

New Jersey Stormwater Best Management Practices Manual

February 2004

C H A P T E R 9 . 5

Standard for Infiltration Basins

Definition

An infiltration basin is a facility constructed within highly permeable soils that provides temporary storage of stormwater runoff. An infiltration basin does not normally have a structural outlet to discharge runoff from the stormwater quality design storm. Instead, outflow from an infiltration basin is through the surrounding soil. An infiltration basin may also be combined with an extended detention basin to provide additional runoff storage for both stormwater quality and quantity management. The adopted TSS removal rate for infiltration basins is 80 percent.

It should be noted that a dry well is a specialized infiltration facility intended only for roof runoff. See *Chapter 9.3: Standard for Dry Wells* for further details.

Purpose

Infiltration basins are used to remove pollutants and to infiltrate stormwater back into the ground. Such infiltration also helps to reduce increases in both the peak rate and total volume of runoff caused by land development. Pollutant removal is achieved through filtration of the runoff through the soil as well as biological and chemical activity within the soil.

Infiltration basins may also be used to meet the groundwater recharge requirements of the NJDEP Stormwater Management Rules. See *Recharge BMP Design Guidelines* in *Chapter 6: Groundwater Recharge* for a complete discussion of these requirements and the use of infiltration basins and other groundwater recharge facilities to meet them.

Conditions Where Practice Applies

The use of infiltration basins is applicable only where the soils have the required permeability rates. Specific soil permeability requirements are presented below in *Design Criteria*.

Like other BMPs that rely on infiltration, infiltration basins are not appropriate for areas where high pollutant or sediment loading is anticipated due to the potential for groundwater contamination.

Specifically, infiltration basins must not be used in the following locations:

- Industrial and commercial areas where solvents and/or petroleum products are loaded, unloaded, stored, or applied or pesticides are loaded, unloaded, or stored.
- Areas where hazardous materials are expected to be present in greater than “reportable quantities” as defined by the U.S. Environmental Protection Agency in the Code of Federal Regulations at 40 CFR 302.4.
- Areas where infiltration basin use would be inconsistent with an NJDEP-approved remedial action work plan or landfill closure plan.
- Areas with high risks for spills of toxic materials such as gas stations and vehicle maintenance facilities.
- Areas where industrial stormwater runoff is exposed to “source material.” “Source material” means any material(s) or machinery, located at an industrial facility, that is directly or indirectly related to process, manufacturing, or other industrial activities, that could be a source of pollutants in any industrial stormwater discharge to groundwater. Source materials include, but are not limited to raw materials, intermediate products, final products, waste materials, by-products, industrial machinery and fuels, and lubricants, solvents, and detergents that are related to process, manufacturing, or other industrial activities that are exposed to stormwater.

In addition, as required by the Stormwater Management Rules, infiltration basins must not be used where their installation would create a significant risk for basement seepage or flooding, cause surficial flooding of groundwater, or interfere with the operation of subsurface sewage disposal systems and other subsurface structures. Such adverse impacts must be assessed and avoided by the design engineer.

Infiltration basins must be configured and located where their construction will not compact the soils below the basin. In addition, an infiltration basin must not be placed into operation until the contributing drainage area is completely stabilized. Basin construction must either be delayed until such stabilization is achieved, or upstream runoff must be diverted around the basin. Such diversions must continue until stabilization is achieved.

Finally, an infiltration basin must have a maintenance plan and, if privately owned, should be protected by easement, deed restriction, ordinance, or other legal measures that prevent its neglect, adverse alteration, and removal.

Design Criteria

The components of a typical infiltration basin are shown in Figure 9.5-1. Additional details of each component are described below.

