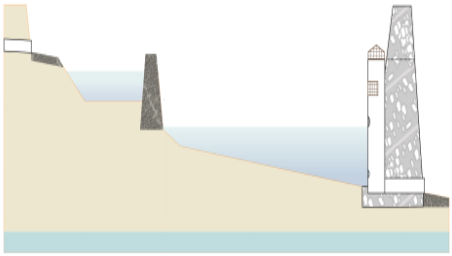
9.4 Extended Detention Basins



An extended detention basin is a stormwater management facility that temporarily stores and attenuates stormwater runoff. In addition, extended detention basins provide pollutant treatment for runoff from the Water Quality Design Storm through settling. When designed in accordance with this chapter, the total suspended solids (TSS) removal rate is 40 - 60%, depending on the duration of runoff detention.

N.J.A.C. 7:8 Stormwater Management Rules - Design and Performance Standards		
	Nonstructural Strategies	Not Allowed
	Water Quantity	Yes, when designed for the 2-, 10- and 100-year design storms
GR	Groundwater Recharge	Not Allowed
%	Water Quality	40 - 60% TSS Removal, depending on duration of detention

Water Quality Mechanisms and Corresponding Criteria	
Settling	
Minimum Detention Time for Calculation of TSS Removal Rate	12 hours
Maximum Detention Time for Calculation of TSS Removal Rate	24 hours

Introduction

Extended detention basins are used to address both the stormwater runoff quantity and quality impacts of land development. The lower stages of an extended detention basin detain runoff from the Water Quality Design Storm promoting pollutant removal through settling. The higher stages of the basin attenuate the peak rates of runoff from larger storm events.

Extended detention basins may be used at sites where significant increases in runoff are expected as a result of site development; however, their limited efficacy in removing both particulate and soluble pollutants may limit their use for water quality.

Extended detention basins 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 or removal.

Applications

Extended detention basins may be designed to convey storm events larger than the Water Quality Design Storm; however, regardless of the design storm chosen, all extended detention basins must be designed for stability in accordance with the *Standards for Soil Erosion and Sediment Control in New Jersey,* as required by N.J.A.C. 7:8.

To receive credit for a TSS removal rate of 40-60%, extended detention basins must be designed to treat the Water Quality Design Storm and in accordance with the criteria below.

Design Criteria

Basic Requirements

There are two categories of extended detention basins; the following design criteria apply to all categories and must be met in order to receive the 40 - 60% TSS removal rate for this BMP. It is critical that all extended detention basins are designed in accordance with these criteria in order to ensure proper operation, to maximize the functional life of the system, and to ensure public safety. For criteria specific to each category, see the applicable section, beginning on page 5.

Elevation Above Seasonal High Water Table

- The lowest elevation in a surface extended detention basin, excluding low flow channels, must be at least 1 foot above the seasonal high groundwater table. The lowest elevation in any low flow channel, must be at or above the seasonal high groundwater table.
- The lowest elevation in a subsurface extended detention basin, including any pipes and bedding material, must be at least 1 foot above the seasonal high water table.

Detention Time

- The minimum detention time that can be used to calculate the TSS removal rate is 12 hours, and the maximum detention time that can be used to calculate the TSS removal rate is 24 hours.

Outlet Structure

- The minimum diameter of any outlet orifice in an extended detention basin is 2.5 inches, as required by N.J.A.C. 7:8-5.7(a)4; additional information regarding outlet structures can be found in the Residential Site Improvement Standards at N.J.A.C. 5:21-7.

- Trash racks must be installed at the intake to the outlet structure. They must also be designed to avoid acting as the hydraulic control for the system, and they must meet the following criteria, as required by N.J.A.C. 7:8-5.7(a)2 and 6.2(a):

    - □ Parallel bars spaced at 1-inch intervals, up to the elevation of the Water Quality Design Storm,
    - □ Minimum bar spacing: 1 inch, for elevations in excess of the Water Quality Design Storm,
    - □ Maximum bar spacing: 1/3 the diameter of the orifice or 1/3 the width of weir, with a maximum spacing of 6 inches, for elevations in excess of the Water Quality Design Storm,
    - □ Maximum average velocity of flow through clean rack: 2.5 feet/second, under full range of stage and discharge, computed on the basis of the net area of opening through rack,
    - □ Constructed of rigid, durable and corrosion-resistant material, and
    - □ Designed to withstand a perpendicular live loading of 300 lbs./sf.

