10.13 Infiltration Controls

10.13.1 Introduction

Infiltration controls are best management practices (BMPs) where the primary discharge of stormwater is to the ground water table. These include infiltration trenches and basins. In some cases, the stormwater is intercepted after it has infiltrated a few meters by an under drain and is discharged to a storm sewer or surface water. One of the primary concerns with the use of infiltration BMPs is the risk of groundwater contamination especially in an Aquifer Protection Area. This is why there should be at least 1.5 m (5 ft) between the bottom of the facility to the seasonable high water table and 1.5 m (5 ft) to the underlying bedrock. Another factor is the residence time in the facility. Sources recommend that the first flush stormwater be infiltrated within 24 to 72 h. The infiltration rate is directly related to the soil type and disposition. Soil investigation should be performed at all facility locations prior to construction. Table 10-7 provides some considerations in evaluating an infiltration control.

Table 10-7 Summary Of Considerations For An Infiltration Facility

Quality	Infiltrate WQV within 24 to 72 h; minimum residence time of 24 h.
Quantity	Control 2- and 10-year peak flows (could lead to a large expensive facility; could be used with detention pond to control quantity)
Shape	Dependent on site constraints
Maintenance	Inspect once a year; preferably during wet weather; mow area as required; remove sediment every 5-10 years
Other considerations	Filter strip to remove sediments (2-5% slope with minimum 6 m (20 ft) length); infiltration rate (minimum 25 mm/h (1 in/h); depth to groundwater and bedrock (1.5 m (5 ft)); effects of facility on quality of groundwater
Pollutant removal	Moderate to high
Additional Guidance	**The Connecticut Stormwater Quality Manual outlines considerations and design criteria for infiltration facilities as related to stormwater quality control. The design of all such facilities shall be consistent with the Connecticut Stormwater Quality Manual and ConnDOT Drainage Manual. The more stringent criteria of the two manuals shall apply.**

10.13.2 Site Selection

Refer to the Connecticut Stormwater Quality Manual for siting considerations. Additionally, the FHWA-TS-80-218 “Underground Disposal of Stormwater Runoff” describes a procedure that rates different sites by using several parameters (reader is referred to this study for details of the procedure). Upon completion of this procedure, several sites can be compared to determine which is the best for the infiltration BMP or if infiltration is even feasible. Other selection considerations, include size of drainage area, proximity to foundations **(the facility should be no closer than 3 m (10 ft) down-gradient and 30 m (100 ft) up-gradient from a foundation and septic leaching fields)**.

Infiltration rate The infiltration rate is a very important parameter when an infiltration facility is designed. It is rarely used to determine the outflow from the facility for quantity and quality control. Infiltration rates of greater than 25 mm/h (1 in/h) are preferred for infiltration facilities. After a suitable site for the facility has been found, several soil tests must be made before the facility is designed.

First, borings should be taken at the site to determine the soil types, depth to bedrock and groundwater and infiltration rates. Infiltration rates should be determined through an appropriate field permeability test that is representative of vertical water infiltration through the soil, excluding lateral flows. A double-ring infiltrometer test is recommended (ASTM, 1994).

Observation well An observation well should be included in an infiltration facility with a covered bottom (i.e., trenches) to allow an inspector to determine how well the facility is operating (e.g., whether the stormwater is infiltrating as designed or whether maintenance is required). A schematic of a typical observation well in an infiltration trench is shown in Figure 10-30. It may also be necessary to install wells in infiltration basins to determine if they are working properly, but this can be determined visually because the stormwater is stored on the surface whereas the storage in trenches is hidden from view.

10.13.3 Infiltration Trench

An infiltration trench is a facility where a trench is excavated and then filled with a porous medium. Stormwater is stored in the voids of the fill material until it can be infiltrated. In a variation of this design, the stormwater is collected by an under drain pipe after the stormwater has been detained and filtered by the trench. Infiltration trenches can be used with a minimum offset of 3.0m (10 ft.) from the edge of pavement, or other facilities (e.g. along the centerline of a 6.09m (20 ft.) wide roadside swale).

Quality The bottom of the facility must be 1.5 m (5 ft) above the bedrock and the seasonably high groundwater table, and the bottom of the stone reservoir must be below the frost line. The WQV must be infiltrated within 48 h. The primary removal mechanisms in trenches are sedimentation and filtration, along with some biological uptake. Filtering is achieved in the top layers of the facility as stormwater enters. In the stone reservoir, the main removal mechanisms are sedimentation and adsorption.

As the stormwater leaves, it is filtered again by the underlying soil, where more pollutants will be removed. Unfortunately, all infiltration facilities are vulnerable to clogging, thereby reducing their effectiveness. Therefore, a vegetated buffer strip filtering the runoff is recommended as part of an infiltration facility. The strip would decrease the amount of suspended solids in the stormwater and thus increase the useful life of the infiltration facility. The filter strip should be at least 6 m (20 ft) wide. It should also be sloped from 2% to 5% to prevent water from ponding and to ensure a slow velocity.

