0.5603845 | 15.53385834 | | | |
| 1.2500 | 75 | 6:35 PM | 15 | 0.5976012 | 16.56550526 | | | |
| 1.3333 | 80 | 6:45 PM | 16 | 0.5204656 | 14.42730643 | | | |
| 1.4167 | 85 | 6:55 PM | 17 | 0.5970697 | 16.55077208 | | | |
| 1.5000 | 90 | 7:05 PM | 18 | 0.5850075 | 16.2164079 | | | |
| 1.5833 | 95 | 7:15 PM | 19 | 0.5338969 | 14.79962207 | | | |
| 1.6667 | 100 | 7:25 PM | 20 | 0.6396102 | 17.72999474 | | | |
| 1.7500 | 105 | 7:35 PM | 21 | 0.5442991 | 15.08797105 | | | |
| 1.8333 | 110 | 7:45 PM | 22 | 0.5767291 | 15.98693065 | | | |
| 1.9167 | 115 | 7:55 PM | 23 | 0.5368064 | 14.88027341 | | | |
| 2.0000 | 120 | 8:05 PM | 24 | 0.5201635 | 14.41893222 | | | |
| 2.0833 | 125 | 8:15 PM | 25 | 0.5855744 | 16.23212237 | | | |
| 2.1667 | 130 | 8:25 PM | 26 | 0.5440212 | 15.08026766 | | | |
| 2.2500 | 135 | 8:35 PM | 27 | 0.5502297 | 15.25236728 | | | |
| 2.3333 | 140 | 8:45 PM | 28 | 0.5389059 | 14.93847155 | | | |
| 2.4167 | 145 | 8:55 PM | 29 | 0.5416116 | 15.01347355 | | | |
| 2.5000 | 150 | 9:05 PM | 30 | 0.5485572 | 15.20600558 | | | |
| 2.5833 | 155 | 9:15 PM | 31 | 0.541056 | 14.99807232 | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | **Average Infiltration Rate:** | **0.73** | |
| | | | | | | | | |
| | | | | | | **Factor of Safety:** | **0.45** | |
| | | | | | | | | |
| | | | | | | **Design Infiltration Rate:** | **0.33** | |

# APPENDIX B

PRODUCT

CAMPBELL SCIENTIFIC
WHEN MEASUREMENTS MATTER

# CRS451V

**Stainless-Steel Vented Stand-Alone Pressure Transducer**

## Pressure Transducer Combined with a Recorder

**High resolution and accuracy**

## Overview

The CRS451V consists of a submersible water-level and water-temperature sensor with its own time clock and memory to store the collected data—in a compact stainless-steel case. This data logging capability frees users to place the sensor in remote sites and let it collect data for long periods. HydroSci software is included and elegantly supports test setup, data retrieval, and data display. Long battery life and rugged construction mean you can trust the CRS451V to collect important data. Low cost and ease of use make it a good choice in a variety of applications. The CRS456V is the same as this, but with a titanium case.

## Benefits and Features

- Sensors and data-collection features in one instrument case
- Rugged stainless-steel case protects piezoresistive sensor
- Quality construction ensures product reliability
- Fully temperature-compensated
- Fast scan rate
- Large data-storage capacity
- Long battery life
- Easy-to-use software

## Detailed Description

The CRS451V has several pressure range options.

HydroSci software is available for download. This software simplifies the process of configuring the CRS451V. Users can configure the CRS451V to monitor surface water, ground water, or a standard pump test.

HydroSci software will display the data in tabular or graphical formats.

## Specifications

| | | | |
|---|---|---|---|
| Venting | Vented | Measurement Time | < 1.0 s |

# APPENDIX C

## *INFILTRATION TEST*

The Washington State Department of Ecology Stormwater Manual provides testing procedures and best practices, which are described below.

- Testing should occur between December 1 and April 1.
- The horizontal and vertical locations of the PIT shall be surveyed by a licensed land surveyor and accurately shown on the design drawings.
- Excavate the test pit to the estimated elevation of the proposed infiltration into the native soil. Note that for some proposed BMPs, such as and BMP T5.15: Permeable Pavements, this will be below the proposed finished grade. If the native soils will have to meet a minimum subgrade compaction requirement (for example, the road subgrade if using BMP T5.15: Permeable Pavements), compact the native soil to that requirement prior to testing. Lay back the slopes sufficiently to avoid caving and erosion during the test. Alternatively, consider shoring the sides of the test pit.
- The horizontal surface area of the bottom of the test pit should be approximately 100 square feet. Document the size and geometry of the test pit.
- Install a vertical measuring rod (long enough to measure the ponded water depth, minimum 5- ft. long) marked in half-inch increments in the center of the pit bottom.
- Use a rigid 6-inch diameter pipe with a splash plate on the bottom to convey water to the test pit and reduce side-wall erosion or excessive disturbance of the test pit bottom. Excessive erosion and bottom disturbance will result in clogging of the infiltration receptor and yield lower than actual infiltration rates.
- Add water to the pit at a rate that will maintain a water level between 6 and 12 inches above the bottom of the pit. A rotameter can be used to measure the flow rate into the pit.

The depth should not exceed the proposed maximum depth of water expected in the completed BMP. For infiltration BMPs serving large drainage areas, designs with multiple feet of standing water can have infiltration tests with greater than 1 foot of standing water.

- Every 15-30 min, record the cumulative volume and instantaneous flow rate in gallons per minute necessary to maintain the water level at the same point on the measuring rod.
- Keep adding water to the pit until one hour after the flow rate into the pit has stabilized (constant flow rate; a goal of 5% or less variation in the total flow) while maintaining the same pond water level. The total of the pre-soak time plus one hour after the flow rate has stabilized should be no less than 6 hours.
- After the flow rate has stabilized for at least one hour, turn off the water and record the rate of infiltration (the drop rate of the standing water) in inches per hour from the measuring rod data, until the pit is empty. Consider running this falling head phase of the test several times to estimate the

dependency of the infiltration rate with head.