- All extended detention basins must be designed to safely convey system overflows to downstream drainage systems. The design of the overflow structure must be sufficient to provide safe, stable discharge of stormwater in the event of an overflow. Safe and stable discharge minimizes the possibility of erosion and flooding in down-gradient areas. Therefore, discharge in the event of an overflow must be consistent with the current version of *Standards for Off-Site Stability* found in the *Standards for Soil Erosion and Sediment Control in New Jersey,* as required by N.J.A.C. 7:8. Extended detention basins 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. Overflow capacity can be provided by a hydraulic structure such as a drain inlet, weir, or catch basin, or a surface feature such as a swale or open channel as site conditions allow.

- The hydraulic design of the outlet structure, outlet pipe, emergency spillway, and underdrain systems in an extended detention basin must consider any significant tailwater effects of downstream waterways or facilities. This includes instances where the lowest invert in the outlet or overflow structure is below the flood hazard area design flood elevation of a receiving stream.

- Information regarding outlet structures, bottom and side slopes, low flow channels, conduit outlet protection, and vegetative cover can be found in N.J.A.C.7:8 and *Soil Erosion and Sediment Control Standards for New Jersey*.

Drain Time

- Extended detention basins are intended to be dry between storm events; therefore, the basin must fully empty within 72 hours. Storage in excess of this time can render the basin ineffective and may result in anaerobic conditions, odor, and both water quality and mosquito breeding issues.

Types of Extended Detention Basins

There are two types of extended detention basins:

1. Surface Extended Detention Basins
2. Subsurface Extended Detention Basins

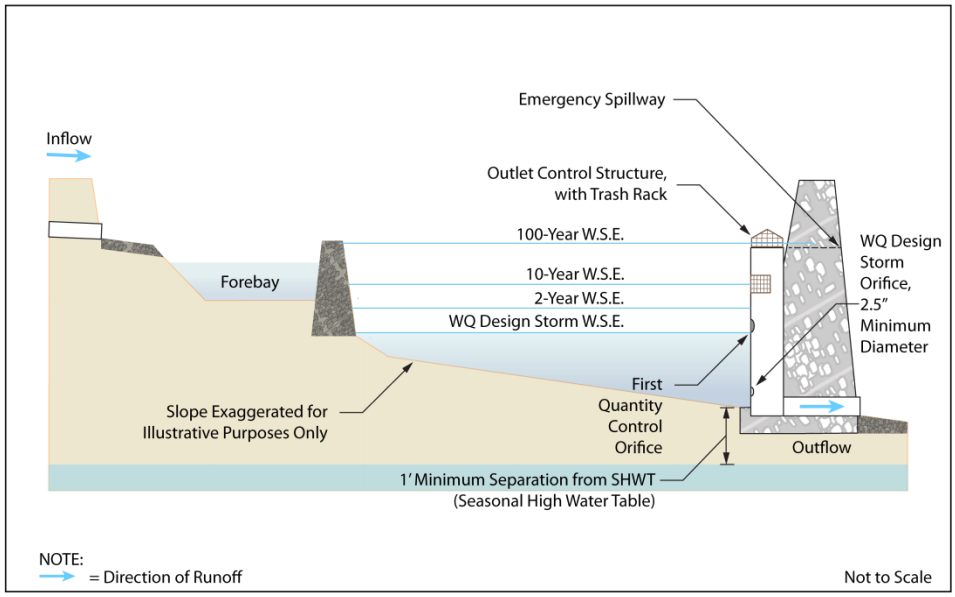
Individual Types of Extended Detention Basins

The following section provides detailed design criteria for each type of extended detention basin; the illustrations include a forebay in the pretreatment zone. These illustrations depict possible configurations and flow paths and are not intended to limit the design.