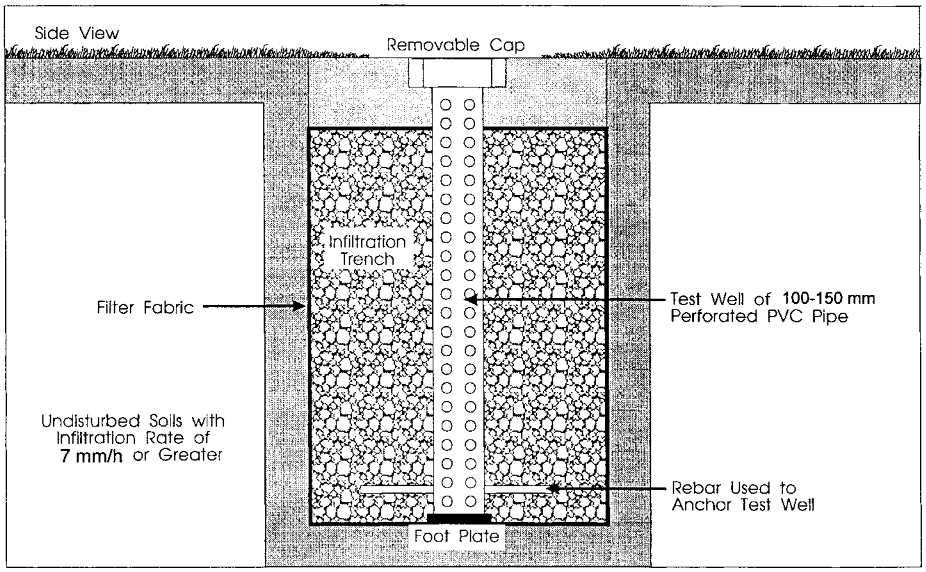

Figure 10-30 Infiltration Trench With Observation Well (after Schueler, 1987)

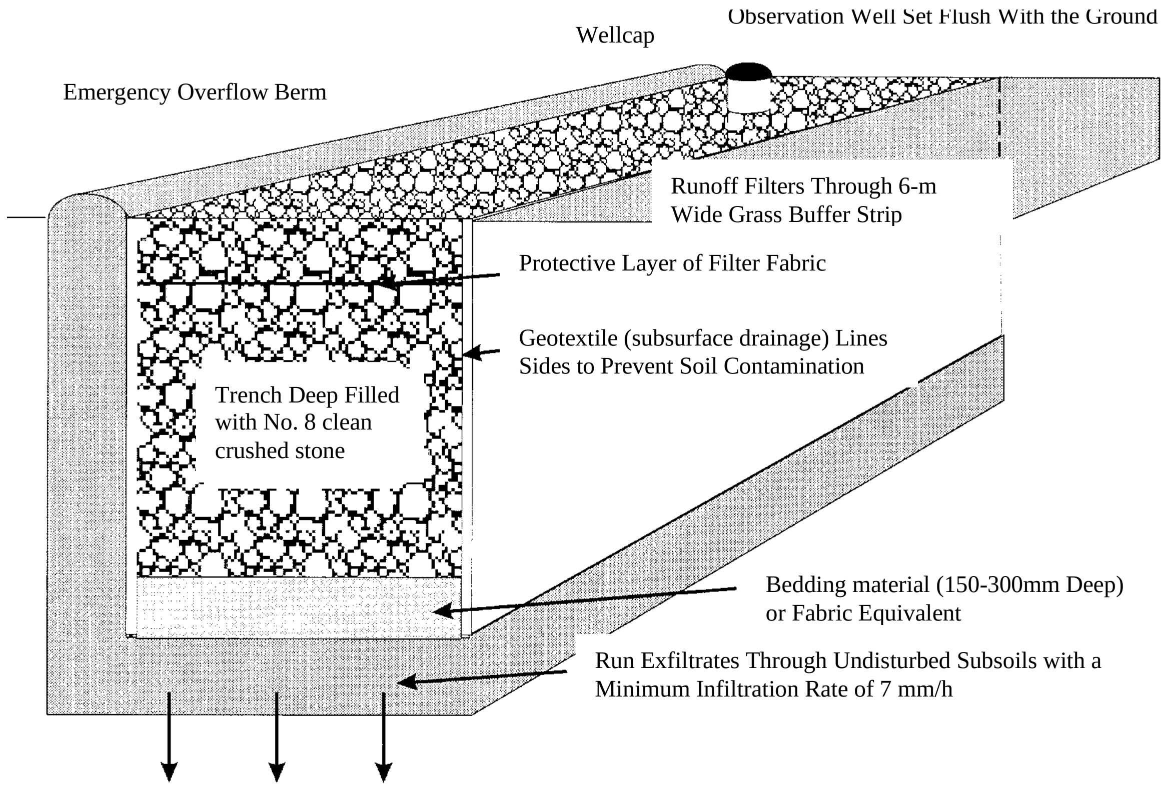

Figure 10-31 Infiltration Trench (after Schueler, 1987)

Quantity Because of the large size of the trench that would be required to control a 10-year storm, it is suggested that trenches not be used for large drainage areas or areas where the increase in peak flow, and, therefore, the amount of storage required, is very large.

