Infiltration Trenches

Description: Excavated trench filled with stone aggregate used to capture and allow infiltration of stormwater runoff into the surrounding soils from the bottom and sides of the trench. Runoff from each rain event is captured and treated primarily through settling and filtration.

Advantages/Benefits:
- Provides for groundwater recharge
- Good for small sites with porous soils
- Cost effective
- Groundwater recharge (if soils are sufficiently permeable)

Disadvantages/Limitations:
- Potential for groundwater contamination
- High clogging potential; should not be used on sites with fine-particle soils (clays or silts) in drainage area
- Cannot be used in karst soils
- Geotechnical testing required

Selection Criteria:

50% – 90% Runoff Reduction Credit

Land Use Considerations:

- [x] **Residential**
- [x] **Commercial**
- [x] **Industrial**

Maintenance:
- Inspect for clogging
- Remove sediment from forebay
- Replace pea gravel layer as needed
- Maintain side slopes/remove invasive vegetation

H — **Maintenance Burden**
L = Low M = Moderate H = High

SECTION 1: DESCRIPTION

Using the natural filtering properties of soil, infiltration trenches can remove a wide variety of pollutants from stormwater through sorption, precipitation, filtering, and bacterial and chemical degradation. Infiltration trenches are excavations typically filled with stone to create an underground reservoir for stormwater runoff. By diverting runoff into the soil, an infiltration trench not only treats the water quality volume, but also helps to preserve the natural water balance on a site and can recharge groundwater and preserve base flow. Due to this fact, infiltration systems are limited to areas with highly porous soils where the water table and/or bedrock are located well below the bottom of the trench.

In addition, infiltration trenches must be carefully located to avoid the potential of groundwater contamination. Infiltration trenches are not intended to trap sediment and must always be designed with appropriate pretreatment measures to prevent clogging and failure. Due to their high potential for failure, these facilities must only be considered for sites where upstream sediment control can be ensured.

SECTION 2: PERFORMANCE

When used appropriately, infiltration has a very high runoff volume reduction capability, as shown in **Table 4.1.**

Table 4.1. Summary of Runoff Reduction Provided by Infiltration[1]

Stormwater Function	Level 1 Design	Level 2 Design
Runoff Volume Reduction (RR)	50%	90%
Treatment Volume (Tv) Multiplier*	1.0	1.25
Soil Infiltration Rate	> 0.5 in/hr & < 1 in/hr	≥ 1 in/hr

*Incorporated into LID Site Design Tool calculations
[1] CSN (2008) and CWP (2007)

SECTION 3: TYPICAL DETAILS

See Appendix 4-B and 4-C for required standard notes and applicable details for use in construction plans.

SECTION 4: PHYSICAL FEASIBILITY & DESIGN APPLICATIONS

Infiltration trenches are generally suited for areas where the subsoil is sufficiently permeable to provide a reasonable infiltration rate. Infiltration trenches can either be used to capture sheet flow from a drainage area or function as an off-line device. Key considerations with infiltration trenches include the following:

Infiltration/Soils. Infiltration is a key component of Low Impact Development (LID) design. Infiltration testing shall be required for all infiltration trenches (see Section 5.1). Soil conditions can constrain the use of infiltration trenches. Hydrologic Soil Groups (HSG) should be determined from NRCS soil data. For more information on soil types go to: http://websoilsurvey.nrcs.usda.gov/app/. Alternative HSG classifications will be considered when supporting reports from a licensed soil scientist or geotechnical engineer are provided.

Available Space. Planners and designers can assess the feasibility of using infiltration trenches based on a simple relationship between the contributing drainage area (CDA) and the corresponding required surface area. The infiltration trench surface area will depend on the imperviousness of the CDA, the subsoil infiltration rate, and the desired infiltration trench design level. Due to the relatively narrow shape, infiltration trenches can be adapted to many different types of sites and can be utilized in retrofit situations. Unlike some other structural stormwater controls, they can easily fit into the margin, perimeter, or other unused areas of developed sites.