A. Storage Volume, Depth, and Duration

An infiltration basin must be designed to treat the total runoff volume generated by the basin’s maximum design storm. This may either be the groundwater recharge or stormwater quality design storm, depending upon the basin’s proposed use. Techniques to compute these volumes are discussed in *Chapter 6: Groundwater Recharge* and *Chapter 5: Computing Stormwater Runoff Rates and Volumes*. An infiltration basin must also fully drain this runoff volume within 72 hours. Runoff storage for greater times can render the basin ineffective and may result in anaerobic conditions, odor, and both water quality and mosquito breeding problems. The bottom of the infiltration basin must be at least 2 feet above seasonal high water table or bedrock. For surface basins, this distance must be measured from the bottom of the sand layer as shown in Figure 9.5-1. The basin bottom must be as level as possible to uniformly distribute runoff infiltration over the subgrade soils.

To enhance safety by minimizing standing water depths, the vertical distance between the basin bottom and the maximum design storm water surface in surface infiltration basins should be no greater than 2 feet.

As discussed in *Considerations* below, construction of an infiltration basin must be done without compacting the basin's subgrade soils. As such, all excavation must be performed by equipment placed outside the basin whenever possible. This requirement should be considered when designing the dimensions and total storage volume of an infiltration basin.

It is important to note that the use of infiltration basins is recommended in this manual only for the stormwater quality design storm and smaller storm events. Use of infiltration basins for larger storm events and the requirements by which such basins are to be designed, constructed, and maintained should be reviewed and approved by all applicable reviewing agencies.

B. Permeability Rates

The minimum design permeability rate of the soils below an infiltration basin will depend upon the basin's location and maximum design storm. The use of infiltration basins for stormwater quality control is feasible only where soil is sufficiently permeable to allow a reasonable rate of infiltration. Therefore, infiltration basins designed for storms greater than the groundwater recharge storm can be constructed only in areas with Hydrologic Soil Group A and B soils. Additional permeability requirements are presented below in Table 9.5-1.

Table 9.5-1: Minimum Design Permeability Rates for Infiltration Basins

Maximum Design Storm	Basin Location	Minimum Design Permeability Rate (Inches/Hour)
Groundwater Recharge*	Subsurface	0.2
Groundwater Recharge	Surface	0.5
Stormwater Quality	Surface and Subsurface	0.5
*See text for required diversion of runoff from greater storms.		

It is important to note that, for subsurface infiltration basins that are used only for groundwater recharge (see Table 9.5-1 above), all runoff from storms greater than the basin's groundwater recharge storm must be directed around the basin by a diversion structure or device located upstream of the basin. If the basin does receive runoff and associated pollutants from greater storm events, a minimum permeability rate of 0.5 inches/hour must be used. Minor basin inflows from greater storms during normal operation of the diversion are permissible provided they represent a small percentage of the total storm runoff volume. Details of an infiltration basin's groundwater recharge storm are presented in *Chapter 6*. See *E. Online and Offline Systems* below for additional information.

In addition to the above, the design permeability rate of the soil must be sufficient to fully drain the infiltration basin's maximum design storm runoff volume within 72 hours. This design permeability rate must be determined by field or laboratory testing. See *A. Soil Characteristics* in *Considerations* below for more information. Since the actual permeability rate may vary from test results and may also decrease over time due to soil bed consolidation or the accumulation of sediments removed from the treated stormwater, a

factor of safety of two must be applied to the tested permeability rate to determine the design permeability rate. Therefore, if the tested permeability rate of the soils is 4 inches/hour, the design rate would be 2 inches/hour (i.e., 4 inches per hour/2). This design rate would then be used to compute the basin's maximum design storm drain time.

