5.3.3 Infiltration Trench

Description

An infiltration trench consists of a linear trench of open-graded aggregate or media that can capture, hold, and infiltrate stormwater (see Figures 5.3.3-1a and 1b). Its functions are similar to a stormwater infiltration bed except that it may also serve as part of a conveyance system, especially during larger storm events. Infiltration trenches capture and store stormwater runoff until it infiltrates into the subsurface below. The storage media may consist of clean-washed, open-graded stone aggregate, proprietary stormwater products, or perforated pipes set in a stone trench.

Very often, an infiltration trench is an effective method for conveying stormwater while also providing stormwater volume capture. In suitable areas, a stormwater pipe can be constructed as an infiltration trench. For an “on-line” trench that is part of a conveyance system, small storms are captured by the trench while large storms are conveyed through the BMP (infiltration trench). As a result, infiltration trenches, when used as part of a larger stormwater conveyance system, can be one of the most cost-effective BMPs.

Infiltration trenches are well suited to linear areas such as along roads, where they may be “on-line” (where all flows go through the trench) or “off-line” (where larger storms are intended to bypass the trench).

Infiltration trenches that are parallel to the road are generally only cost-effective on slopes of 5 percent or less. On steeper roads, infiltration trenches can be constructed perpendicular to the road and along the contour if space is available.

In situations where infiltration is not feasible, a stormwater trench may include an underdrain system for slow release. Underdrained trenches can work very well as roadside retrofits in urban areas, and are highly beneficial in CSO areas to reduce runoff volume during rainfall periods.

Figures 5.3.3-1a and b. Infiltration trench during installation and afterwards.

BMP Functions Table

BMP	Applicability*	Volume Reduction	Water Quality	Peak Rate Reduction	Recharge	Runoff Temperature Mitigation	Heat Island	Habitat Creation	Maintenance Burden	Cost
Infiltration Trench	U/S/R	H	H	M	H	H	M	L	L	M

KEY: U = Urban; S = Suburban; R = Rural; H = High; M = Medium; L = Low

*Rating varies based on design considerations.

Key Design Features (see Figure 5.3.3-2)

- Linear in nature and generally designed to capture runoff from small (1.6 inches or less) rainfall events.
- The trench may capture all or only a portion of the SOV.
- Often built “on-line” as part of a stormwater conveyance system.
- Water is conveyed into the trench, usually with pipes or other structures.
- Always includes an overflow control structure and the capacity to safely convey or bypass larger storm events.
- Usually limited in maximum width (6 feet or less) and depth (4 feet or less), although this may vary according to conditions.
- Minimum trench width is 3 feet.
- The length, width, and depth may be a function of “available space” for the infiltration trench.
- Clean-washed, open-graded aggregate storage trench with minimum of 40 percent void space.
- Perforated pipe is used within the trench.
- Surface material above trench may be pervious or impervious.
- Compacted fill material may be placed above the trench.
- Level, uncompacted subgrade in the trench bottom.
- Nonwoven geotextile at soil/stone interface, including top of trench to prevent soil movement into the trench.
- Designed with a method to convey water into the stormwater trench.
- Prior sediment removal is required for runoff from parking lots, roads, or other high sediment source drainage areas.
- Should not be placed on compacted fill if designed for infiltration.
- When possible, place infiltration trenches on upland soils.

Applications

- As part of a stormwater conveyance system in segments where there is limited grade change
- Road shoulders, medians, alleys, and sidewalks
- Parking lot edges
- Individual home lots
- As a component to “connect” larger BMPs
- Useful as a retrofit when replacing sidewalks, repairing roads, etc.

Advantages

- Very cost-effective when part of a stormwater conveyance system.
- When used to provide volume reduction (SOV), may provide a Curve Number reduction and may reduce the peak rate requirements for the site.
- Well suited to directly receive “clean” roof runoff.
- Effective for maintaining soil moisture conditions for planting areas or wooded slopes.
- Can enhance health and longevity of street trees if properly designed.
- Landscape features may be built above an infiltration trench; it does not preclude other uses of the surface space.

Disadvantages

- High clogging potential if runoff from high-sediment areas is not pretreated.
- Limited capacity for volume storage due to size.
- Not visible and may be “forgotten.”
- Must be offset from foundations/basements.
- May encounter utility conflicts in roadway right-of-way applications, especially in retrofit situations.
- Must be designed to prevent damage to pavement subbase material from infiltration.

