2.7 Infiltration Trench

Description

An infiltration trench is a rock-filled trench that receives stormwater runoff, allowing it to infiltrate into the ground. These structures provide temporary underground storage in the form of an excavated trench filled with uniform graded stone. Manufactured storage units may be used to enhance or maximize the underground storage in the available space Infiltration trenches require sediment pretreatment practices that remove most suspended solids before runoff enters the infiltration trench. Pretreatment is typically accomplished by passing runoff through a forebay, grass filter strip, swale and/or sump as well as incorporating the specified surface layer of the infiltration trench.

Infiltration is the single most efficient post-construction stormwater practice, providing several benefits other control practices don't. Most notably, infiltration tends to reverse the hydrologic consequences of urban development by reducing peak discharge and increasing base flow to local streams. Unfortunately, infiltration trenches must be very carefully constructed to ensure they will continue to function, and they often have high long-term maintenance requirements. Infiltration practices also are limited by site constraints, particularly soils, which must be within a narrow range of permeability.

Conditions Where Practice Applies

Smaller Sites – Infiltration trenches are generally not considered practical for sites larger than 5 acres. Used in small areas they offer flexibility in incorporating water quality treatment into a site's drainage system. They may be used prior to runoff entering the site's drainage system, such as along parking lot perimeters. They can be located in small areas, which cannot readily accommodate wet ponds or similar facilities.

Soil Hydraulic Conductivity – Hydraulic conductivity describes the ability of water to move through a soil. Hydraulic conductivity should be at least 0.5 in/hr. These rates represent saturated soil conditions, not dry conditions. Rates slower than this will lead to unreasonably large trench sizes that are prone to failure. Infiltration trenches located in gravelly soils or coarse sands (typically sites with Ksat > 4 in/hr) will not provide adequate runoff treatment and protection against groundwater contamination. Trenches should not be constructed in fill. On-site evaluation of soil parameters related to hydraulic conductivity and groundwater by a trained professional is recommended.

Industrial or Other Areas of Potential Ground Water Contamination – This practice should not be used in heavy industrial developments, areas with chemical storage, pesticide storage or fueling stations.

Stable Slope – Trenches should not be used in slip prone areas where they may cause slope instability.

Hydrologic Recharge – Infiltration practices help reduce runoff and may help support recharge of groundwater and baseflow to streams. This practice may be a particularly desirable option when the receiving stream is a cold water habitat.

Planning Considerations

Sediment Clogging – The principle threat to infiltration trenches and a common reason for their failure is sediment clogging of the permeable soil layer. An effective pretreatment (sediment trapping) system is an essential part of all infiltration trench designs. Vegetated swales, buffer strips or sediment settling ponds should be planned so that most sediment is removed from runoff prior to reaching the infiltration trench. Additionally infiltration trenches may not be installed until disturbance from construction has ended and soils are stabilized.

Groundwater Protection – Precautions must be taken to guard against the facility introducing contaminants into water supply aquifers. Excessively permeable soils will not effectively stop pollutants and should not be used for infiltration practices Infiltration trenches should be used with caution in well-head protection areas, i.e., areas of the state where the public water supply comes from ground water. At a minimum, infiltration structures should not be located within 100 feet of an active water supply well. A minimum vertical separation of 3 feet between the bottom of the infiltration trench and the seasonal high water elevation of the ground water must be maintained, although larger separations are recommended where achievable. Normally, infiltration through soil is a highly effective and safe means of removing pollutants and protecting groundwater from contamination. Removal mechanisms involve sorption, precipitation, trapping, and bacterial degradation or transformation and are quite complex.

Considerations for Cold Climates – The design volume of the infiltration trench may need to be increased in order to treat snowmelt. In addition, if the practice is used to treat roadside runoff, it may be desirable to divert flow around the trench in winter to prevent infiltration of chlorides from road salt. Finally, a minimum setback of 20 feet from road subgrade is required to ensure that the practice does not cause frost heaving.