Accessibility. Infiltration trenches require periodic maintenance and must be accessible to various types of equipment. A path of travel for equipment no less than twelve feet in width with a maximum slope of 3:1 must be provided for the infiltration trench. The path of travel shall be along no less than 50% of the perimeter of the infiltration trench and must be accessible by common equipment and vehicles.

Elevation Considerations. Infiltration trenches shall be located on slopes less than 15% and a minimum of 200 feet away from downstream slopes greater than 20%. Terracing or other inlet controls upstream may be used to slow runoff velocities entering the facility. Infiltration trenches cannot be used in fill soils.

Subsurface Constraints. Vertical constraints such as retaining walls, structures, or other impermeable barriers are prohibited around the infiltration trench perimeter. Infiltration trench subgrade shall always be separated from the water table and bedrock. Groundwater intersecting the filter bed can lead to possible groundwater contamination or failure of the infiltration trench. A separation distance of 2 feet is required between the bottom of the excavated infiltration trench and the seasonally high ground water table and/or bedrock.

Utilities. Public underground utilities and associated easements shall not be located within the infiltration trench footprint. Local utility design guidance shall be consulted in order to determine clearances required between stormwater infrastructure and other dry and wet utility lines. Private utilities should not be located within the infiltration trench when possible.

Contributing Drainage Area. Infiltration trenches are applicable primarily for impervious areas where there are not high levels of fine particulates (clay/silt soils) in the runoff and should only be considered for sites where the sediment load is relatively low. Infiltration trenches are best applied when the grade of contributing slopes is less than 15%. Typical drainage area size can range from 0.1 to 2.0 acres of impervious cover. Contributing drainage areas to infiltration trenches shall be clearly conveyed in the construction plans.

Hotspot Land Uses. Runoff from hotspot land uses should not be treated with infiltration trenches without appropriate pretreatment and MWS staff approval. For additional information on stormwater hotspots, please consult **Section 6.3**.

Floodplains. Infiltration trenches shall be constructed outside the limits of the 100-year floodplain. Flood waters from the 100-year event or smaller shall be prohibited from entering the overflow system.

Baseflow. The planned infiltration trench shall not receive baseflow, chlorinated wash-water or other such non-stormwater flows.

Setbacks. It is not recommended to place infiltration trenches immediately adjacent to structures. To avoid the risk of seepage, a licensed professional engineer should be consulted to determine the appropriate setbacks necessary to prevent the infiltration trench from compromising structural foundations or pavement. At a minimum, infiltration trenches should be located a horizontal distance of 25 feet from building foundations, 100 feet from any water supply well, and 50 feet from septic systems.

Applications. Infiltration trenches are generally suited for medium-to-high density residential, commercial and institutional developments. It should be noted that special care must be taken to provide adequate pre-treatment for infiltration trenches in space-constrained high traffic areas. Typical locations for infiltration trenches could include parking lot features and unused pervious areas on a site.

Infiltration trenches shall not be located below paved surfaces.

SECTION 5: DESIGN CRITERIA

5.1 Soil Infiltration Rate Testing

One must measure the infiltration rate of subsoils at the subgrade elevation of the infiltration trench. The infiltration rate shall exceed 0.5 inch per hour. If the infiltration rate is 0.5 inch per hour or less infiltration trenches shall not be used. On-site soil infiltration rate testing procedures are outlined in **Appendix 4-A**. The number of soil tests varies based on the length of the infiltration trench:

- ≤50 linear feet = 2 tests
- >50 linear feet = 2 tests + 1 test for every additional 50 linear feet

A separation distance of 2 feet is required between the bottom of the excavated infiltration trench and the seasonally high ground water table and/or bedrock.

For sites with large amounts of cut or fill it may not be practical to perform infiltration testing prior to grading the site. In these cases, a mass grading permit will be required.