A trial and error process of routing the design storms through the facility can be used to determine the amount of storage required for quantity control. Although the methods used to determine the amount of storage required for the ponds are not derived for infiltration BMPs, they can still be used to obtain an initial estimate of the required storage.

After a storage volume has been determined, the dimensions of the facility can be estimated. The depth should be designed such that the bottom is 1.5 m (5 ft) above the bedrock and high water table and below the frost line. The top of the storage area must be at or below the top of subgrade for all trenches in the vicinity of a roadway. The surface area can be manipulated to suit the site conditions so long as it yields the required storage volume. The amount of surface area required is:

$$S_a = \frac{Vol_s}{V_r \; d} \qquad \textbf{(10.33)}$$

Where: S_a = surface area, m^2 (ft^2)
Vol_s = storage volume, m^3 (ft^3)
V_r = void ratio (= 0.4 for 37.5 to 75 mm (1.5 to 3 in.) aggregate)
d = depth, m (ft)

The inflow hydrograph can be calculated by a number of methods, and the outflow versus storage curve can be found from a falling head test. Thus, the storms can be routed through the facility and the size of the trench can be changed to reduce the peak outflows to the pre-construction levels of the design storm. When routing the storm through the trench, one can determine whether and how much flow will bypass the trench when it is filled with stormwater. The overflow from the trench must be contained in an adequate channel.

Other considerations Detention time is an important factor in determining the effectiveness of a trench facility. A facility which drains quickly is capable of treating more stormwater volume. A maximum detention time of 72 h is recommended. The actual detention time can be estimated by:

$$T_s = \frac{d\ V_r}{f} \qquad \textbf{(10.34)}$$

Where: T_s = storage time (h) or detention time
d = depth of storage in the trench, mm (in)
V_r = void ratio of stone reservoir
f = steady infiltration rate, mm/h (in/hr)

From this equation, it can be seen that detention time is directly related to trench depth. Since the WQV will most likely be much smaller than the storage required for a 10-year storm, the depth of the WQV will be very small in the trench. Therefore, infiltration trenches are much better suited for small drainage areas where the change in peak flow between pre and post construction is small. Modifications can be made to the trench design to increase the depth of the WQV storage, but these will increase the cost and could make this BMP option infeasible.

10.13.4 Infiltration Basin

An infiltration basin looks very similar to a dry pond, see Figure 10-32. Stormwater from smaller, more frequent storms is infiltrated through the bottom of the basin. Larger storms can be controlled through infiltration and/or by a "peak shaving" outlet. The most important consideration for an infiltration basin is keeping the bottom from clogging with sediment. The clogging of basins, along with the overestimating of their infiltration rates, has led to the failure of many infiltration basins.

Quality To protect groundwater quality, the bottom of the infiltration basin must be 1.5 m (5 ft) or more above the bedrock and the seasonably high groundwater table. The WQV should be infiltrated within 48 h. The primary removal mechanisms in infiltration basins are sedimentation, filtration and biological uptake. Filtering is provided by the vegetation at the bottom of the pond and, preferably, also by a buffer strip before the stormwater runoff enters the facility. The filter strip should be at least 6 m (20 ft) wide and should also be sloped from 2% to 5% to prevent water from ponding and to ensure a slow velocity. Vegetation can also contribute to the removal of pollutants through biological uptake. As the stormwater leaves, it is filtered again by the underlying soil.

An estimation of the maximum ponding depth for a desired drain time can be found with the equation:

$$d = f\,T_s \qquad (10.35)$$

Where: d = depth, mm (in)
f = steady infiltration rate, mm/h (in/hr)
T_s = time of storage, h

The recommended maximum allowable storage time is 48 h. Considering the fact that basins may fail because of clogging and an infiltration rate that is lower than expected, a shorter time of storage, say 40 h, might be used to compensate for inaccuracies in estimating infiltration rates.

Several other considerations can help enhance the pollutant removal of these facilities. First, vegetation should be established on the basin floor. A dense stand of water-tolerant grass with a deeply penetrating root system would help stabilize the bottom of the basin and help keep the soil open. Vegetation would also provide biological uptake of nutrients.