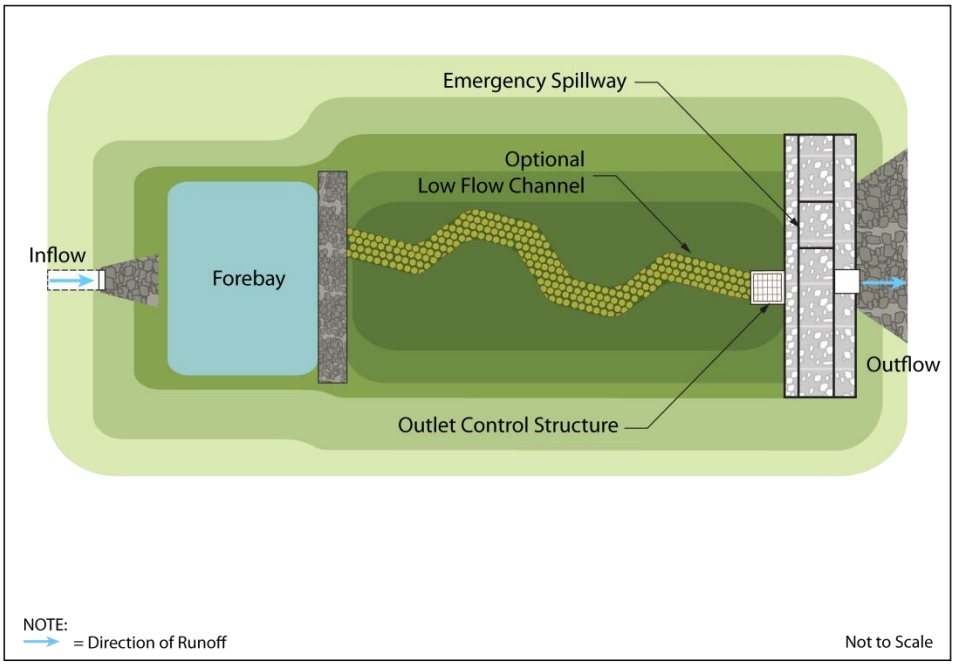
Surface Extended Detention Basins

The following illustrations show a surface extended detention basin in both plan and profile views. The water surface elevation (W.S.E.) for the Water Quality Design Storm and the 2-, 10- and 100-year storms are individually labeled.

Surface Extended Detention Basin – Profile View



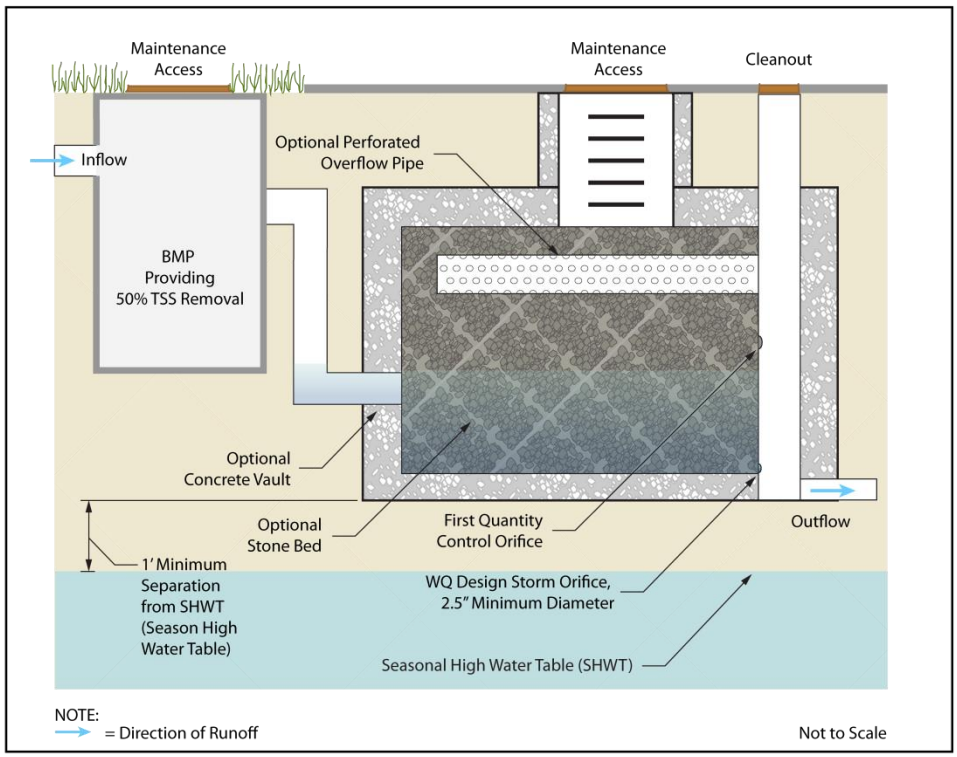
Surface Extended Detention Basin – Plan View



Subsurface Extended Detention Basins

A subsurface detention basin is located entirely below the ground surface. Runoff may be stored in a vault, perforated pipe, and/or stone bed. Because it is difficult to remove accumulated sediment from the stone bed, if a stone bed is utilized, all runoff must be pretreated to remove at least 50% of the TSS from the runoff volume of the system's maximum design storm. For additional information, see the discussion of pretreatment found on page 10. Instead of pretreatment, the basin's storage volume can be increased to account for the loss of storage in the stone bed due to sediment accumulation; the calculation of the additional storage volume must be based upon the expected life of the system.