5.2 Sizing of Infiltration Trenches

5.2.1 Stormwater Quality

Sizing of the surface area (SA) for the infiltration trench is based on the computed Treatment Volume (T_v) of the contributing drainage area and the storage provided in the facility. The required surface area (in square feet) is computed as the Treatment Volume (in cubic feet) divided by the equivalent storage depth (in feet). The equivalent storage depth is computed as the depth of gravel and surface ponding multiplied by the accepted porosity. All layer depths shall be uniform with regard to surface area. The surface should generally be flat, so the infiltration trench fills up like a bathtub. See Section 5.5 for material specifications.

Table 4.2 Infiltration Trench Typical Section for Water Quality Calculations

	Level 1 or Level 2 (inches)	Porosity Value (n)
Ponding	6	1.0
Surface Cover	3	0.40*
Choker	3	0.40
Reservoir	36-96	0.40
Trench Bottom	6	N/A
* Cannot be used in De and surface area calculations when using turf.		

The equivalent storage depth for Level 1 and 2 is therefore computed as:

Equation 4.1. Infiltration Trench Level 1 and 2 Design Storage Depth

$$\text{Equivalent Storage Depth} = D_E = n_1(D_1) + n_2(D_2) + \cdots$$

$$D_E = (3 \text{ to } 8 \text{ ft.} \times 0.4) + (0.5 \times 1.0) = 1.7 \text{ to } 3.7 \text{ ft.}$$

Therefore, the Level 1 Infiltration Trench Surface Area (SA) is computed as:

Equation 4.2.* Infiltration Trench *Level 1 Design Surface Area

$$SA \text{ (sq. ft.)} = [(1.00 * T_v) - \text{the volume reduced by an upstream SCM}] / D_E$$

And the Level 2 Infiltration Trench Surface Area is computed as:

Equation 4.3.* Infiltration Trench *Level 2 Design Surface Area

$$SA \text{ (sq. ft.)} = [(1.25 * Tv) - \text{the volume reduced by an upstream SCM}] / D_E$$

Where:

SA = Minimum surface area of Infiltration Trench filter (sq. ft.)

D_E = *Equivalent Storage Depth (ft.)*

T_v = Treatment Volume (cu. ft.) = [(1.0 in.)(R_v)(A)*3630]

5.2.2 Stormwater Quantity

It is recommended that rain events larger than the 1-inch storm bypass infiltration trenches to prevent additional maintenance burden. However, if designed with sufficient volume and appropriate outlet structures, peak attenuation control utilizing exfiltration may be provided. Hydrologic calculations utilizing the SCS method may be necessary to demonstrate pre versus post peak flow rates.

Surface Storage. Designers may be able to create surface storage by locating infiltration trenches within dry detention ponds.

Subsurface Storage. Designers may be able to create additional subsurface storage for flow attenuation by increasing the subsurface volume without necessarily increasing the infiltration trench footprint. Additional volume can be provided by increasing the depth of stone or approved proprietary storage products. Subsurface storage will not be allowed without sufficient infiltration (see Section 5.1). Maximum trench depth of 10 feet.

Adjusted CN. With infiltration rates greater than 0.5 inch per hour (see Section 5.1), the removal of volume by infiltration trenches changes the runoff depth entering downstream flood control facilities. An approximate approach to accounting for the removal of volume is to calculate an "effective SCS curve number" (CN_{adj}), which is less than the actual curve number (CN). CN_{adj} can then be used in hydrologic calculations and in routing. This method is detailed in Volume 5 Section 3.2.5.

5.3 Pretreatment/Inlets

Pretreatment facilities must always be used in conjunction with an infiltration trench to remove floatables and sediment to prevent clogging and failure. Every infiltration practice should include multiple pretreatment techniques, although the nature of pretreatment practices depends on the type of flow received. The number, volume and type of acceptable pretreatment techniques needed for the types of receiving flow are found in **Table 4.3**.