Second, the pond bottom should be sloped as close to zero as possible in order to obtain a uniform depth of stormwater over the basin. The side slopes should be sloped at 1V:4H, or flatter, to allow for easy maintenance access and prevent erosion.

A third consideration has to do with the incoming stormwater. A combination of a level spreader/sediment forebay can be constructed to spread the stormwater evenly, thereby reducing erosion, and trap sediments before they clog the basin. Riprap should also be placed at the inlet to help reduce erosion.

Quantity For an infiltration basin, quantity can be controlled very similarly to a detention basin. The basin should be designed to reduce the peak flow from a 2, 10, and a 25-year storm, considered individually and be able to pass a 100-year storm safely.

After a required storage volume is estimated, the design storms should be routed through the basin to determine if the estimated value is correct.

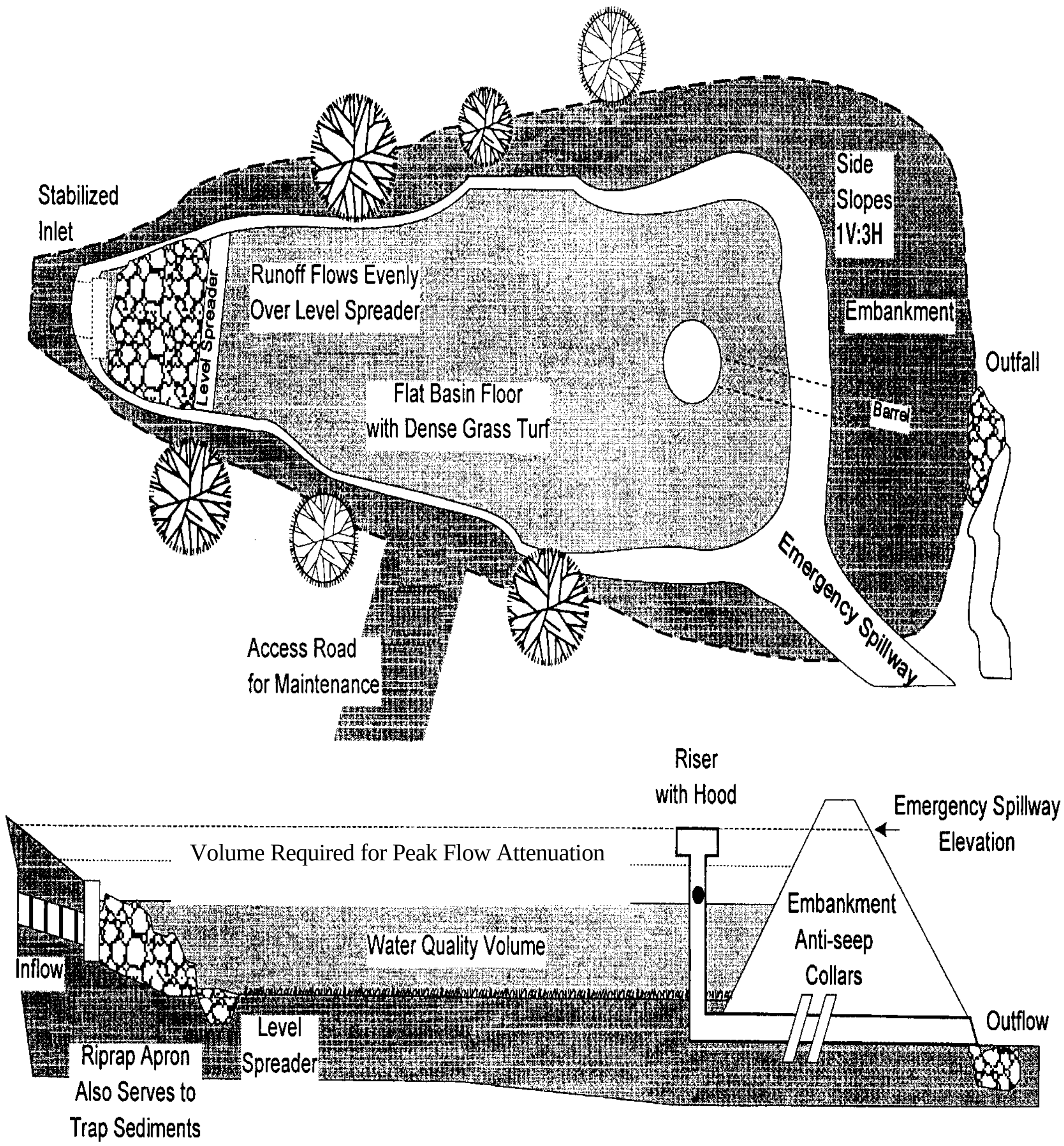

Figure 10-32 Infiltration Basin