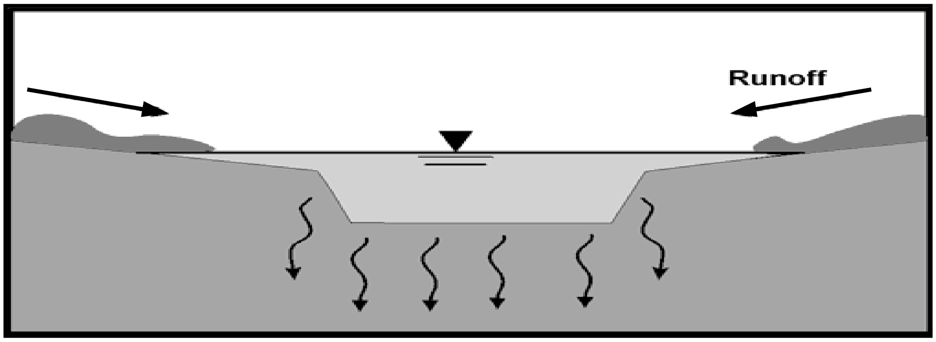
ACTIVITY: Infiltration Basin

I – 02



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 the infiltration basins, in which stormwater runoff is infiltrated into an excavated pond rather than discharged to a surface channel. Much of the information and design characteristics are similar to that of an infiltration trench. The reader is referenced to section I-01, Infiltration/Percolation Trench, for more information. It is usually designed to accept the first flush of stormwater runoff, temporarily store it, and eventually allow it to infiltrate into the subsoil through its sides and bottom. Infiltration rates in many areas of the state are typically poor due to clay soils and bedrock. Such locations may not be suitable of infiltration trench 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

Following are some criteria for placement of infiltration basins:

- Infiltration basins may be used for stormwater quality and stormwater detention at project sites up to 50 acres in size, only if soil, geologic and groundwater conditions are suitable. Soils must have adequate infiltration rates as measured or tested in the field. No unfavorable geologic conditions shall be present that would indicate sinkholes or underground passageways.
- Infiltration basins are often used in low to medium density, residential and commercial areas with limited and costly land space. They are usually used for small drainage areas of less then five acres. They require highly permeable soils and a water table depth much lower than the bottom of the basin to prevent contamination of the groundwater.
- Infiltration basins should always be designed to have pretreatment facilities, such as a filter strip or grass swale, to aid in the removal of suspended materials, oil, grease, and other particulate pollutants.
- Natural sinkholes (or other evidences of karst topography and drainage) are not considered to be suitable locations for 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 to remove suspended materials. In addition, they should be designed to completely drain in two days or less.

Infiltration basins can be used for water quantity control, provided that the basin is properly maintained. They can also provide groundwater recharge and help maintain baseflow in nearby streams. There are several methods and designs for infiltration basins that can be found in various design manuals.

Following are some factors to consider in design:

- 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.
- 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.
- A maximum side slope of 3:1 (H:V) is recommended to provide bank stabilization and easier mowing.
- The slope of the drainage area to an infiltration basin should not exceed five percent. This helps to keep runoff velocities low.
- The water table should be at least three feet below the bottom of the basin. This can be determined with soil borings taken at the site.
- The bottom of the infiltration basin should be at least four feet above the bedrock.
- Basins can be 3 to 12 feet deep. The depth can be calculated using the infiltration rate, aggregate void space, and basin storage time.
- Infiltration basins should be located 20 feet down-slope and 100 feet up-slope from building foundations.
- To help prevent premature clogging of the infiltration facility, a pretreatment facility such as a filter strip or grass swale should be installed to remove suspended materials, oil, grease, etc. before it enters the trench. If an area is expected to have high levels of sediment input, an infiltration trench may not be recommended at all.
- The sides, top, and bottom of the infiltration basin should be vegetated to protect from erosion.
- An infiltration basin should be designed to completely drain two days after the

design storm event. This allows the underlying soil to dry between storm events.