Volumetric pretreatment practices, such as forebays, are sized based on a percentage of the required treatment volume of the GIP. The percentage requirement for the pretreatment practice will vary depending on the design level of the GIP and is exclusive of the required treatment volume for the GIP. Exclusive, in this application, is defined as being separate from the required treatment volume of the GIP. The volume provided by pretreatment practices cannot be included in the calculation for overall treatment volume provided by the GIP.

Table 4.3. Required Pretreatment Elements for Infiltration Practices

Flow Type	Level 1 Facility Options	Level 2 Facility Options
Point/ Concentrated	**Forebay** o 15% pretreatment volume (exclusive) o enhanced check dam (TDOT EC-STR-6A) o flat bottom without stone **Proprietary structure** (MWS approval)	**Forebay** o 25% pretreatment volume (exclusive) o enhanced check dam (TDOT EC-STR-6A) o flat bottom without stone **Proprietary structure** (MWS approval)
Sheet	Gravel diaphragm to grass filter strip (15' with maximum 3:1 slope)	
Upstream GIP	Outlet protection may be required at upstream GIP outfall	

5.4 Conveyance and Overflow

For On-line infiltration trenches: An overflow structure should always be incorporated into on-line designs to safely convey larger storms through the infiltration trench. Common overflow systems within infiltration trench consist of an overflow structure(s) and/or emergency spillway in compliance with the Stormwater Management Manual, Volume 2, Section 8.

Off-line infiltration trenches: Off-line designs are preferred. One common approach is to create an alternate flow path at the inflow point into the structure such that when the maximum ponding depth is reached, the incoming flow is diverted past the facility. In this case, the higher flows do not pass over the stone bed and through the facility.

Another option is to utilize a low-flow diversion or flow splitter at the inlet to allow only the Treatment Volume to enter the facility. This may be achieved with a weir or curb opening sized for the target flow, in combination with a bypass channel. Using a weir or curb opening helps minimize clogging and reduces the maintenance frequency.

5.5 Infiltration Trench Material Specifications

Table 4.4 outlines the standard material specifications used to construct infiltration trenches.

Table 4.4. Infiltration Trench Material Specifications

Material	Specification	Notes
Surface Cover	River stone Turf (acceptable with subsurface inflow, ie. roof leader)	Lay a 3-inch layer on the surface of the filter bed in order to suppress weed growth & prevent erosion.
Geotextile	Use a non-woven geotextile fabric with a flow rate of > 110 gal./min./ft^2 (e.g., Geotex 351 or equivalent)	Apply to the sides and below surface cover. AASHTO M288-06, ASTM D4491 & D4751
Choker Layer	#8 or #89 clean washed stone	Meet TDOT Construction Specifications.
Reservoir Layer	#57 or #2 clean washed stone	Meet TDOT Construction Specifications.
Trench Bottom	Coarse sand	Meet TDOT Construction Specifications
Observation Well	6-inch SDR 35 PVC pipe with vented cap and anchor plate	Install one per 50 feet of length of infiltration trench (minimum 1)

SECTION 6: SPECIAL CASE DESIGN ADAPTATIONS

6.1 Shallow Bedrock and Groundwater Connectivity

Many parts of Nashville have shallow bedrock, which can constrain the application of deeper infiltration trenches. In such settings, other GIPs may be more applicable. For more information on bedrock depths download the GIS data set from:

http://water.usgs.gov/GIS/metadata/usgswrd/XML/regolith.xml.

6.2 Karst

Karst regions are found in much of Middle Tennessee, which complicates both land development and stormwater design. While infiltration trenches produce less deep ponding than conventional stormwater practices (e.g., ponds and wetlands); they shall not be used in any area with a high risk of sinkhole formation.