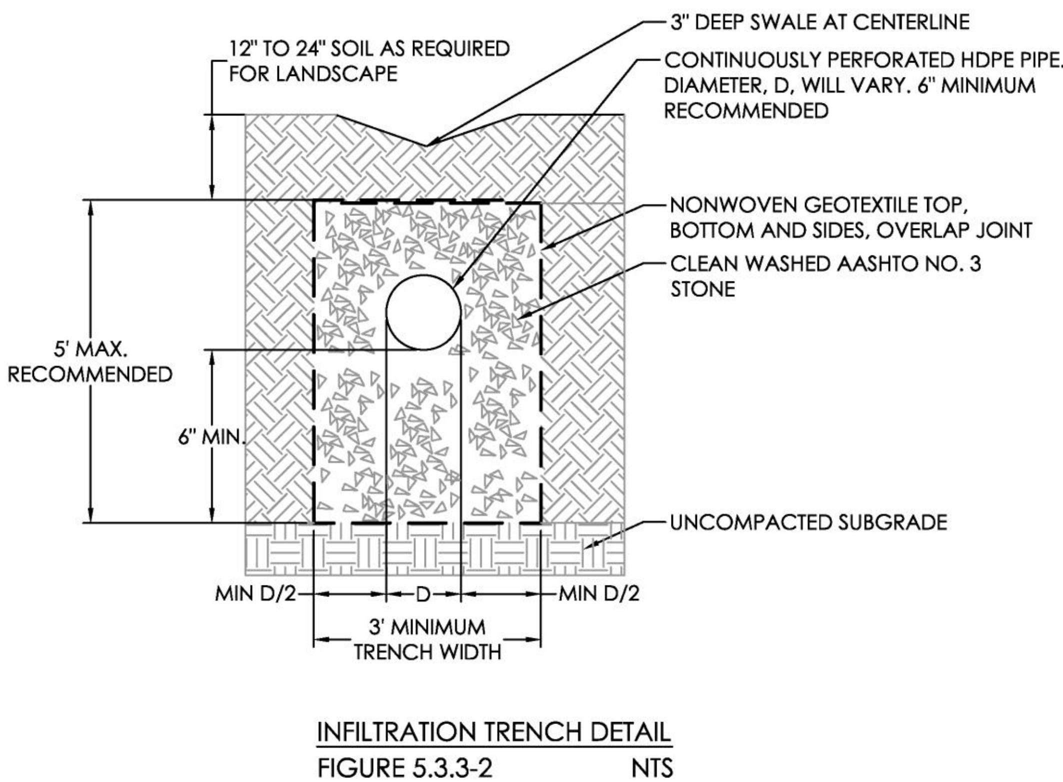


Figure 5.3.3-2. Typical infiltration trench cross-section.

Applications

An infiltration trench is often a "leaky pipe" by intention. In small, linear areas, the stormwater conveyance system can be designed to reduce runoff volume by allowing small storm events to partially or entirely infiltrate within the trench. Infiltration trenches are well-suited to the linear nature of roads.

Roadside Infiltration Trench

Figures 5.3.3-3a and b. Infiltration trenches were incorporated into an existing storm sewer system within the road at the Washington National Cathedral (Washington, DC). The trench is lined with an impervious liner along the asphalt edge to prevent damage to the roadway subbase from water movement. Overlain by standard asphalt, runoff enters the trench through stormwater inlets.

Infiltration Trench as Part of Conveyance System

Figure 5.3.3-4. The subgrade storm sewers beneath the lawn at this university campus include infiltration trenches "on-line" as part of the storm sewer system. This is appropriate where the grade is relatively level and the storm sewer is constructed along the contour, as shown here.

Urban Greening Infiltration Trench

Figure 5.3.3-5. Tree trenches capture street runoff, via curb inlets, and improve urban greening and streetscapes, especially in ultra-urban locations.

Applicable Protocols and Specifications

The following Protocols and Specifications (see Appendices A through F) are applicable to infiltration trenches and must be addressed:

- Protocol 2 Coordination with Other Utilities
- Protocol 3 Site Evaluation and Infiltration Testing
- Protocol 4 Infiltration System Design and Construction Guidelines
- Protocol 5 Planting Guidelines

- Bioretention Soil Specifications
- Stormwater System Specifications
  - Aggregates and Drainage Layers
  - Pipes
  - Control Structures
  - Geotextiles
  - Impervious Liners and Waterproofing

Design Considerations for Infiltration Trenches

Infiltration trenches are a linear BMP. The key design components for infiltration trenches discussed below allow design flexibility to ensure maximum performance. A trench may capture only a portion of the SOV, but be part of a larger system that meets volume requirements.

