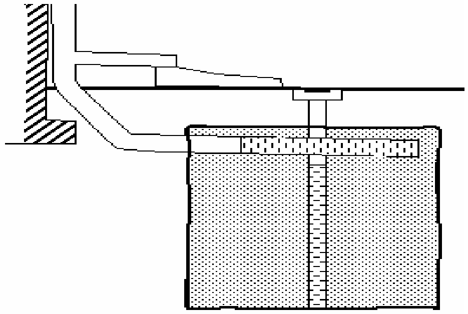
# ACTIVITY: Underground Drainage Systems | I – 03



| Targeted Constituents | | | | |
|---|---|---|---|---|
| ● Significant Benefit | ◗ Partial Benefit | ○ Low or Unknown Benefit | | |
| ● Sediment | ◗ Heavy Metals | ◗ Floatable Materials | ◗ Oxygen Demanding Substances | |
| ◗ Nutrients | ◗ Toxic Materials | ◗ Oil & Grease | ○ Bacteria & Viruses | ○ Construction Wastes |
| **Implementation Requirements** | | | | |
| ● High | ◗ Medium | ○ Low | | |
| ◗ Capital Costs | ◗ O & M Costs | ● Maintenance | ○ Training | |

## Description

This BMP covers subsurface infiltration BMPs such as drywells and vaults. Infiltration rates in much of the state are typically poor due to clay soils and bedrock. Such locations may not be suitable of infiltration BMPs. Infiltration systems work best at sites having sandy loam types of soils. Areas containing karst topography and sinkholes may initially appear to have excellent infiltration, but should be considered as unreliable and will require very careful investigation and analysis.

## Selection Criteria

- Underground drainage systems, such as drywells and vaults are suitable for draining small impervious surfaces, such as parking lots or residential rooftops, for which the adjacent pervious area has soils with adequate infiltration rates.
- Natural sinkholes (or other evidences of karst topography and drainage) are not considered to be infiltration systems for use in treating stormwater quality or in providing stormwater detention. In general, stormwater drainage may continue to flow to a natural sinkhole at a rate that is representative of natural undeveloped conditions. No unusual or unfavorable geologic conditions shall be present near the sinkhole that indicates subsidence, piping, increased limestone dissolution, potential collapse or other safety concerns.

## Design and Sizing Considerations

Infiltration can be a very desirable method of stormwater treatment for land uses which do not heavily pollute stormwater runoff. For instance, established residential areas typically have less pollution than industrial and commercial areas. The primary physical conditions necessary for infiltration are: 1) permeable soils which have not been compacted or graded, and 2) low and non-interfering groundwater tables. Stormwater runoff from parking lots or buildings should be pretreated with a water quality enhancing inlet, oil/water separator, grass swale or other type of stormwater treatment BMPs. Small amounts of stormwater runoff from selected impervious areas are given an opportunity to infiltrate. A factor of safety should be incorporated into the design to ensure that the system still works even when partially clogged.

The recommended minimum infiltration rate is at least 0.5 inches per hour, but may depend on type of infiltration system and the desired water quality treatment involved. Drawdown should occur within 48 hours. An infiltration basin or trench must have at least 3 feet separation from seasonal high groundwater and at least 4 feet separation from bedrock. Coarse soils are not as effective in filtering groundwater; therefore provide at least 6 to 8 feet separation from seasonal high groundwater for sand and gravel soils.

Unless adequate engineering documentation is submitted, an infiltration system must be located at least 100 feet away from any drinking water well, septic tank or drainfield. It is also recommended that an infiltration trench should not be located near building foundations, buildings with basements or crawl spaces, major roadways, wetlands, streams, or potentially unstable slopes and hillsides.

### *Overview of Infiltration Theory*

The overall degree of water quality treatment achieved by infiltration is a function of the amount of stormwater that is captured and infiltrated over time. Minimum infiltration storage is generally required to be the first flush volume.

Typical infiltration rates are shown in Table I-03-1. The USDA soil texture classification is based upon the triangle shown in Figure I-03-1, with the following definitions:

| | Approximate size | Rough description |
|---|---|---|
| Gravel | > 2 mm | > No. 8 sieve or so |
| Sand | 0.05 mm to 2 mm | > No. 200 sieve |
| Silt | 0.002 mm to 0.05 mm | Little plasticity or cohesion |
| Clay | < 0.002 mm | Can be rolled and compressed |

For preliminary design, infiltration rates may be estimated using a published soil survey. However, final design must include soil gradation testing and measurement of unsaturated vertical infiltration rates in the field by the double-ring infiltrometer test. This test is not appropriate for clay soils or other soils which clearly appear to be unsuitable for infiltration methods. The allowable infiltration rate is 0.5 inches per hour, although an infiltration rate of 1 inch per hour is highly recommended. Table I-03-1 shows that soils with a hydrologic soil group of C or D will not have sufficient infiltration rates.