- A factor of safety should be incorporated into the design to ensure that the system still works even when partially clogged.
- The water levels measured in these wells can be used to monitor clogging potential and de-watering times.
- An infiltration basin can be effective year-round as long as the surface is cleared of snow and ice. If the surface freezes, its infiltration abilities are greatly impaired.
- If the infiltration basin is to be used for stormwater detention, the designer should take infiltration rates into account when designing outlet structure elevations and sizes.
- The design of the infiltration basin should be very similar to that of a detention pond. See P-01, Detention Basin, for more information.

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-02-1. The USDA soil texture classification is based upon the soils triangle shown in Figure I-02-1, 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

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-02-1
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

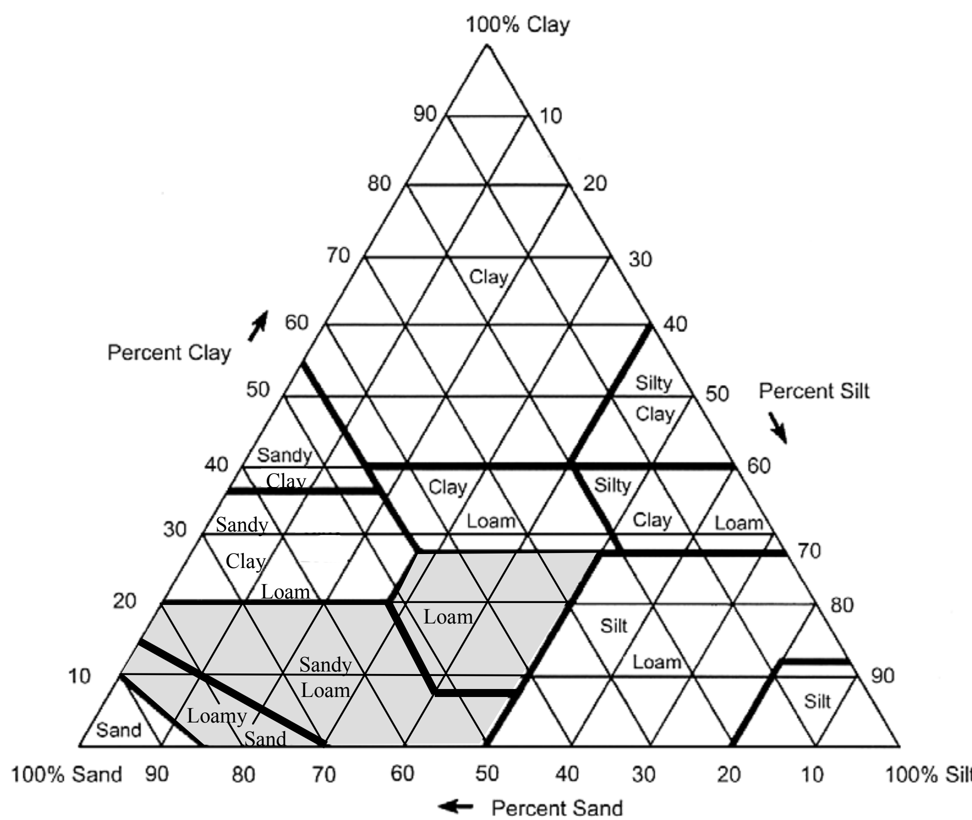


Figure I-02-1
USDA Soils Triangle

Part of the stormwater runoff storage in an infiltration trench is located within a gravel trench. The volume available for water storage is found by multiplying the total gravel volume by the porosity (η). Typical details for an infiltration basin are shown in Figure I-02-2. Pretreatment is highly recommended for areas with fine grained soils, dust, sediment, debris, or other materials with the potential to clog the soils of an infiltration basin. Design an emergency overflow of a bypass for larger storms (using overland relief swales or possibly even street drainage in the case of 100-year floods).

At a minimum, the infiltration basin should have adequate volume to treat the first flush. An infiltration basin does not have organic soil layers or surface vegetation to trap some types of pollutants. A basin may be ineffective for soluble pollutants such as hydrocarbons, nitrates, salts or organic compounds.