Design Criteria

Diversion – Storm water runoff should be directed to the infiltration trench via dispersed sheet flow wherever possible. A grass filter strip of at least 25 feet must precede the infiltration trench in these situations. Where runoff is directed to the infiltration trench as concentrated flow (via a swale, storm sewer or other discrete conveyance), the infiltration trench must be designed “off-line” such that flows in excess of the Water Quality Volume (WQv) are diverted around the infiltration trench.

In addition, a diversion that allows the trench to be bypassed when the pretreatment system becomes clogged or otherwise fails should be included in the design. This can be accomplished by providing a drain valve.

Soil Hydraulic Conductivity – Soil infiltration rates within the trench must be greater than 0.50 in/hr. The soil should have no greater than 20 percent clay content and less than 40 percent silt/clay content.

Soils that meet the required infiltration rates and are potentially suitable for the installation of infiltration trenches can be found in Appendix E. However, do not use this or county soil surveys to determine final suitability. Site-specific soil tests should be performed to confirm that the hydraulic conductivity falls within the required range. A certified Soil Scientist or other trained professional shall perform one test hole per 5000 square feet of infiltration trench area, with a minimum of two borings within the planned facility location. This evaluation shall include an evaluation of the normal and seasonal high groundwater levels.

Pretreatment – The potential for failure of infiltration practices due to clogging by sediments is high. Failure will result if sediment is not trapped before runoff enters the trench. Thus, it is imperative that the facility design includes a durable, maintainable pretreatment system for removing sediment from stormwater before the trench. This is accomplished by pretreatment options before runoff enters the infiltration trench such as forebay, filter strip, swale or deep sump trap and the proper surface layer of the infiltration trench. Where infiltration trenches collect rooftop runoff (with drainage areas of 1 acre or less) pretreatment can be accomplished by providing a deep sump trap with a permanent pool between downspouts and the infiltration trench (Fig 2.7.1). The trap must be accessible, but sealed tightly so that it does not become a breeding ground for mosquitoes.

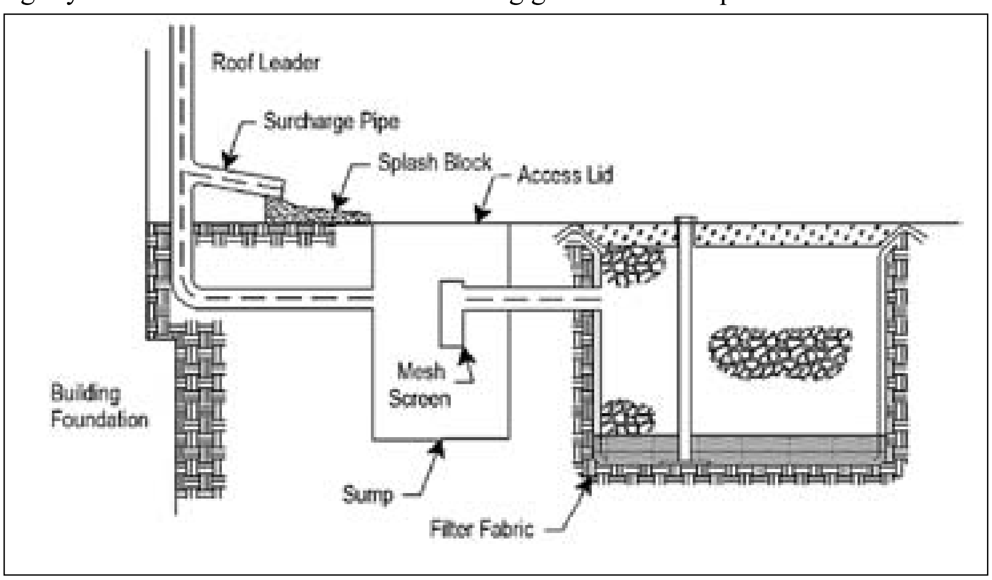


Figure 2.7.1 **Underground pretreatment facility and infiltration trench for treating rooftop runoff.**

Sizing the Pretreatment Facility – See the criteria for pretreatment practices that are also contained within Chapter 2 of this manual.