Another well-known method of categorizing soils and evaluating soil properties is by the Unified Soil Classification System (USCS). The following soil groups are generally acceptable as good soils for infiltration:

| | |
|---|---|
| SW | Well-graded sands and gravelly sands, little or no fines |
| SP | Poorly graded sands and gravelly sands, little or no fines |
| SM | Silty sands, sand-silt mixtures |

**Table I-03-1**
**Typical Infiltration Rates from USDA Soil Texture**

| | USDA Soil Texture | Typical Water Capacity (inches per inch of soil) | Typical Infiltration Rate (inches per hour) | Hydrologic Soil Group |
|---|---|---|---|---|
| * | Sand | 0.35 | 8.27 | A |
| ** | Loamy sand | 0.31 | 2.41 | A |
| ** | Sandy loam | 0.25 | 1.02 | B |
| ** | Loam | 0.19 | 0.52 | B |
| | Silt loam | 0.17 | 0.27 | C |
| | Sandy clay loam | 0.14 | 0.17 | C |
| | Clay loam | 0.14 | 0.09 | D |
| | Silty clay loam | 0.11 | 0.06 | D |
| | Sandy clay | 0.09 | 0.05 | D |
| | Silty clay | 0.09 | 0.04 | D |
| | Clay | 0.08 | 0.02 | D |

* - Suitable for infiltration with typical 6' to 8' separation from seasonal high groundwater
** - Suitable for infiltration with at least 3' separation from seasonal high groundwater

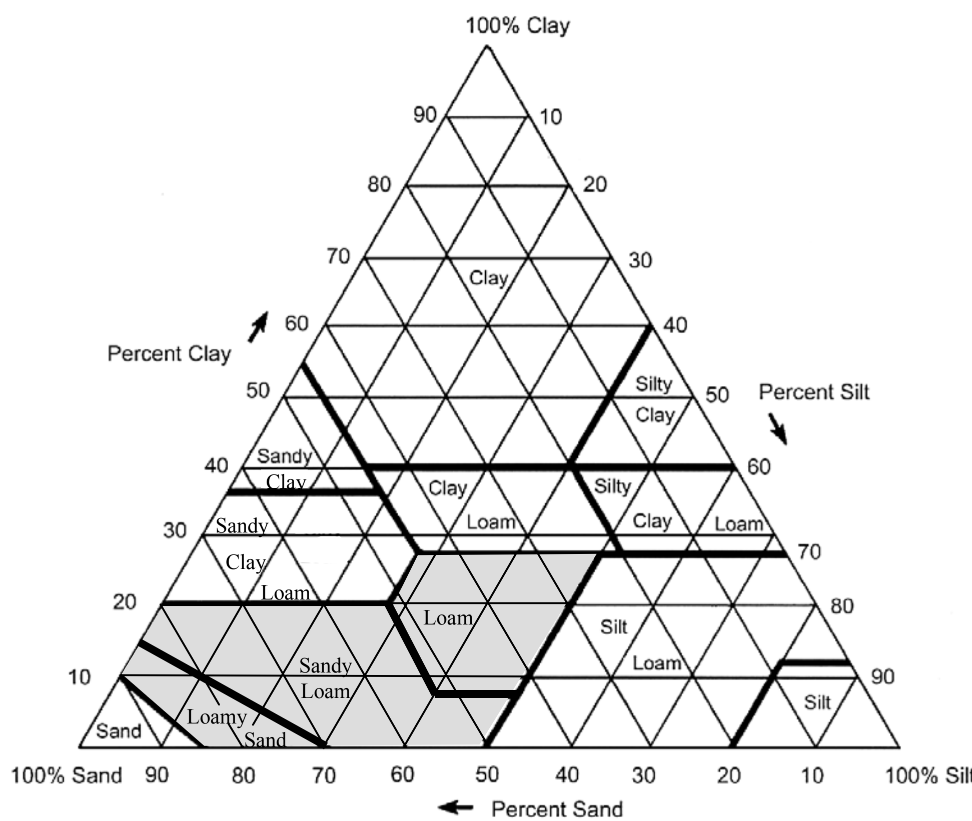



**Figure I-03-1**
**USDA Soils Triangle**

***Natural Depressions, Sinkholes, and Karst Topography***

Much bedrock in Tennessee is composed of fractured limestone formations that are likely to contain unusual strike angles and/or nonconformities. Karst topography is defined as the presence of limestone or other soluble geology that is likely to form caverns, sinkholes, or other dissolved formations. A sinkhole is a surface depression, typically linked to an underground cavern system, which occurs primarily in limestone regions. See Figure I-03-3 for a typical sketch of a sinkhole.