1. Location and Capture Area

Locate infiltration trenches:

- Close to the source of runoff (if possible) to minimize the need for additional stormwater structures.
- Between larger BMPs or as part of the stormwater conveyance system.
- To capture small drainage areas, generally less than 10,000 square feet. If necessary, use several connected infiltration trenches or combine with other BMPs to address larger areas.

Infiltration trenches can be located beneath or within roadways or impervious paved areas with proper design. When located in or adjacent to pavement, the following site-specific conditions should be considered:

- Saturated conditions in the trench cannot create saturation under or within the impermeable pavement subbase. This is especially important when infiltration trenches are adjacent to standard impervious pavement.

Figure 5.3.3-6. Impervious liners can be used to prevent lateral movement of water beneath standard pavement.

- Water levels in the trench should never be high enough to saturate the subbase of overlying impervious areas (through the top of the trench). Provide for controlled overflow and maximum water surface elevation.
- When located adjacent to pavement, the maximum water level must be lower than the pavement subbase. Alternatively, a secured impervious liner can be used to prevent lateral water movement (see Figure 5.3.3-6).

Slopes

- Infiltration trenches should not be constructed on fill material, because compacted fill will prevent infiltration. Slow release (underdrained) infiltration trenches may be built in fill material.
- The trench bottom must be level or with a slope less than 0.5 percent. If needed, the infiltration trench may be benched or terraced on slopes.
- Grade changes can often be accommodated by a series of connected infiltration trenches that “step” down the hill. (See BMPs 5.3.1 and 5.3.2 for “stepped” details.)

Drainage Area

- The type of land use in the drainage area must be carefully considered. Roof runoff is generally “clean” with regard to sediment and is ideal for discharge to an infiltration trench. Runoff from other areas, such as parking lots, must be treated with sediment-reduction measures, such as sediment traps in inlets or inlet water quality inserts, before runoff is discharged into the trench (see Figure 5.3.3-7).
- Infiltration trenches should not be used in hot areas where there is the potential for runoff with higher than average pollutant levels to enter the groundwater. Only the hot area is precluded from infiltration; other portions of the site may be well-suited for infiltration trench use.

Figure 5.3.3-7. If a catch basin is used to collect street runoff into a tree trench, the inlet must include a sump and a water quality insert to control sediment. This tree trench is built with a porous pavement sidewalk. (Also see Figures 5.3.11a and b.)

2. Entrance/Flow Conditions

Stormwater runoff must be conveyed into an infiltration trench, usually with storm sewer pipes. Pipes usually continue through the trench as a continuously perforated pipe. A cleanout or pipe access through a structure should always be provided for future pipe cleaning if necessary. **The minimum diameter of the continuously perforated pipe within the trench is 6 inches.** If the trench must convey large storms ("on-line" infiltration trench), the designer must confirm that the overflow capacity from the trench is adequate to meet City conveyance requirements (see Overflow discussion). For "on-line" infiltration trenches, it is recommended that the pipe be located in the upper portion of the trench, with storage provided below.

Trenches that are "off-line" receive runoff until the trench is full, at which point stormwater runoff must be designed to "bypass" the trench and be managed by other methods (see Figure 5.3.3-8). A trench may also be designed with entrance conditions that constrict the rate of flow into the trench, such that high flow rates from high-intensity rainfall cannot enter the trench.

Figure 5.3.3-8. This roadway trench is designed with catch basins to capture and convey runoff into the trench. When the trench is full, flows cannot enter the trench and continue to the next catch basin that conveys the runoff to the larger combined sewer system.

3. Management of Sediment, Trash, and Debris

In areas of high sediment load, all infiltration trenches **must** include measures to prevent the movement of material into the trench. Sediment can clog an infiltration trench and limit its functional lifespan (see Figure 5.3.3-9).

- Roadside infiltration trenches **must** include sediment-reduction practices (such as sumps, water quality inserts, and trash screens). Additionally, roadside trenches must be approved with a maintenance plan that identifies the method and frequency of maintaining the roadside trench.
- Roof runoff is generally lower in sediment and can be conveyed directly into a trench; however, a cleanout for roof leaders is required in the event that pipe clogging occurs.
- Runoff from roof areas that receive high amounts of leaf debris or other materials (such as deposition from equipment) should include sediment traps, or should be reconsidered. It may be preferable to discharge these roof areas to a vegetated swale or a filter strip prior to discharge into the trench.