Exit Velocity from Pretreatment Facility – The velocity of runoff as it exits from the pretreatment device must be non-erosive.

Drain Time Requirements – The practice should be designed to infiltrate the Water Quality Volume (WQv, see page 30 of this chapter) in 24 to 48 hours. Flows in excess of the WQv are to be diverted around the trench.

Dimensions – The dimensions of the storage reservoir (infiltration trench) are made by fitting the length, width and depth into a configuration, which satisfies drain time and storage volume requirements. The trench dimensions shall be sized by accepted engineering methods such as those outlined below:

1. Determine Initial Storage Depth – The bottom of the infiltration trench must be deeper than 2 feet to avoid freezing and shallow enough to leave at least 2 feet between the seasonal high-water table or bedrock and the trench bottom. Soil morphology also must be considered in determining the dimensions of the storage reservoir to utilize the optimum horizons or strata. The presence of a thin, slowly permeable soil horizon may require a trench depth which completely penetrates into more permeable underlying material. Long trenches may need to be curved parallel to the topographic contour in order to keep the trench bottom elevation within the optimal depth in the soil profile.

2. Determine Area of Trench Bottom – The bottom of the trench is to be completely flat so as to allow runoff to infiltrate through the entire surface. The minimum infiltration area (A_{inf}) at the bottom of the excavated trench must meet the two following criteria:

(1) Minimum infiltration area $A_{inf} > 0.05 * A_{imp}$

Where: A_{inf} = minimum area of the bottom of the trench (ft^2);
A_{imp} = impervious area within the drainage area (ft^2)

(2) Minimum infiltration area $A_{inf} \geq WQv/(Kfs * td)$

Where: A_{inf} = minimum area of the bottom of the trench (ft^2);
WQ_v = Water Quality Volume (ft^3) (Trench volume less stone volume);
Kfs = field saturated hydraulic conductivity of the underlying soil (in/hr or ft/hr) (Soil infiltration rate at trench bottom);
td = drawdown or drain Time (hr) (Must be ≤ 48 hours)

The excavated volume of the trench is the WQ_v divided by porosity or the void space of the stone.

Determine Length and Width – A long, narrow trench is less affected by water table mounding. If depth to seasonal high-water table or bedrock is within 5 feet of the trench bottom, it is advisable to design the trench as long and narrow as possible. Otherwise, the configuration of the trench is not restricted and is only limited by site design constraints.

Stone – The infiltration trench is filled with clean, washed uniform, open graded aggregate. Stone with a diameter of between 1 and 3 inches should be used.

Geotextile – The sides and top of the trench must be lined with a non-woven geotextile to restrict the amount of sediment entering the structure. The top layer of the geotextile should be covered by 6-to-12 inches of smaller sized gravel (0.75-inch diameter). This top layer of gravel and geotextile must be replaceable. The bottom of the trench must NOT be covered with geotextile to prevent clogging with sediment. The geotextile should meet the following specifications:

Table 2.7.1 Geotextile specification

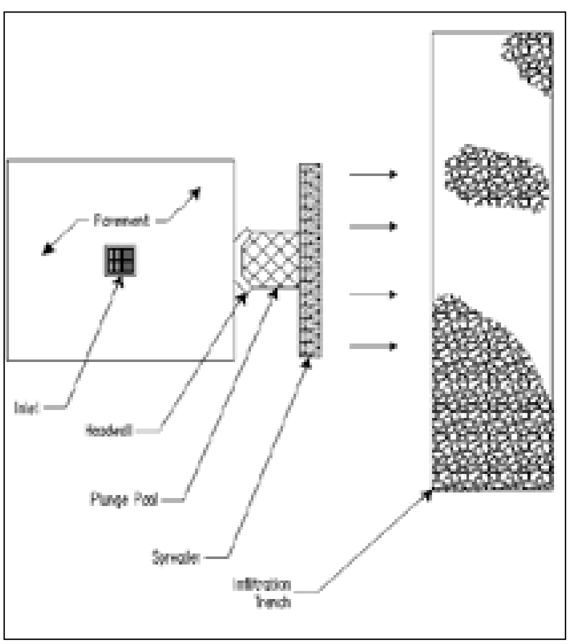
Specification	Criteria
Material	ASTM D-3776
Weight, oz/yd2	4
Grab tensile strength, lb/min (ASTM D4632)	90
Elongation at break, % (ASTM D4632)	30
Toughness, lb/min	6000