For natural depressions and sinkholes, it is generally required that the post-developed peak flows and total stormwater runoff volume must be limited to the pre-developed values. In addition, it may be required that no structures will be flooded from a 100-year storm assuming plugged conditions (zero outflow). It is greatly desired that runoff should be treated using one or more stormwater treatment BMPs, prior to discharging toward a sinkhole or other natural depression.

Consideration may be given to recommendations that are based upon advanced subsurface testing or visual inspection by experts or professional engineers with demonstrated experience in hydrogeology. Tennessee Department of Environment and Conservation (TDEC) requires anyone who performs a dye trace study to obtain a TDEC registration for this activity (see TDEC website). Major sinkholes are considered to be waters of the state; filling or otherwise altering a large sinkhole requires an Aquatic Resources Alteration Permit from TDEC.

A drywell or dry vault can be used to infiltrate stormwater runoff from small areas of impervious runoff, such as roofs or parking lots. The designer should be very careful to avoid adverse impacts to foundations, basements, unstable slopes or hillsides, septic tanks, utility lines, etc. A small pretreatment chamber with a screen is recommended in many instances to handle leaves (roofs) or trash and sediment (parking lots).

A typical drywell adjacent to a house foundation is shown in Figure I-03-2 (without a pretreatment chamber). A dry vault (larger than a drywell) can be constructed using masonry blocks and a poured concrete lid to hold a larger volume of stormwater runoff. Inspect the drywell or dry vault on a regular basis.

## Construction/ Inspection Considerations

- It is very important to protect the natural infiltration rate by using light equipment and construction procedures that minimize compaction. Stormwater must be allowed to enter the facility until all construction in the catchment area is completed and the work area is stabilized. If this prohibition is not feasible in particular situations, do not excavate the facility to final grade until after all construction is complete upstream.
- Protect infiltration surface during construction.
- Inspect frequently for clogging during construction.
- Improperly functioning infiltration systems must be replaced by other stormwater treatment BMPs that are capable of providing water quality treatment.

## Maintenance

- Maintenance can be difficult and costly for infiltration systems, with a potential for high maintenance costs due to clogging. Maintenance costs and site access should be carefully considered prior to design.

- Pretreatment of stormwater runoff may reduce maintenance costs by capturing coarse sediments and floatable materials in a smaller structure that can be more easily cleaned.

- Inspect and observe the infiltration system several times during the first year, particularly after heavy rainfall events. Use observation wells and cleanout ports to monitor water levels and drawdown times. Record all observations and measurements taken. Perform any maintenance and repairs promptly.

- Inspect the infiltration system annually thereafter, and after extreme rainfall events. If stormwater does not infiltrate within 48 hours after a storm, it is generally time to clean, repair or replace the facility. Remove debris and sediment at least annually to avoid high concentrations of pollutants and loss of infiltration capacity.

- The primary objective of maintenance and inspection activities is to ensure that the infiltration facility continues to perform as designed. Regular inspection can substantially lengthen the required time interval between major rehabilitations.

- Prevent compaction of the infiltration surfaces by physical controls such as gates or fences. Maintain dense grass vegetation for infiltration basins. Use rotary tillers on infiltration surfaces when needed to restore infiltration capacity and to control weed growth.

- Maintenance plans should include provisions to repair or replace this type of structure after 5 years or so.

- Maintain records of inspections and maintenance performed.

### *Sediment Removal*

A primary function of stormwater treatment BMPs is to collect and remove sediments. The sediment accumulation rate is dependent on a number of factors including watershed size, facility sizing, construction upstream, nearby industrial or commercial activities, etc. Sediments should be identified before sediment removal and disposal is performed. Special attention or sampling should be given to sediments accumulated from industrial or manufacturing facilities, heavy commercial sites, fueling centers or automotive maintenance areas, parking areas, or other areas where pollutants are suspected. Treat sediment as potentially hazardous soil until proven otherwise.

Some sediment may contain contaminants for which TDEC requires special disposal procedures. Consult TDEC – Division of Water Pollution Control if there is any uncertainty about what the sediment contains or if it is known to contain contaminants. Clean sediment may be used as fill material, hole filling, or land spreading. It is important that this material not be placed in a way that will promote or allow resuspension in stormwater runoff. Some demolition or sanitary landfill operators will allow the sediment to be disposed at their facility for use as cover. This generally requires that the sediment be tested to ensure that it is innocuous.