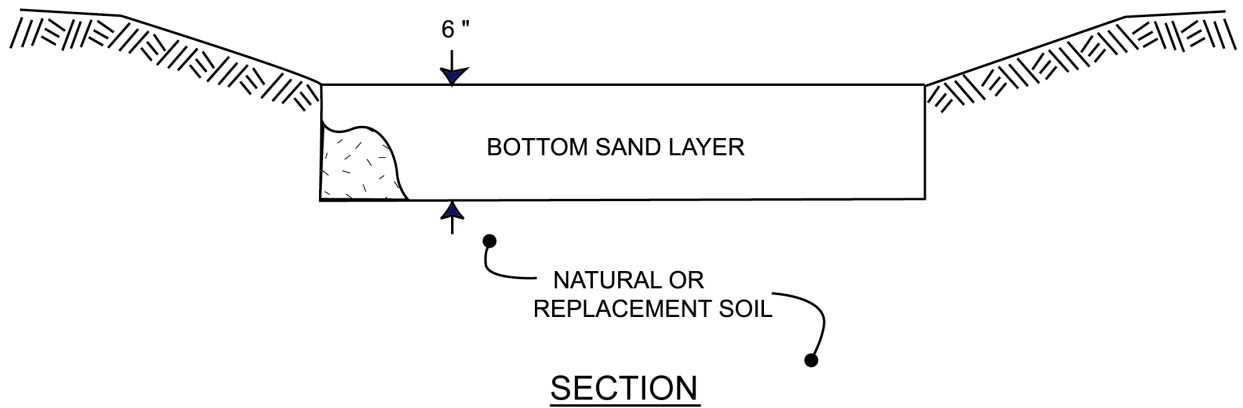
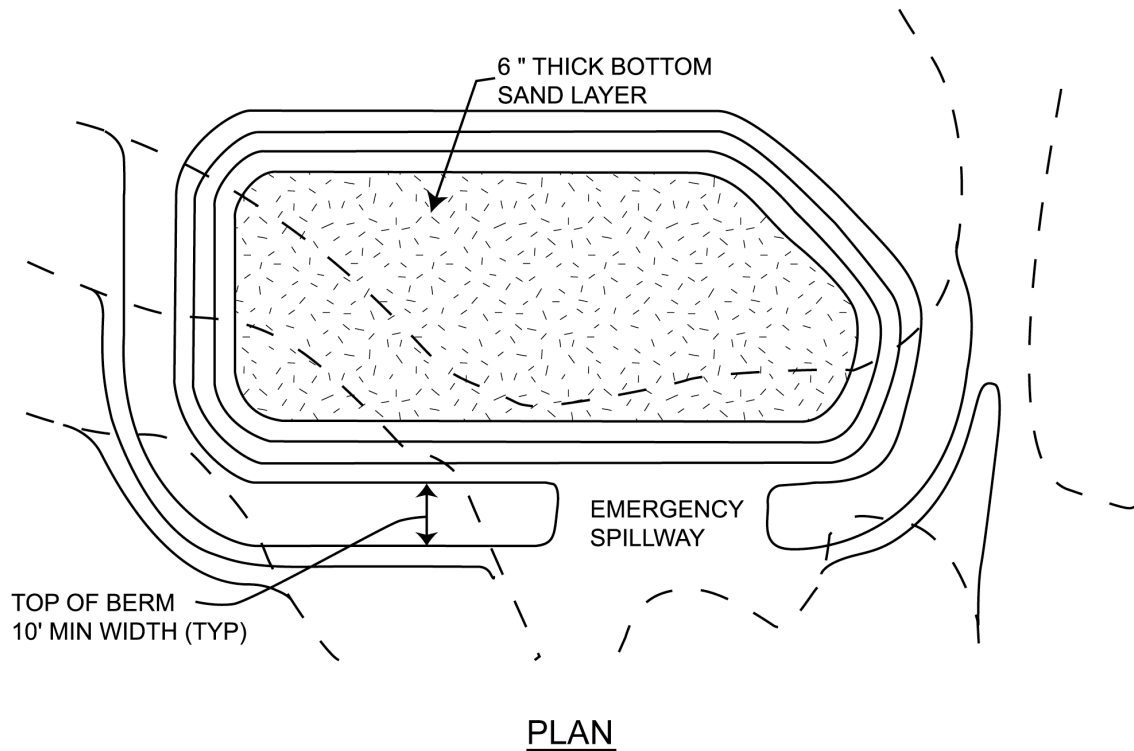
C. Bottom Sand Layer

To help ensure maintenance of the design permeability rate over time, a 6 inch layer of sand must be placed on the bottom of an infiltration basin (see Figure 9.5-1). This sand layer can intercept silt, sediment, and debris that could otherwise clog the top layer of the soil below the basin. The sand layer will also facilitate silt, sediment, and debris removal from the basin and can be readily restored following removal operations. The sand layer must meet the specifications of a K5 soil. This must be certified by a professional engineer licensed in the State of New Jersey.