6.3 Hotspots

Stormwater hotspots are operations or activities that are known to produce higher concentrations of stormwater pollutants and/or have a greater risk for spills, leaks or illicit discharges. Infiltration trenches shall not be used in any area with a hotspot designation without appropriate pretreatment and MWS staff approval. Staff may also require additional treatment for runoff from hotspots.

SECTION 7: CONSTRUCTION

7.1 Construction

Construction Stage Erosion and Sediment Controls. Small-scale infiltration trenches areas should be fully protected by perimeter EPSC measures and construction fencing to prevent sedimentation and compaction. Ideally, infiltration trenches should remain outside the limit of disturbance during construction to prevent soil compaction by heavy equipment.

Excavation. The proposed site should be checked for existing utilities prior to any excavation. It is very important to minimize compaction of the infiltration trench. When possible, excavators should work from the sides of the infiltration trench to remove original soil. If the infiltration trench is excavated using a loader, the contractor must use wide track or marsh track equipment, or light equipment with turf type tires. Use of equipment with narrow tracks or narrow tires, rubber tires with large lugs, or high-pressure tires will cause excessive compaction resulting in reduced infiltration rates and is not acceptable. Compaction will significantly contribute to design failure.

The trench excavation should be limited to the width and depth specified in the design. Excavated material should be placed away from the open trench so as not to jeopardize the stability of the trench sidewalls. The sides and bottom of the trench shall be trimmed of all large roots and scarified with no voids prior to backfilling.

7.2 Infiltration Trench Installation

Construction should take place during appropriate weather conditions. The following is a typical construction sequence to properly install an infiltration trench. These steps may be modified to reflect different applications or expected site conditions:

Step 1. The designer and the installer should have a preconstruction meeting, checking the boundaries of the contributing drainage area and the actual inlet elevations to ensure they conform to original design. Since other contractors may be responsible for constructing portions of the site, it is quite common to find subtle differences in site grading, drainage and paving elevations that can produce hydraulically important differences for the proposed infiltration trench. The designer should clearly communicate, in writing, any project changes determined during the preconstruction meeting to the installer and the plan review/inspection authority.

Step 2. Ensure that the entire contributing drainage area has been stabilized prior to infiltration trench construction. Otherwise, use EPSC measures as outlined in Section 7.1.

Step 3. Excavation of the infiltration trench should follow the guidelines found in Section 7.1.

Step 4. Remove any roots and scarify the sides and bottom .

Step 5. Install all layers and components of the infiltration trench per the approved plans.

Step 6. Conduct the final construction inspection (see **Section 8**). Then log the GPS coordinates for each infiltration trench and submit them to MWS.

SECTION 8: AS-BUILT REQUIREMENTS

After the infiltration trench has been constructed, the owner/developer must have an as-built certification of the infiltration trench conducted by a registered Professional Engineer. The as-built certification verifies that the GIP was installed per the approved plan. The following items shall be provided in addition to the as-built requirements found in SWMM Volume 1.

1. The Engineer shall include a copy of the GIP summary table found in Appendix 4-D.
2. Supporting documents such as invoices and photographs should be included in the submittal package.

SECTION 9: MAINTENANCE

Each SCM must have a Maintenance Document submitted to Metro for approval and maintained and updated by the SCM owner. Refer to Volume 1, Appendix C for information about the Maintenance Document for infiltration trenches, as well as an inspection checklist. The Maintenance Document must be completed and submitted to Metro with grading permit application. The Maintenance Document is for the use of the SCM owner in performing routine inspections. The developer/owner is responsible for the cost of maintenance and annual inspections. The SCM owner must maintain and update the SCM operations and maintenance plan. At a minimum, the operations and maintenance plan must address:

- Ensure that contributing area, facility and inlets are clear of debris.
- Ensure that the contributing area is stabilized.
- Remove sediment and oil/grease from pretreatment devices, as well as overflow structures.
- Check observation wells following 3 days of dry weather. Failure to percolate within this time period indicates clogging.
- Inspect pretreatment devices and diversion structures for sediment build-up and structural damage.
- Remove trees that start to grow in the vicinity of the trench.
- Replace pea gravel/topsoil and top surface filter fabric (when clogged).
- Perform total rehabilitation of the trench to maintain design storage capacity.
- Excavate trench walls to expose clean soil.