**Cost Considerations**

- Maintenance is difficult and costly for underground trenches.
- Potential for high maintenance costs due to clogging.
- Pretreatment will reduce maintenance costs by capturing gross settleable solids and floatables in a smaller space that can be more easily cleaned.

**Limitations**

- The four major concerns with infiltration systems are clogging, potential impact on other structures and properties, accumulation of heavy metals, and the potential for groundwater contamination.
- Clogging and high maintenance costs are very likely to occur in fine soils that are marginally allowable for infiltration rates. Erosion control is extremely important to prevent clogging; infiltration systems fail if they receive high sediment loads. Perform regular maintenance and inspections to minimize the potential for clogging and loss of infiltration capacity. Pretreatment is highly recommended for stormwater runoff from many land uses, prior to discharging to an infiltration system.
- Infiltration systems are not appropriate for areas with high groundwater tables, steep slopes, lots of underground infrastructure, and nearby buildings.
- Heavy metals are likely to settle in any of the stormwater treatment BMPs, but particularly for infiltration systems (which have the lowest velocity). High levels of heavy metals have been observed in other states where adequate maintenance was not performed. Toxic levels are not likely to be exceeded, but the sediments will need to be handled as hazardous waste after a few years of neglect.
- There is a higher risk of groundwater contamination in very coarse soils. It is highly recommended that a monitoring and inspection program should be used to verify that no contamination occurs. Infiltration systems may not be appropriate where there is significant potential for hazardous chemical spills, or near drinking water wells.

**Additional Information**

- Underground drainage systems are suitable only for small sites of a few acres.
- Infiltration systems or wet detention should be considered where dissolved pollutants discharging to surface waters are of concern. However, satisfactory removal efficiencies require soils that contain loam. Coarse soils are not effective at removing dissolved pollutants and fine particulates before the stormwater reaches the ground water aquifer.
- Problems can be expected with infiltration systems placed in finer soils. The State of Maryland has emphasized these systems for about 10 years where they have been installed in soils with infiltration rates as low as 0.27 inches (0.69 cm) per hour. A recent survey (Lindsey, et al., 1991) found that a third of the facilities examined (177) were clogged and another 18% were experiencing slow infiltration. Dry wells that treat roof runoff had the fewest failures (4%) and porous pavement the most (77%). Dry wells may have the lowest failure rate because they only handle roof runoff. The primary causes of failure appear to be inadequate pretreatment and lack of soil stabilization in the tributary watershed, as well as poor construction practices (Shaver, personal communication).

- Based on a review of several studies of infiltration facilities in sandy and loamy soils, it has been concluded that "monitoring . . . has not demonstrated significant contamination . . . although highly soluble pollutants such as nitrate and chloride have been shown to migrate to ground water" (USEPA, 1991). However, pollution has been found in ground water where infiltration devices are in coarse gravels (Adophson, 1989; Miller, 1987).
- Clogging has not been a problem with well maintained systems discharging to sands and coarser soils, suggesting that pretreatment for these infiltration devices in the aforementioned soil conditions is not necessary. Pretreatment when infiltrating to finer soils is suggested. An infiltration facility sized only for treatment is much smaller than one sized for flood control and therefore may be more susceptible to clogging.
- For small systems treating less than a few acres of pavement, pretreatment can be accomplished with a stormwater quality inlet, catch basin and a submerged outlet. The diameter and depth of the sump should be at least four times the diameter of the outlet pipe to the infiltration system (Lager, et al., 1977). Swales can also be used although they will not likely be feasible in industrial sites that tend to be fully utilized.
- Pretreatment of the stormwater is highly recommended for drywells where access for maintenance is difficult if not impossible. Such pretreatment may include biofilters, sumps, stormwater quality enhancing inlets, or oil water separators.