Bottom Sand Filter – To promote continued infiltration, the bottom of the trench should be covered with a clean layer of sand, approximately 6 inches deep.

Observation Well – An observation well, consisting of a perforated vertical 6-inch diameter PVC pipe with lockable cap should be installed in the trench to monitor performance. The original depth of the well must be marked on the top of the well.

Overflow – Infiltration trenches, like all stormwater facilities, must be designed to handle storms, which exceed their storage capacity without damage. Discharges must be non-erosive and overflow must always pass around the infiltration trench without being restricted by sediment filters. For example, the infiltration trenches that accept concentrated runoff from a subsurface pipe must have an overflow structure that collects overflow from within the structure rather than forcing runoff up and out through the geotextile cover.

Construction Sediment – Due to their sensitivity to sediment, infiltration trenches should not receive runoff from disturbed areas of the site. It is advisable to construct the infiltration trench only after the contributing drainage area has been stabilized.



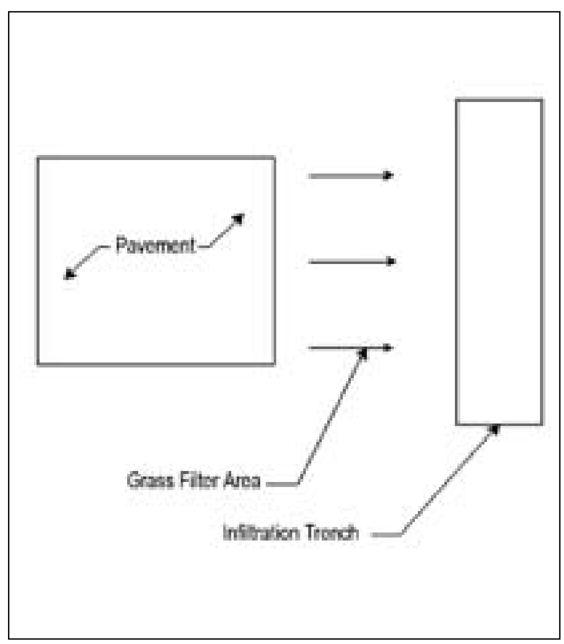


Figure 2.7.2 Typical Infiltration Trench with Plunge Pool

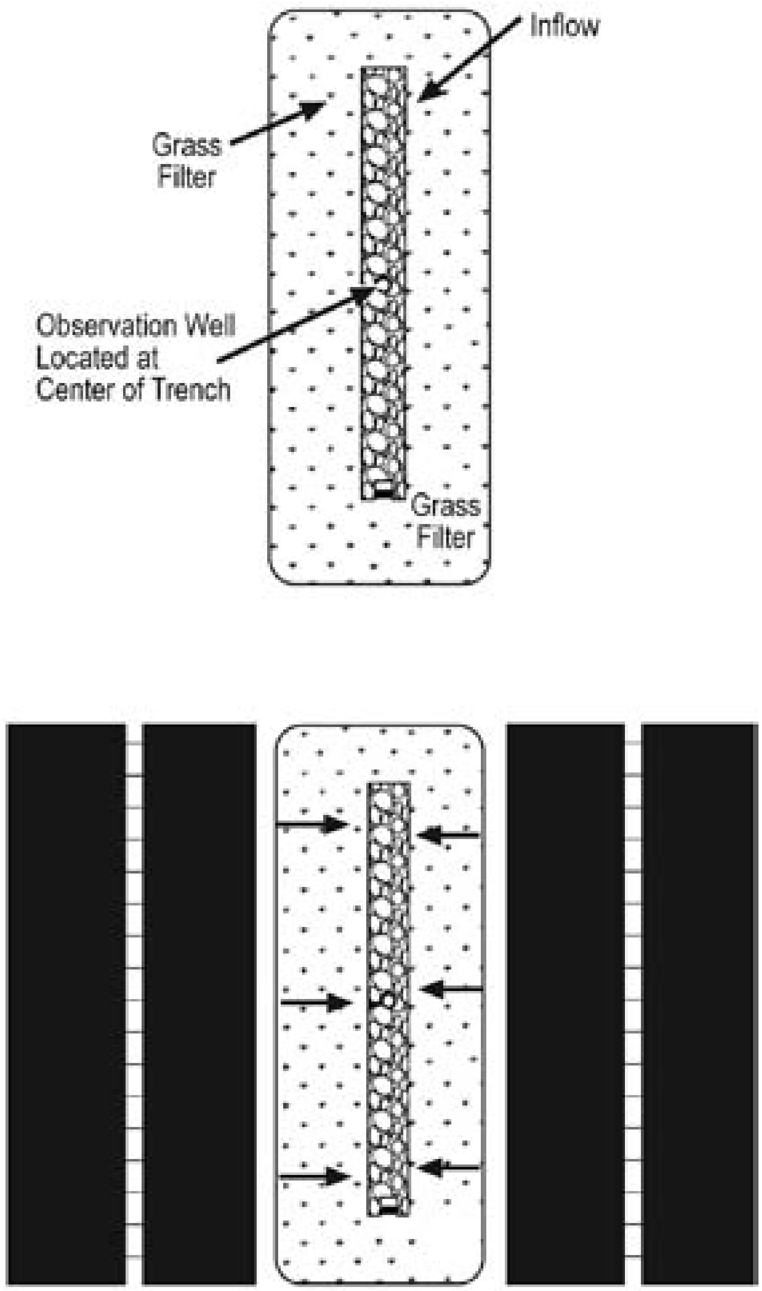


Figure 2.7.3 Illustration of a median strip trench design

Infiltration trenches have a high rate of failure. In one study in Prince George's County, Maryland (Galli, 1992), less than half of the trenches investigated were still functioning properly and less than one third still functioned properly after 5 years. However, many of these structures did not incorporate pretreatment of runoff. Thus, it is critical to ensure that proper pretreatment of runoff has been provided.

Maintenance

The following regular maintenance and inspection protocol is recommended:

Table 2.7.2 Typical Maintenance for Infiltration Practice

Schedule	Activity
Twice per year	Check observation wells following 3 days of dry weather. Failure to percolate within this timeCheck 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.
Standard maintenance	Remove sediment and oil/grease from pretreatment devices as well as overflow structure.
Upon failure	Total rehabilitation of the trench should be conducted to maintain storage capacity within 67% of the design treatment volume and 72-hour exfiltration rate limit. Trench walls should be excavated to expose clean soil.
Annually	Trim adjacent trees to assure that drip-line does not extend over the surface of the infiltration trench.

Adapted from WMI, 1997 and SMRC

References

ASCE/WEF (American Society of Civil Engineers/Water Environment Federation), 1998. Urban Runoff Quality Management, WEF Manual of Practice No. 23, ASCE Manual and Report on Engineering Practice No. 87, Alexandria and Reston, VA.