D. Overflows

All infiltration basins must be able to convey overflows to downstream drainage systems in a safe and stable manner. Infiltration basins that are classified as dams under the NJDEP Dam Safety Standards at N.J.A.C. 7:20 must also meet the overflow requirements of these Standards.

Figure 9.5-1: Infiltration Basin Components



NOTES

1. BOTTOM SAND LAYER MUST CONSIST OF K5 SAND WITH A MAXIMUM OF 15% FINES AND A MINIMUM PERMEABILITY RATE OF 20 INCHES PER HOUR.
2. BASIN CONSTRUCTION MUST NOT COMPACT SOILS BELOW BASIN BOTTOM.
3. SEE TEXT FOR ADDITIONAL REQUIREMENTS.

Source: Adapted from T&M Associates.

E. On-Line and Off-Line Systems

Infiltration basins may be constructed either on-line or off-line. On-line systems receive upstream runoff from all storms, providing runoff treatment for the maximum design storm and conveying the runoff from larger storms through an overflow. With the proper soil and drainage area conditions, an infiltration basin may also be combined with a detention basin to provide runoff quantity control in the detention portion of the basin. In such systems the invert of the lowest stormwater quantity control outlet is set at or above the maximum stormwater quality design storm water surface.

In off-line infiltration basins, most or all of the runoff from storms larger than the maximum design storm bypass the basin through an upstream diversion. This not only reduces the size of the required basin storage volume, but also reduces the basin's long-term pollutant loading and associated maintenance. See *B. Permeability Rates* above for additional information on diversion requirements, particularly for subsurface infiltration basins used only for groundwater recharge.

F. Subsurface Infiltration Basins

A subsurface infiltration basin is located entirely below the ground surface. It may consist of a vault, perforated pipe, and/or stone bed. However, due to the greater difficulty in removing silt, sediment, and debris, all runoff to a subsurface infiltration basin must be pretreated. This pretreatment must remove 80 percent of the TSS in the runoff from the basin's maximum design storm.

Following pretreatment, additional TSS removal can then be provided by the subsurface infiltration basin as the secondary BMP in a treatment train. Computation of the total TSS removal rate is described in *Chapter 4: Stormwater Pollution Removal Criteria*. See *A. Pretreatment in Recommendations* below for information on runoff pretreatment.

G. Basis of Design

The design of an infiltration basin is based upon Darcy's Law:

$$Q = KIA$$

where:

Q = the rate of infiltration in cubic feet per second (cfs)

K = the hydraulic conductivity of the soil in feet per second (fps)

I = the hydraulic gradient

A = the area of infiltration in square feet (sf)