- In areas of high trash or with specific concerns such as plastic shopping bags, entrance conditions should include a screen to prevent material from entering the infiltration trench. The designer must consider the site-specific conditions and adjacent land uses in each application.
- Water quality inserts or sumped inlets can reduce sediment from parking areas and low-volume streets. High-volume streets should discharge to a vegetated system such as a filter strip or vegetated swale before discharge into the trench.
- Cleanouts should be installed as necessary to allow access at "both ends" of the distribution pipes, if these pipes cannot be accessed through inlets or other structures.

Figure 5.3.3-9. Lack of inlet maintenance can prevent water from entering an urban tree trench.

4. Storage and Stay-on-Volume

An infiltration trench may be designed to capture the SOV, but often the trench may be able to capture only a portion of the SOV. In this situation, the remaining SOV and water quality volume must be managed by downstream BMPs.

The storage capacity of an infiltration trench is measured as the volume below the lowest discharge invert (overflow).

Storage Volume (ft^3) =

Trench Length (ft) x Trench Width (ft) x Trench Depth (ft) Below Overflow x Void Ratio

Void ratios are generally:

- 0.40 for clean-washed aggregate such as AASHTO No. 3
- 0.85 to 0.95 for manufactured storage units depending on manufacturer
- 1.0 for the interior volume in perforated pipes within the trench

The **SOV** is a function of the storage volume available for the 1-inch or 1.6-inch storm.

Infiltration Volume (ft^3) = Trench Bottom Area (ft^2) x Infiltration Rate (in/hr) x 12 hours x 1/12

5. Surface Area and Dimensions

The size and surface area of an infiltration trench may be a function of the drainage area that will discharge to the trench. It is important **not** to concentrate too much flow in one location. This can lead to accelerated clogging from sediment, high water depths that may compress soils, and soils that do not dry out between storms (and change structure). A basic rule-of-thumb is to design an infiltration trench with a surface area that is a ratio of the impervious and compacted pervious areas draining to it. The amount of rainfall volume must also be considered. The following ratios based on design rainfall depth can be used to estimate the dimensions for an infiltration trench:

<u>1-inch Rainfall</u>

1:10 ratio of trench surface area to impervious drainage area

<u>1.6-inch Rainfall</u>

1:8 ratio of trench surface area to impervious drainage area

For example, an infiltration trench that receives runoff from 5,000 square feet of roadway and is designed for the 1-inch rainfall would be:

5,000 square feet / ratio of 10 = 500 square feet of infiltration trench

The trench depth of water storage is a function of the rainfall depth managed and the loading ratio, and influenced to a lesser extent by the infiltration rate. Very often the storage depth of an infiltration trench will be limited by site conditions (i.e., the elevation of the downstream stormwater system to which the trench connects). Trench depth may also be limited by topography and slope.

The minimum recommended width for infiltration trenches is 3 feet. Designers are strongly discouraged from designing infiltration trenches that are more than 5 feet deep. Excavation and placement of trench material may become difficult at deeper depths. Applicable health and safety requirements must be adhered to in the installation of any trench.

A 5-foot-deep stone infiltration trench (with 40 percent void space) can provide 2 feet of runoff storage:

2 feet of water / 0.40 void space = 5-foot stone storage trench

Additional storage may be available in the conveyance pipe if the pipe volume is lower than the control invert from the trench (see Overflow discussion).

Proprietary products may be utilized as storage media and as a substitute for stone subbase; however, all products must be approved by the City. An example is use of modular subsurface, plastic, interlocking storage units, which provide higher void space and structural stability comparable to AASHTO No. 3 aggregate, but may be more costly.

The land use type draining into an infiltration trench should be considered in trench area design. It is **strongly** discouraged that trenches receiving runoff from high-sediment areas such as streets and high-use parking lots exceed the recommended loading ratios. The recommended ratios can be significantly increased when managing runoff from clean roof areas. “Clean” and “dirty” runoff should not be mixed if possible.

If the surface of the trench is vegetated, adequate soil cover must be maintained above the infiltration trench to support successful vegetation. Minimum cover over pipes for structural integrity is required.

6. Overflow and Peak Rate

All infiltration trenches must provide a safe way for water to exit the system when large storms generate more stormwater runoff than the trench can hold. The inclusion of a positive overflow route ensures that flooding risks and related property damage are minimized.