SECTION 10: REFERENCES

Chesapeake Stormwater Network (CSN). 2008. *Technical Bulletin 1: Stormwater Design Guidelines for Karst Terrain in the Chesapeake Bay Watershed.* Version 1.0. Baltimore, MD. Available online at: http://www.chesapeakestormwater.net/all-things-stormwater/stormwater-guidance-for-karst-terrain-in-the-chesapeake-bay.html

CWP. 2007. *National Pollutant Removal Performance Database, Version 3.0*. Center for Watershed Protection, Ellicott City, MD.

ARC, 2001. Georgia Stormwater Management Manual Volume 2 Technical Handbook.

CDM, 2000. Metropolitan Nashville and Davidson County Stormwater Management Manual Volume 4 Best Management Practices.

Federal Highway Administration (FHWA), United States Department of Transportation. Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring. Accessed January 2006. http://www.fhwa.dot.gov/environment/ultraurb/index.htm.

VADCR. 2011. Stormwater Design Specification No. 8: Infiltration, Version 1.9. Virginia Department of Conservation and Recreation.

VADEQ. 2013. Stormwater Design Specification No. 8: Infiltration, Version 2.0. Virginia Department of Environmental Quality.

APPENDIX 4-A

INFILTRATION SOIL TESTING PROCEDURES

I. Test Pit/Boring Procedures

1. The number of required test pits or standard soil borings is based on proposed infiltration area:
   - **≤50 linear feet = 2 tests**
   - **>50 linear feet = 2 tests + 1 test for every additional 50 linear feet**
2. The location of each test pit or standard soil boring should correspond to the location of the proposed infiltration area and be performed in in situ soils.
3. Excavate each test pit or penetrate each standard soil boring to a depth at least 2 feet below the bottom of the proposed infiltration area.
4. If the groundwater table is located within 2 feet of the bottom of the proposed facility, determine the depth to the groundwater table immediately upon excavation and again 24 hours after excavation is completed.
5. Determine the USDA or Unified Soil Classification system textures at the bottom of the proposed infiltration area and at a depth that is 2 feet below the bottom. All soil horizons should be classified and described.
6. If bedrock is located within 2 feet of the bottom of the proposed infiltration area, determine the depth to the bedrock layer.
7. Test pit/soil boring stakes should be left in the field to identify where soil investigations were performed.

II. Infiltration Testing Procedures

1. The number of required infiltration tests is based on proposed infiltration area:
   - **≤50 linear feet = 2 tests**
   - **>50 linear feet = 2 tests + 1 test for every additional 50 linear feet**
2. The location of each infiltration test should correspond to the location of the proposed infiltration area.
3. Install a test casing (e.g., a rigid, 4 to 6-inch diameter pipe) to the bottom of the proposed infiltration area. Record the testing elevation.
4. Remove all loose material from the sides of the test casing and any smeared soil material from the bottom of the test casing to provide a natural soil interface into which water may percolate. If desired, a 2-inch layer of coarse sand or fine gravel may be placed at the bottom of the test casing to prevent clogging and scouring of the underlying soils. Fill the test casing with clean water to a depth of 2 feet, and allow the underlying soils to presoak for 24 hours.
5. After 24 hours, refill the test casing with another 2 feet of clean water and measure the drop in water level within the test casing after one hour. Repeat the procedure three (3) additional times by filling the test casing with clean water and measuring the drop in water level after one hour. A total of four (4) observations must be completed.
6. The infiltration rate of the underlying soils may be reported either as the average of all four observations or the value of the last observation. The infiltration rate shall be reported in terms of inches per hour along with the elevations and locations of the test pits. Locations shall be shown on site map.
7. Infiltration testing may be performed within an open test pit or a standard soil boring. After infiltration testing is completed, the test casing should be removed, and the test pit or soil boring should be backfilled and restored.