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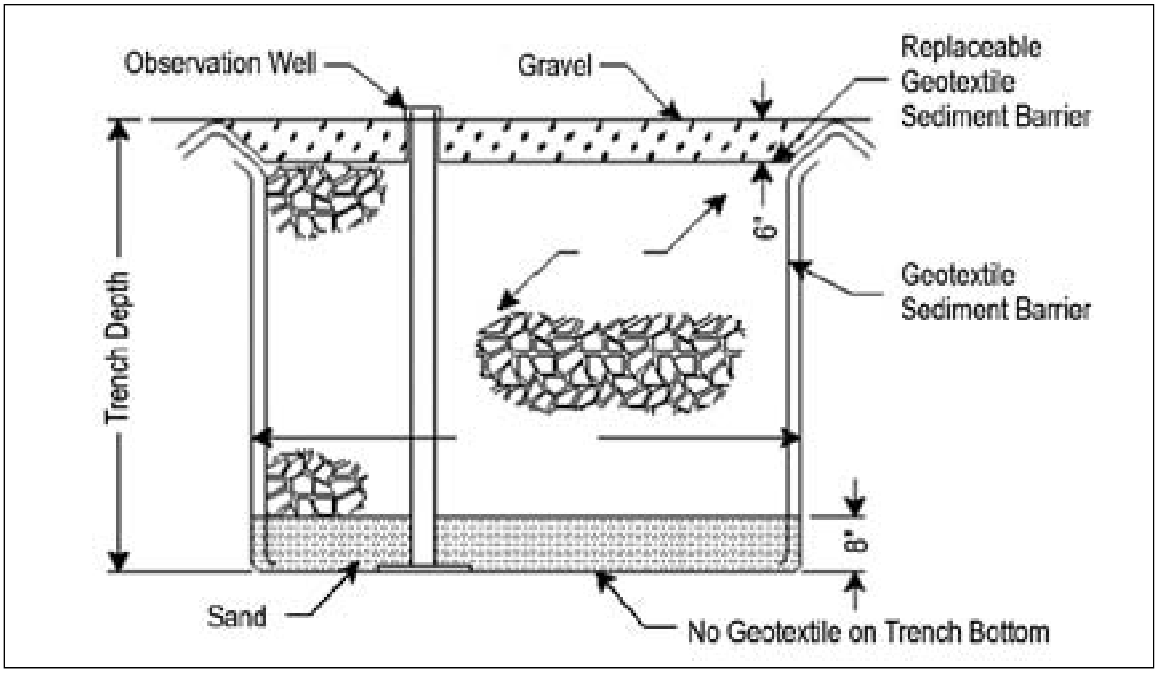
Specifications
for

Infiltration Trench



1. SEDIMENT SHALL BE PREVENTED FROM ENTERING THE INFILTRATION TRENCH. Sediment clogging and sealing off the permeable soil is the most common cause of infiltration trench failure. Runoff from the construction site shall NOT be allowed to flow to the trench until construction is complete and upslope areas have been stabilized. If storm drains enter the infiltration trench directly and cannot be rerouted, they shall be sealed with a masonry plug until all contributing drainage areas are stabilized.
2. The infiltration trench design shall include a system for removing sediment from stormwater before it enters the infiltration structure. However, this system shall NOT be used to control sediment during construction.
3. Trench excavation and backfilling of sand and rock shall be done when the soil moisture is low enough to allow the soil to crack or fracture. No trench excavation or fill shall occur on wet soil to prevent compaction and maintain soil permeability.
4. Bottom Sand Filter - The bottom of the trench shall be covered with an 8-inch layer of clean sand. The sand layer shall be placed the same day excavation is completed.
5. Observation Well - A 4-inch diameter, rigid perforated vertical pipe shall be installed in the trench. The vertical pipe shall be securely and permanently attached to a base to prevent upward movement. The top of the vertical pipe shall have a secure removable cap. The original depth shall be permanently marked on the top of the observation well.
6. Geotextile - The sides and top of the trench shall be lined with geotextile. The bottom of the trench shall NOT be covered with geotextile.
7. Rock - Rock fill shall be clean, poorly-graded, uniform size crushed washed rock. Well-graded rock has less void space available for runoff storage and shall not be accepted.
8. Gravel Top Layer - The top layer of the geotextile shall be covered by 6 inches of gravel (0.75-inch diameter).