The positive overflow route is often in the form of a modified inlet box with an internal concrete weir (or weir plate), or simply an overflow pipe at a higher invert elevation. This maximizes the volume managed by the trench, while providing sufficient cover for overflow pipes. When water overtops the weir, it discharges via a pipe to the storm sewer or to another approved discharge point (see Figure 5.3.3-10).

The overflow structure can be designed to function as a detention rate control structure for peak rate control, and can be modeled or evaluated as a detention system. Temporarily higher effective water depths are acceptable during large storm events managed for peak rate control. Infiltration trenches do not usually have sufficient capacity for significant detention storage/mitigation.

The minimum allowable diameter of an overflow pipe is 12 inches unless otherwise approved by the City. The overflow structure must have capacity to meet the conveyance requirements of the City.

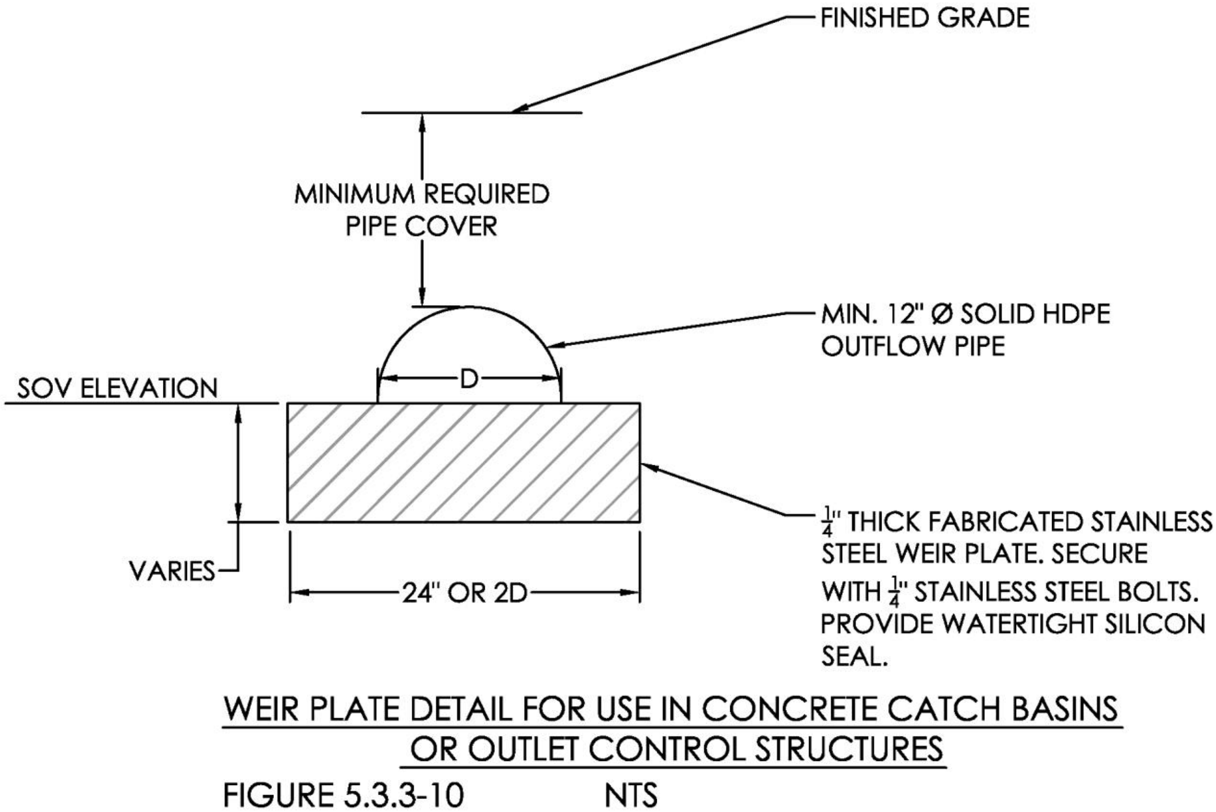


Figure 5.3.3-10. In an infiltration trench, placement of a weir plate over a portion of the outflow pipe allows the trench to capture small storms and maintain minimum cover over the pipe. The designer must confirm that large storms are conveyed through the trench.

<u>Peak Rate Control and Infiltration Credit</u>

For the purposes of site peak rate control, the designer may adjust the Curve Number value based on the volume managed by both the SOV and the infiltration volume that occurs during a portion of a 24-hour storm event. This allows the designer to account for runoff that was captured by applying LID, and to develop a representative lower Curve Number. This is described in Chapter 7.