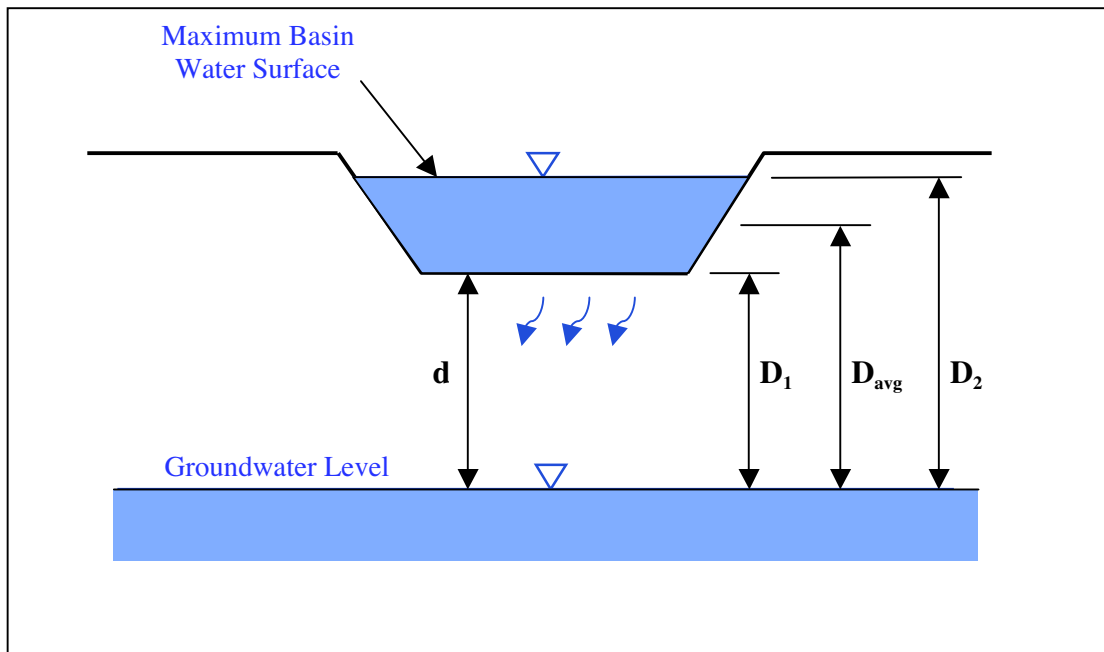
From the variables shown in Figure 9.5-2 below:

Average Hydraulic Gradient = D_{avg}/d

Minimum Hydraulic Gradient = D_1/d

Maximum Hydraulic Gradient = D_2/d

Figure 9.5-2: Schematic of Darcy's Law



The hydraulic conductivity is either field measured or laboratory measured for the soil on site. A number of percolation tests should be done to obtain a reliable measurement of permeability of the underlying soil.

Maintenance

Effective infiltration basin performance requires regular and effective maintenance. *Chapter 8: Maintenance and Retrofit of Stormwater Management Measures* contains information and requirements for preparing a maintenance plan for stormwater management facilities, including infiltration basins. Specific maintenance requirements for infiltration basins are presented below. These requirements must be included in the basin's maintenance plan.

A. General Maintenance

All infiltration basin components expected to receive and/or trap debris and sediment must be inspected for clogging and excessive debris and sediment accumulation at least four times annually as well as after every storm exceeding 1 inch of rainfall. Such components may include bottoms, riprap or gabion aprons, and inflow points. This applies to both surface and subsurface infiltration basins.

Sediment removal should take place when the basin is thoroughly dry. Disposal of debris, trash, sediment, and other waste material should be done at suitable disposal/recycling sites and in compliance with all applicable local, state, and federal waste regulations.

Studies have shown that readily visible stormwater management facilities like infiltration basins receive more frequent and thorough maintenance than those in less visible, more remote locations. Readily visible facilities can also be inspected faster and more easily by maintenance and mosquito control personnel.

B. Vegetated Areas

Mowing and/or trimming of vegetation must be performed on a regular schedule based on specific site conditions. Grass should be mowed at least once a month during the growing season. Vegetated areas must also be inspected at least annually for erosion and scour. The structure must be inspected for unwanted tree growth at least once a year.

When establishing or restoring vegetation, biweekly inspections of vegetation health should be performed during the first growing season or until the vegetation is established. Once established, inspections of vegetation health, density, and diversity should be performed at least twice annually during both the growing and non-growing season. If vegetation has greater than 50 percent damage, the area should be reestablished in accordance with the original specifications and the inspection requirements presented above.

All use of fertilizers, mechanical treatments, pesticides, and other means to assure optimum vegetation health must not compromise the intended purpose of the infiltration basin. All vegetation deficiencies should be addressed without the use of fertilizers and pesticides whenever possible.