APPENDIX 4-B

STANDARD NOTES

Required Infiltration trench Notes:

- Contractor, Engineer, or Owners Representative shall notify MWS NPDES staff at least 48 hours prior to backfilling the infiltration trench.
- Vehicular and equipment traffic shall be prohibited in the bioretention area to prevent compaction and sediment deposition.

APPENDIX 4-C

STANDARD DETAILS

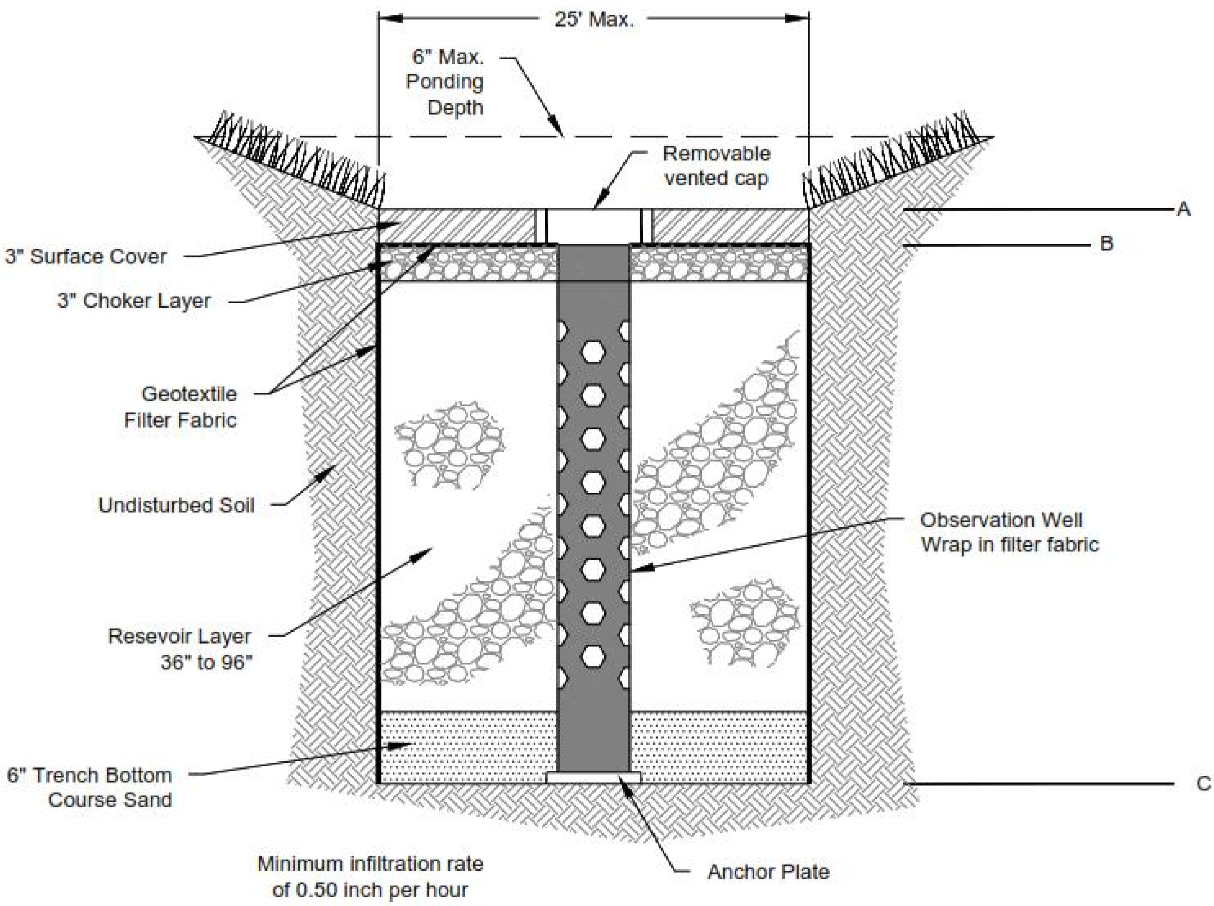

Figure 4.1. Infiltration Trench Section

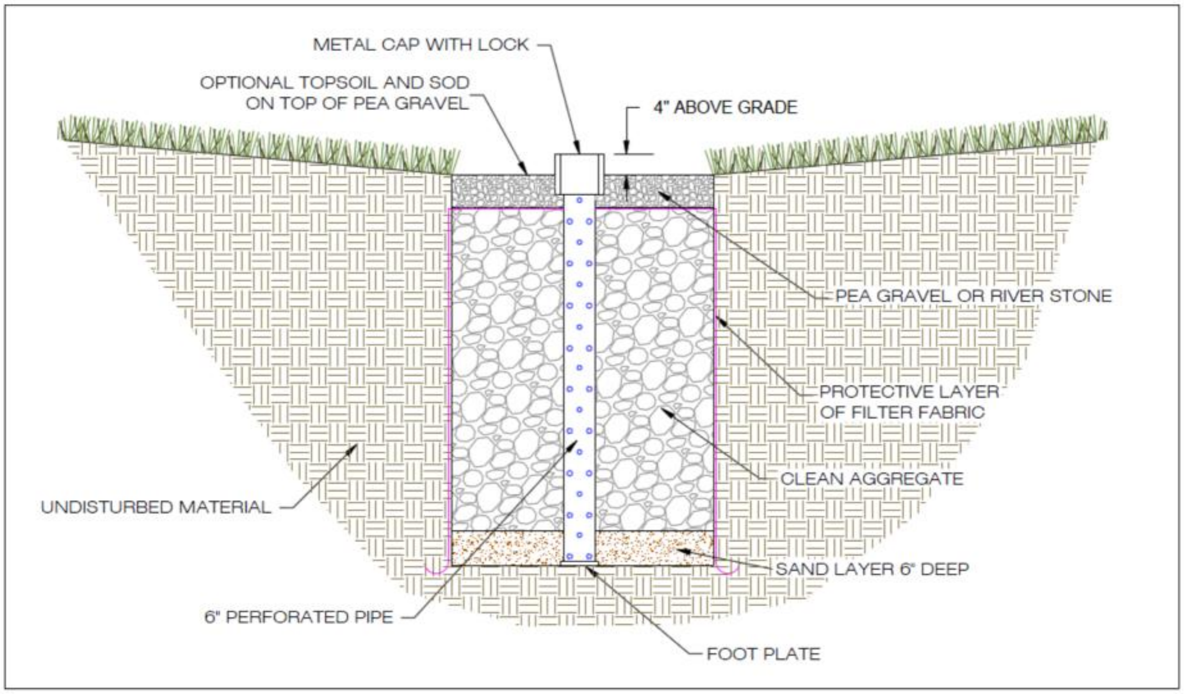

Figure 4.2: Observation Well Detail (VADEQ, 2013)

APPENDIX 4-D

AS-BUILT REQUIREMENTS

A printer friendly version of this table can be found on the MWS Development Services website or by request.

Infiltration Trench Number:

	Design	As-Built
Treatment Volume (Tv), CF		
Surface Area, SF		
Emergency Spillway Elevation*		
Overflow (TOC) Elevation*		
(A) GIP Surface Elevation		
(B) Top of Stone Elevation**		
Outlet Elevation*		
(C) Subgrade Elevation		
* N/A if not required		
** Required if using turf as a surface cover		
ALL Elevation shall be NAVD-88		

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