When adjusting the Curve Number, the infiltration volume can be estimated as the infiltration that occurs during 12 hours of a 24-hour design storm. This will ensure that estimated infiltration volumes are not greater than the actual volume captured within the BMP.

Infiltration Volume (ft^3) = Trench Bottom Area (ft^2) x Infiltration Rate (in/hr) x 1/12 x 12 hours

7. Freeboard

Infiltration trenches can be designed without freeboard and be allowed to completely fill provided that other conditions, such as adjacent pavement subbase, are considered. The designer must always provide an alternate means to manage flows that bypass or overflow a trench.

8. Underdrain

The underdrain system is used to ensure that water moves through the system when the native soil infiltration rate is not high enough to empty the trench of water. If water does not exit the trench quickly enough, the system will back up through the inlet structures, and water may remain in the trench between storm events. Underdrain systems should discharge to the existing stormwater system or to a location approved by the City. Underdrain systems must be included in the design if the native soil infiltration is less than 0.1 inch per hour. See Protocol 3 for the infiltration testing procedure and Protocol 4 for infiltration system guidelines.

9. Waterproofing

In some instances, infiltration trenches may be designed to infiltrate, but there may be concerns about impacts on adjacent structures, such as basements, or impacts on the subbase of adjacent paved surfaces. For all infiltration trenches, the designer must evaluate the impact of the system on adjacent structures and utilities as defined in Protocol 1, Setbacks from Structures and Protocol 2, Coordination with Other Utilities. The liner, if applied, must meet the guidelines provided in the Stormwater Specification. In many situations, a partial liner (i.e., one side of a trench) will adequately protect structures.

10. Water Quality/Total Suspended Solids

Infiltration trenches that can capture and manage the required SOV through infiltration are considered to meet all water quality requirements. Infiltration trenches that are underdrained must be sized to provide water quality treatment. See Chapter 7 for additional discussion, and the Infiltration Trench Worksheet for calculations.

11. Stormwater Tree Trenches and Green Infrastructure

Stormwater tree trenches are a variation of infiltration trenches that are especially applicable in urban areas and as urban roadway retrofits. An infiltration trench can incorporate tree planting areas within the trench or between connected segments of the trench. Specific design considerations for tree trenches include the following (see Figures 5.3.3-11a and b):

- Urban trees require sufficient soil volume for growth and health. This can be achieved by providing adequate soil volume within the tree pit, or by providing adequate soil above the infiltration trench so that the root systems can extend into this soil (see Figure 5.3.3-12).
- Placing tree trenches adjacent to pervious areas (or extending the soil) will also improve tree health and success.
- The stormwater tree trench should not create extended saturated conditions for the root systems.
- The tree trench soil must have sufficient structural stability for placement under pavements and other structures. Soils used in tree trench applications must meet Bioretention Soil Specifications (Appendix F).