- At the conclusion of testing, over-excavate the pit to see if the test water is mounded on shallow restrictive layers or if it has continued to flow deep into the subsurface. The depth of excavation varies depending on soil type and depth to the hydraulic restricting layer, and is determined by the engineer or certified soils professional. Mounding is an indication that a mounding analysis is necessary.

## *DATA ANALYSIS*

Calculate and record the initial $K_{sat}$ rate in inches per hour in 30 minutes or one-hour increments until one hour after the flow has stabilized.

Use statistical/trend analysis to obtain the hourly flow rate when the flow stabilizes. This would be the lowest hourly flow rate. *Example:*

The area of the bottom of the test pit is 8.5-ft. by 11.5-ft. (97.75 sq. ft.).

Water flow rate was measured and recorded at intervals ranging from 15 to 30 minutes throughout the test. Between 400 minutes and 1,000 minutes the flow rate stabilized between 10 and 12.5 gallons per minute or 600 to 750 gallons per hour, or 80.2 to 100 $ft^3$ per hour. Dividing this rate by the surface area gives an initial $K_{sat}$ of 9.8 to 12.3 inches per hour.

### ***$K_{sat}$ Determination Option 2: Small Scale Pilot Infiltration Test (PIT)***

A small-scale PIT can be substituted for Ksat Determination Option 1: Large Scale Pilot Infiltration Test (PIT) in any of the following instances:

- The drainage area to the infiltration BMP is less than 1 acre.
- The testing is for BMP T7.30: Bioretention or BMP T5.15: Permeable Pavements that either serve small drainage areas and/or are widely dispersed throughout a project site.
- The site has a high infiltration rate (>4 in/hr), making a large scale PIT difficult, and the site geo- technical investigation suggests uniform subsurface characteristics.

## *INFILTRATION TEST*

Use the same procedures described above in Ksat Determination Option 1: Large Scale Pilot Infiltration Test (PIT), with the following changes:

- The horizontal surface area of the bottom of the test pit should be 12 to 32 square feet. It may be circular or rectangular. Document the size and geometry of the test pit.
- The rigid pipe with a splash plate used to convey water to the pit may be a 3-inch diameter pipe for pits on the smaller end of the recommended surface area, or a 4-inch pipe for pits on the larger end of the recommended surface area.
- Pre-soak period: Add water to the pit so that there is standing water for at least 6 hours. Maintain the pre-soak water level at least 12 inches above the bottom of the pit.
- At the end of the pre-soak period, add water to the pit at a rate that will maintain a 6-12 inch water level above the bottom of the pit over a full hour. The depth should not exceed the proposed maximum depth of water expected in the completed facility.
- Every 15 minutes, record the cumulative volume and instantaneous flow rate in gallons per minute necessary to maintain the water level at the same point (between 6 inches and 1 foot) on the measuring rod. The specific depth should be the same as the maximum designed ponding depth (usually 6 – 12 inches).

After one hour, turn off the water and record the rate of infiltration (the drop rate of the standing water) in inches per hour from the measuring rod data, until the pit is empty.

- A self-logging pressure sensor may also be used to determine water depth and drain-down.
- At the conclusion of testing, over-excavate the pit to see if the test water is mounded on shallow restrictive layers or if it has continued to flow deep into the subsurface. The depth of excavation varies depending on soil type and depth to the hydraulic restricting layer, and is determined by the engineer or certified soils professional. The soils professional should judge whether a mounding analysis is necessary.

# APPENDIX D

## *CALCULATED DESIGN INFILTRATION RATE:*

**Site variability and number of locations tested ($CF_v$)** - The number of locations tested must be capable of producing a picture of the subsurface conditions that fully represents the conditions throughout the proposed location of the infiltration BMP. The partial correction factor used for this issue depends on the level of uncertainty that adverse subsurface conditions may occur. If the range of uncertainty is low - for example, conditions are known to be uniform through previous exploration and site geological factors

- one pilot infiltration test (or grain size analysis location) may be adequate to justify a partial correction factor at the high end of the range.

If the level of uncertainty is high, a partial correction factor near the low end of the range may be appropriate. This might be the case where the site conditions are highly variable due to conditions such as a deposit of ancient landslide debris, or buried stream channels. In these cases, even with many explorations and several pilot infiltration tests (or several grain size test locations), the level of uncertainty may still be high.

A partial correction factor near the low end of the range could be assigned where conditions have a more typical variability, but few explorations and only one pilot infiltration test (or one grain size analysis location) is conducted. That is, the number of explorations and tests conducted do not match the degree of site variability anticipated.

- **Uncertainty of test method ($CF_t$)** accounts for uncertainties in the testing methods. For the full scale PIT method, $CF_t$ = 0.75; for the small-scale PIT method, $CF_t$ = 0.50; for smaller-scale infiltration tests such as the double-ring infiltrometer test, $CF_t$ = 0.40; for grain size analysis, $CF_t$ = 0.40. These values are intended to represent the difference in each test's ability to estimate the actual saturated hydraulic conductivity. The assumption is the larger the scale of the test, the more reliable the result.
- **Degree of influent control to prevent siltation and bio-buildup ($CF_m$)** Even with a pre-settling basin or a basic treatment BMP for pre-treatment, the soil's initial infiltration rate will gradually decline as more and more stormwater, with some amount of suspended material, passes through the soil profile. The maintenance schedule calls for removing sediment when the BMP is infiltrating at only 90% of its design capacity. Therefore, a correction factor, $CF_m$, of 0.9 is called for.