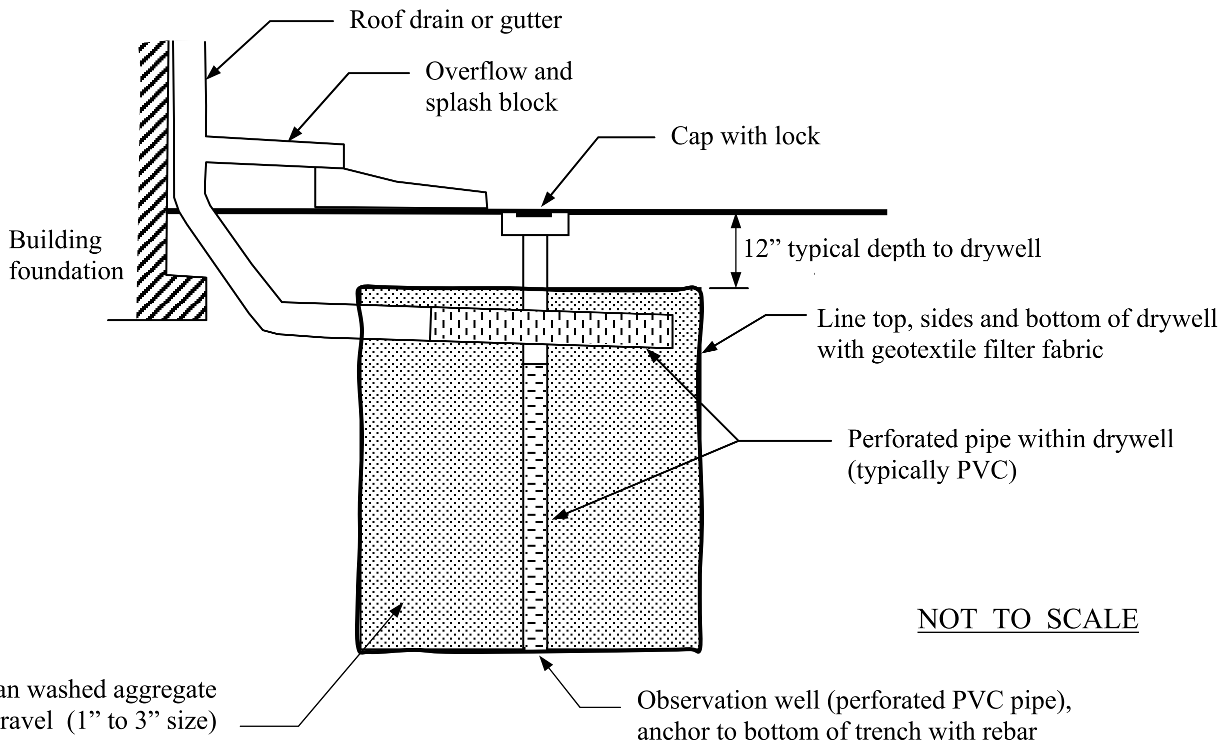
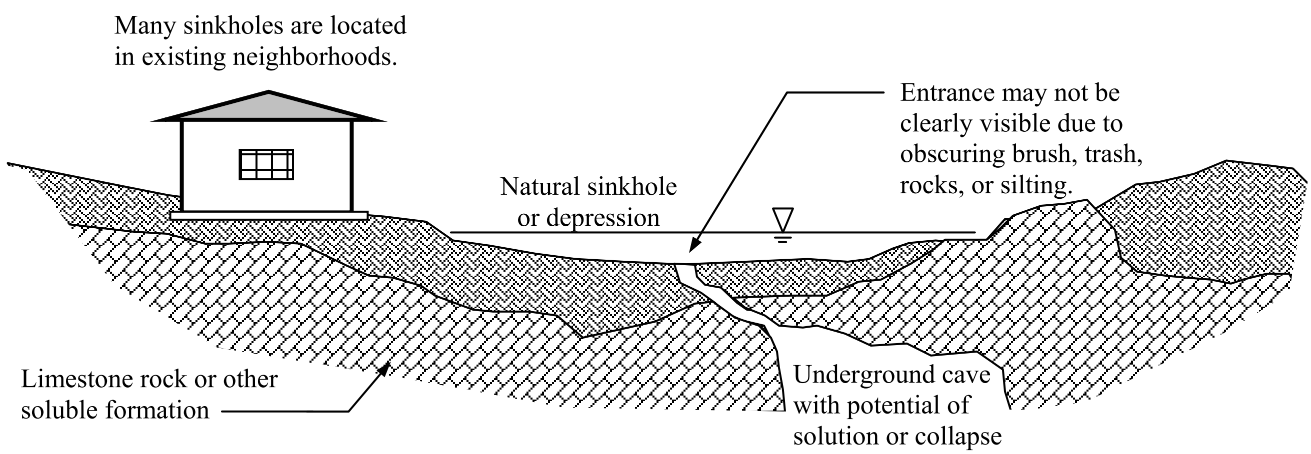



**Figure I-03-2**
**Typical Drywell (With Rooftop Drainage)**




Increasing stormwater runoff to a natural depression may increase sinkhole formation by further dissolving limestone. Even if amount of stormwater runoff has not been increased, stormwater quality treatment is necessary to prevent pollutants from entering groundwater and to reduce potential pH changes and chemicals within stormwater runoff.

NOT TO SCALE

**Figure I-03-3**
**Typical Schematic of Sinkholes and Karst Areas**

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