All vegetated areas should be inspected at least annually for unwanted growth, which should be removed with minimum disruption to the remaining vegetation and basin subsoil.

C. Structural Components

All structural components must be inspected for cracking, subsidence, spalling, erosion, and deterioration at least annually.

D. Other Maintenance Criteria

The maintenance plan must indicate the approximate time it would normally take to drain the maximum design storm runoff volume below the bottom of the basin. This normal drain or drawdown time should then be used to evaluate the basin's actual performance. If significant increases or decreases in the normal drain time are observed, the basin's bottom surface, subsoil, and both groundwater and tailwater levels must be evaluated and appropriate measures taken to comply with the maximum drain time requirements and maintain the proper functioning of the basin. This applies to both surface and subsurface infiltration basins.

The bottom sand layer in a surface infiltration basin should be inspected at least monthly as well as after every storm exceeding 1 inch of rainfall. The permeability rate of the soil below the basin may also be retested periodically. If the water fails to infiltrate 72 hours after the end of the storm, corrective measures must be taken. Annual tilling by light equipment can assist in maintaining infiltration capacity and break up clogged surfaces.

Considerations

Infiltration basins can present some practical design problems. When planning for an infiltration basin that provides stormwater quality treatment, consideration should be given to soil characteristics, depth to the groundwater table, sensitivity of the region, and runoff water quality. Particular care must be taken when constructing infiltration basins in areas underlain by carbonate rocks known as Karst landscapes. See Appendix A10 of the Standards for Soil Erosion and Sediment Control in New Jersey for further guidance in Karst landscape areas.

A. Soil Characteristics

Soils are perhaps the most important consideration for site suitability. In general, County Soil Surveys can be used to obtain necessary soil data for the planning and preliminary design of infiltration basins. However, for final design and construction, soil tests are required at the exact location of a proposed basin in order to confirm its ability to function properly without failure.

Such tests should include a determination of the textural classification and permeability of the subgrade soil at and below the bottom of the proposed infiltration basin. The recommended minimum depth for subgrade soil analysis is 5 feet below the bottom of the basin or to the groundwater table. Soil permeability testing can be conducted in accordance with the Standards for Individual Subsurface Sewage Disposal Systems at N.J.A.C. 7:9A. See *Design Criteria* above for further subgrade soil requirements.

In addition, the results of a basin's soil testing should be compared with the County Soil Survey data used in the computation of development site runoff and the design of specific site BMPs, including the proposed infiltration basin, to ensure reasonable data consistency. If significant differences exist between the basin's soil test results and the County Soil Survey data, additional development site soil tests are recommended to determine and evaluate the extent of the data inconsistency and the need for revised site runoff and BMP design computations. All significant inconsistencies should be discussed with the local Soil Conservation District prior to proceeding with such redesign to help ensure that the final site soil data is accurate.

B. Construction

For infiltration basins, protection of the subgrade soils from compaction by construction equipment and contamination and clogging by sediment are vital. Prior to its construction, the area to be used for the infiltration basin should be cordoned off to prevent construction equipment and stockpiled materials from compacting the subgrade soils. During basin construction, precautions should be taken to prevent both subgrade soil compaction and sediment contamination. All excavation should be performed with the lightest practical excavation equipment. All excavation equipment should be placed outside the limits of the basin.

To help prevent subgrade soil contamination and clogging by sediment, basin construction should be delayed until all other construction within its drainage area is completed and the drainage area stabilized. This delayed construction emphasizes the need, as described above, to cordon off the basin area to prevent compaction by construction equipment and material storage during other site construction activities. Similarly, use of an infiltration basin as a sediment basin is strongly discouraged. Where unavoidable, excavation for the sediment basin should be a minimum of 2 feet above the final design elevation of the basin bottom. Accumulated sediment can then be removed without disturbing the subgrade soils at the basin bottom, which should be established only after all construction within the basin's drainage area is completed and the drainage area stabilized.