Infiltration basins may be used for stormwater quality and stormwater detention at small project sites only if soil, geologic and groundwater conditions are suitable. Soils must have adequate infiltration rates as measured or tested in the field. No unfavorable geologic conditions shall be present that would indicate sinkholes or underground passageways. Unless adequate engineering documentation is submitted, an infiltration basin must be located at least 100 feet away from any drinking water well, septic tank or drainfield. It is also recommended that an infiltration basin should not be located near building foundations, buildings with basements or crawl spaces, major roadways, wetlands, streams, or potentially unstable slopes and hillsides.

Infiltration basins are not effective in some parts of Tennessee due to clay soils and shallow bedrock conditions. Smaller infiltration systems (trenches or drywells) may be applicable if local soil conditions allow. See sections I-01 and I-03 for more information. Avoid steep slopes or other geologic conditions that could potentially be made unstable by infiltrating water into the ground.

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-02-3 for a typical sketch of a sinkhole.

For natural depressions and sinkholes, it is generally required that the postdeveloped peak flows and total stormwater runoff volume must be limited to the predeveloped 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.

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.
- Geotextile fabric should be selected on the basis of durability, with an adequate opening size to resist clogging.
- Use clean washed aggregate (little or no fines).
- If the bottom of the basin has been compacted due to construction vehicles or other means, it should be rototilled to replenish its infiltration capacity.
- Protect the area from heavy equipment and traffic by physical means.
- Improperly functioning infiltration basins must be replaced by other stormwater treatment BMPs that are capable of providing water quality treatment.

Maintenance

- 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 considerations should include the possibility of replacing an infiltration basin every 5 years, as the gravel and geotextile fabric will eventually become clogged and cease to function. Clogging may also occur at the bottom of the basin, along the gravel / soil interface. Clogging will occur even faster if there are fine silts, oil and grease, fertilizers and other materials present in stormwater runoff. Do not allow trees or other woody vegetation to become rooted along an infiltration basin. Inspect operation and recovery of infiltration trench at least a few times a year.
- 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. All infiltration trenches should be inspected several times the first year and at least twice a year thereafter.
- Rake the bottom of the infiltration basin at regular intervals, to prevent clogging.
- 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

Construction costs include clearing, grading, excavation, placement of the filter fabric, placement of the stone aggregate, installation of the monitoring well, and establishment of a vegetated buffer strip. Infiltration basin construction costs are estimated to be ten to twenty percent higher than conventional dry ponds (Schueler, et al, 1992).

Pretreatment will reduce maintenance costs by capturing gross settleable solids and floatables in a smaller space that can be more easily cleaned. Maintenance activities include inspection, maintaining the pretreatment facility, mowing, buffer maintenance, tree pruning or removal, sediment removal, and eventual rehabilitation. The costs of these activities vary from place to place.

Limitations

- The four major concerns with infiltration basins 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 basins 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 basin.
- Infiltration basins are not appropriate for areas with high groundwater tables, steep slopes, lots of underground infrastructure, and nearby buildings.
- Infiltration basins tend to fail very easily and have short life spans. This is due to premature clogging of the facility, low permeable soils, and high water table.
- There are many restrictions on the use of infiltration basins, including soil type, depth to water table and bedrock, slopes, and contributing watershed area. Careful investigations of these conditions must be performed to determine if an infiltration trench is best suited to the location over another BMP.
- Heavy metals are likely to settle in infiltration basins. 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 basins may not be appropriate where there is significant potential for hazardous chemical spills or near drinking water wells.
- Constructing an infiltration basin over compacted fill soils should be avoided because they greatly reduce the exfiltration capacity of the basin.
- The use of infiltration basins is very limited in ultra-urban areas because of unsuitable soils and space considerations.
- Infiltration trenches are generally suitable only for small sites of a few acres.

Additional Information

- Infiltration trenches 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 trenches 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.

- 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.