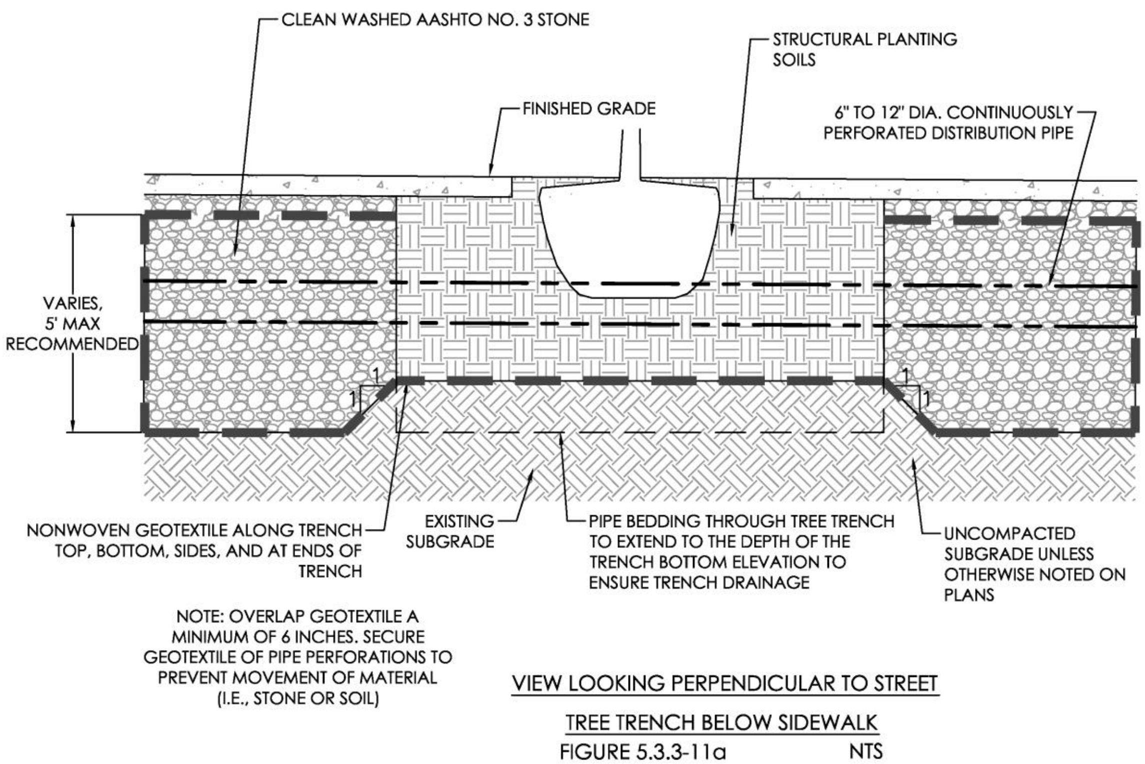
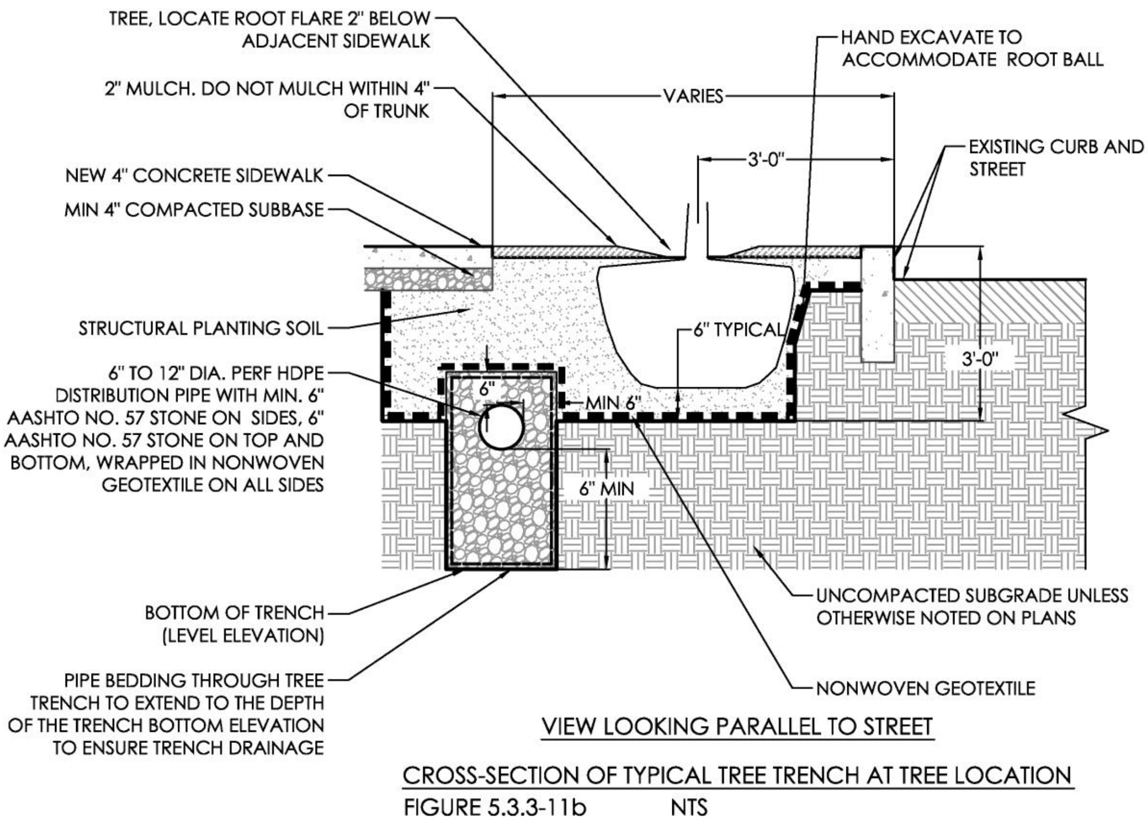


Figure 5.3.3-11a. Typical urban tree trench detail.



Figures 5.3.3-11b. Typical urban tree trench detail.