Once the final grading phase of a surface infiltration basin is reached, the bottom of the basin should be deeply tilled with a rotary tiller or disc harrow and then smoothed out with a leveling drag or equivalent grading equipment. These procedures should preferably be performed with equipment located outside the basin bottom. If this is not possible, it should be performed with light-weight, rubber-tired equipment.

If basin construction cannot be delayed until its drainage area is stabilized, diversion berms or other suitable measures should be placed around the basin's perimeter during all phases of construction to divert all runoff and sediment away from the basin. These diversion measures should not be removed until all construction within the basin's drainage area is completed and the drainage area stabilized.

Broken stone fill used in subsurface infiltration basins should be placed in lifts and compacted using plate compactors. A maximum loose lift thickness of 12 inches is recommended.

A preconstruction meeting should be held to review the specific construction requirements and restrictions of infiltration basins with the contractor.

C. Runoff Quality

The quality of runoff entering an infiltration basin is a primary consideration in determining whether infiltration is advisable and, if so, in designing the basin itself. The planning of an infiltration basin must consider which pollutants will be present in the runoff and whether these pollutants will degrade groundwater quality. Certain soils can have a limited capacity for the treatment of bacteria and the soluble forms of nitrogen, phosphorus, and other pollutants like road salts and pesticides. Such pollutants are either attenuated in the soil column or go directly to the water table. Unfortunately, the soils that normally have the highest and, therefore, most suitable permeability rates also have the least ability to treat such pollutants. As a result, pretreatment of soluble pollutants prior to entry into the infiltration basin may be necessary in these soils. Pretreatment measures may include vegetative filters, bioretention systems (where the infiltration basin takes the place of the standard underdrain), and certain sand filters. Alternatively, the existing soil below the infiltration basin bottom may be augmented or replaced by soils with greater soluble pollutant removal rates.

Recommendations

A. Pretreatment

As with all other best management practices, pretreatment can extend the functional life and increase the pollutant removal capability of an infiltration basin. Pretreatment can reduce incoming velocities and capture coarser sediments, which will extend the life of the system. This is usually accomplished through such means as a vegetative filters, a forebay, and/or a manufactured treatment device. Information on vegetative filters and manufactured treatment devices is presented in Subchapters 9.10 and 9.6, respectively.

Forebays can be included at the inflow points to an infiltration basin to capture coarse sediments, trash, and debris, which can simplify and reduce the frequency of system maintenance. A forebay should be sized to hold the sediment volume expected between clean-outs.

As described above, it should be remembered that the runoff to all subsurface infiltration basins must be pretreated. This pretreatment must provide 80 percent removal of TSS for the maximum design storm runoff. See *Recharge BMP Design Guidelines* in *Chapter 6: Groundwater Recharge* for additional pretreatment information for subsurface infiltration basins used for groundwater recharge.

This pretreatment requirement does not apply to roofs and other above-grade surfaces. However, roof gutter guards and/or sumps or traps (equipped with clean-outs) in the conduits to a subsurface infiltration basin should be included wherever practical to minimize the amount of sediment and other particulates that can enter the basin.

B. Sensitivity of the Area

The planning of an infiltration basin site should consider the geologic and ecological sensitivity of the proposed site. Sensitive areas include FWI streams, areas near drinking water supply wells, and areas of high aquifer recharge. Infiltration basins should be sited at least 100 feet from a drinking water supply well. They should also be sited away from foundations to avoid seepage problems. Measures should be taken in areas of aquifer recharge to ensure good quality water is being infiltrated to protect ground water supplies. Infiltration basins should be located away from septic systems to help prevent septic system failure and other adverse system interference.

C. Slopes

Topography of the location is an important consideration for basin operation. Ideally, basin construction should not occur where surrounding slopes are greater than 10 percent. The grading of the basin floor should be as level as possible (with the slope approaching zero) to achieve uniform spreading across the breadth and the length of the basin.

Grading and landscaping throughout the infiltration basin and its components must be designed to facilitate mowing, trimming, sediment and debris removal, and other maintenance activities.

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