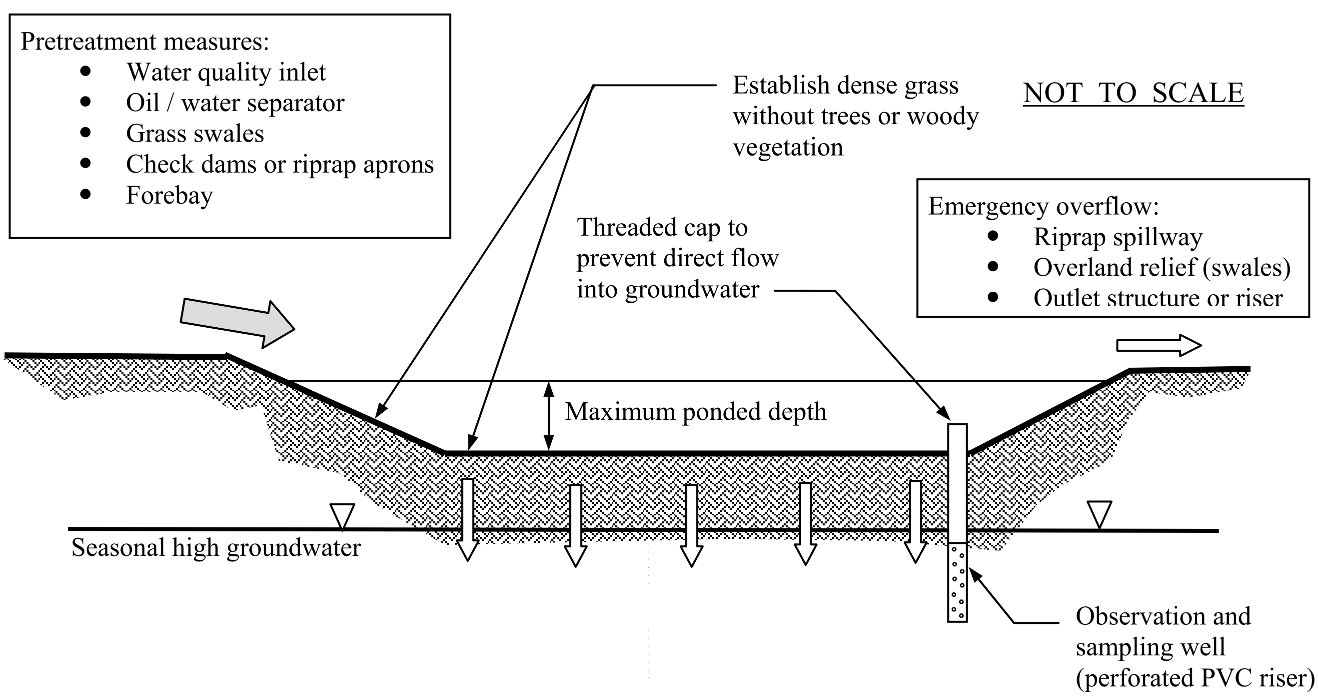


Figure I-02-2
Typical Infiltration Basin

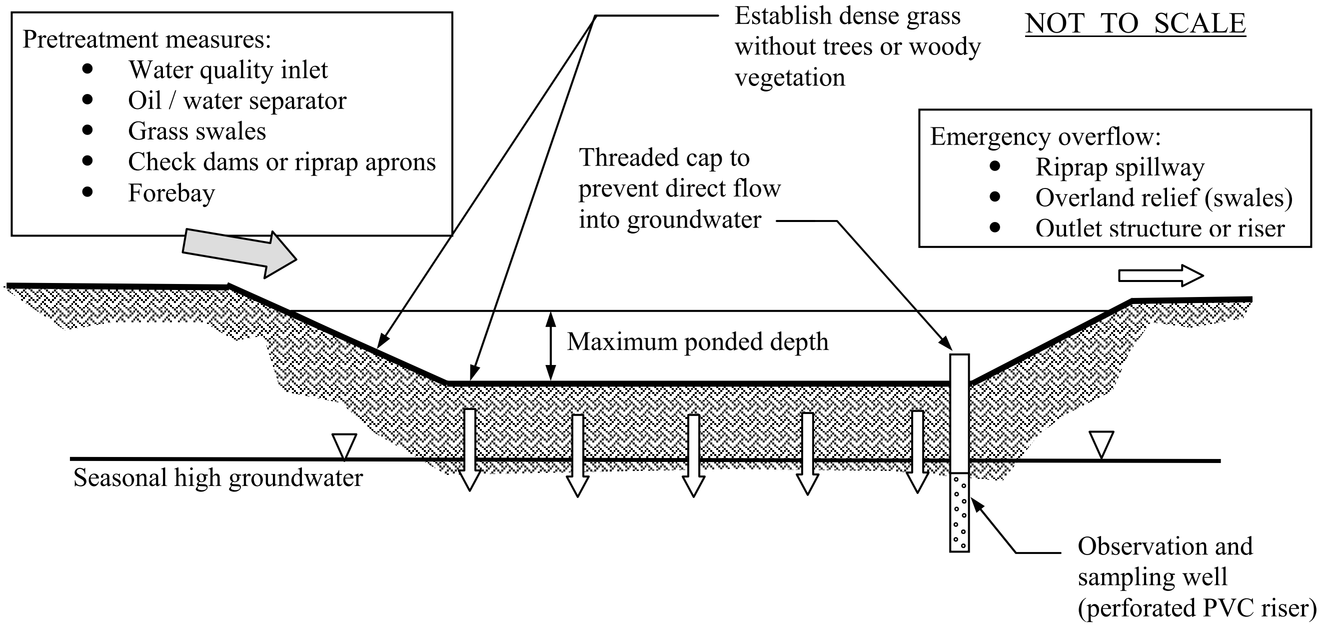
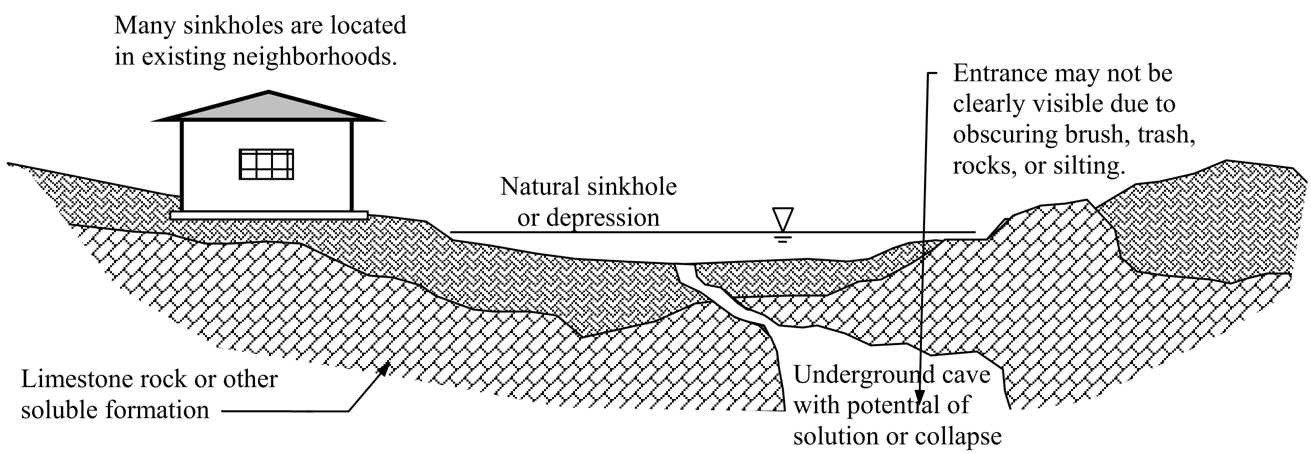


Figure I-02-2
Typical Infiltration Basin



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-02-3
Typical Schematic of Sinkholes and Karst Areas

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