Figure 5.3.3-12. Between the trees in this stormwater tree trench, the soil is extended beneath the porous pavers to provide additional soil volume for the trees.

Sizing Calculations Worksheet for Infiltration Trenches

(Digital link to worksheet or reference on where to find worksheet on City web page)

Construction Considerations

Infiltration trenches can be installed:

1. Early in the construction process, but should not receive any site runoff until site construction is complete and site stabilization has occurred. Runoff should be directed around the completed trench until site stabilization has occurred. Sediment-laden water should not be allowed to enter infiltration trenches.

2. The infiltration trench may be constructed after site construction is substantially complete and site stabilization has occurred. During construction of the site, areas reserved for infiltration beds **must** be protected and should be fenced or barricaded to prevent the movement of equipment over the proposed infiltration area. This is similar in practice and intent to protecting an onsite septic system disposal field from vehicle compaction.

Construction Sequence Example

Step 1 Excavate and Prepare Subgrade

a. Do **not** compact or subject pervious pavement locations to excessive construction equipment traffic during construction. Protect areas from vehicle traffic during construction with construction fence, silt fence, or compost sock.
b. If alternate storage media is used in lieu of stone aggregate, provide a suitable stone subbase for material but do **not** compact trench bottom.
c. Infiltration trenches can be installed at any time during the construction process provided that sediment-laden runoff is prevented from entering the trench. Do not allow runoff from any disturbed areas in the drainage area to discharge into the bed until these areas have been stabilized.
d. Remove fine materials and/or surface ponding in the graded bottom, caused by erosion, with light equipment and scarify the underlying soils to a minimum depth of 6 inches with a York rake or equivalent by light tractor.
e. Leave earthen berms (if used) between infiltration trenches in place during excavation. These berms do not require compaction if the berms were constructed by excavating the trenches between the berms, and are comprised of native material that is collected during construction. The construction of berms by placing fill is discouraged. If necessary, constructed berms shall be keyed into the subbase and compacted to 95 percent density.
f. It is recommended to place trees on native material in tree trenches to avoid settlement.
g. Bring subgrade of infiltration trench to line, grade, and elevations indicated on the plans. Fill and lightly regrade any areas damaged by erosion, ponding, or traffic compaction. All infiltration trenches shall be level grade on the bottom.
h. Halt excavation and notify engineer immediately if evidence of sinkhole activity, unanticipated bedrock or groundwater conditions, or other site conditions are encountered that may affect infiltration trench design or performance. Unanticipated utility crossings may be encountered in urban tree trenches along roadways.

Step 2 Install Overflow Structure and Other Stormwater Structures

a. Place the stormwater overflow structure on suitable subgrade to prevent settling. Install overflow structure, inlet pipes, curbs, and other stormwater structures as appropriate before placement of stone storage bed.
b. Close and secure all inlets, pipes, trench drains, and other structures to prevent runoff from entering infiltration trench before completion and site stabilization.
c. Maintain drainage overflow pathways during construction, while infiltration trench is closed, to provide for drainage during storm events.
d. Infiltration trench conditions must be observed by the design engineer, following excavation and grading and prior to placement of material, to confirm that construction requirements have been met (see Figure 5.3.3-13). Documentation of engineering observation must be provided to the City (see Appendix I).

Figure 5.3.3-13. The bottom of an infiltration trench is level and uncompacted. The design engineer should observe conditions before the trench material is placed.

Step 3 Install Infiltration Trench

a. Place geotextile and trench aggregate immediately after approval of subgrade preparation and installation of structures (see Figure 5.3.3-14). Geotextile shall be placed in accordance with the manufacturer’s standards and recommendations. Overlap adjacent strips of geotextile a minimum of 16 inches.
b. Place clean-washed, uniformly graded aggregate or other storage media in the trench in maximum 8-inch lifts. Compact each layer while keeping construction equipment off the trench bottom as much as possible.

Figure 5.3.3-14. Non-woven geotextile placed between trench and soil prevents movement of soil into trench.

c. Following placement of storage media, place geotextile over the top of the trench to prevent soil movement into the trench. Place and secure geotextile to prevent soil movement.

Operations and Maintenance

All properly designed and installed infiltration trenches require regular annual maintenance, although they require less maintenance than other BMPs:

- Inspect and clean all inlets and catch basins annually.
- Maintain overlying vegetation in good condition and immediately revegetate any bare spots.
- Prohibit vehicular access on vegetated infiltration trenches and avoid excessive compaction by mowers. If access is needed, use of permeable, turf reinforcement should be considered.