Subsurface Extended Detention Basin – Profile View



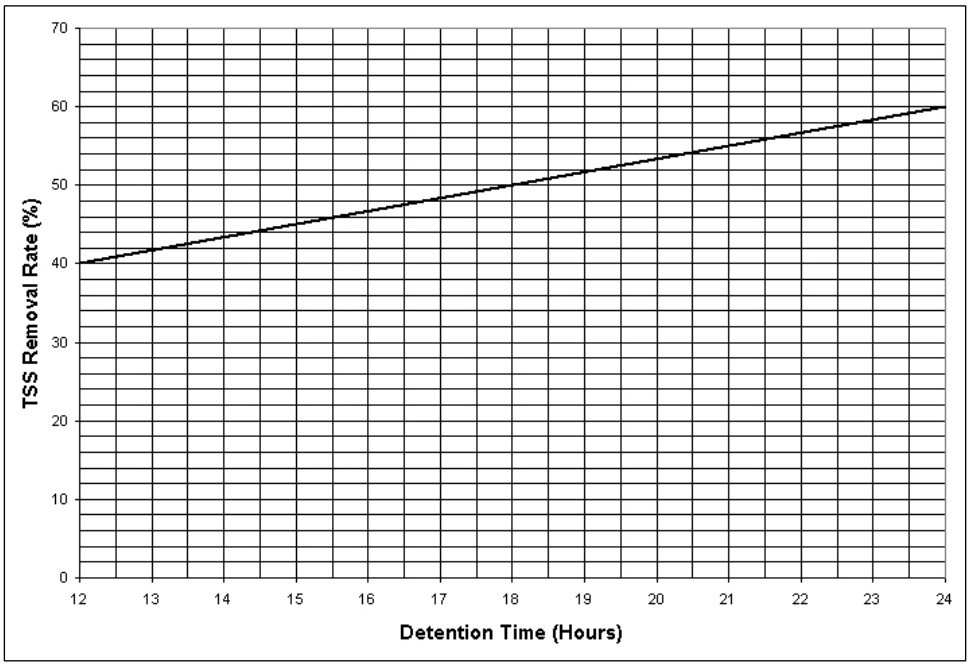
The illustration above shows an example of a stone bed-type subsurface extended detention basin.

TSS Removal Rates for Extended Detention Basins

Extended detention basins are designed to provide treatment of runoff volume generated by the stormwater quality design storm. Techniques to compute this volume are discussed in *Chapter 5: Computing Stormwater Runoff Rates and Volumes.*

The TSS removal rate for an extended detention basin is based on the basin's detention time. The detention time begins when the maximum storage volume is achieved and ends when only 10% of the maximum volume remains. The chart below shows the TSS removal rate for a given detention time. As previously stated, for the purposes of TSS removal rate calculations, the minimum detention time is 12 hours, and the maximum detention time is 24 hours. Systems with detention times in excess of 24 hours will still only be credited with a 60% TSS removal rate.

TSS Removal Rate of Extended Detention Basins



To determine the TSS removal rate for an extended detention basin, either the chart above or the following equation may be used:

$$\% \text{ TSS Removal Rate} = 40 + \left\{\left[\frac{t-12}{12}\right] \times 20\right\},$$

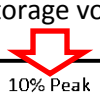
where t is the time of detention in hours and $12 \leq t \leq 24$.

The following example illustrates how to use the chart to determine the TSS removal rate provided:

Example: A number of extended detention basins are to be evaluated for TSS removal rates

Design Number	Time to Peak Elevation (hr)	Peak Storage Volume for WQ Design Storm (cf)	10% Peak Storage Volume (cf)	Time to 10% WQ Volume (hr)	Detention Time Used {12<=Td<=24} (hr)	% TSS Removal
1	3.5	1536.0				
2	2.4	584.5				
3	1	182.0				

Step #1: For each row, multiply the peak storage volume by 0.10 (10%).



Design Number	Time to Peak Elevation (hr)	Peak Storage Volume for WQ Design Storm (cf)	10% Peak Storage Volume (cf)	Time to 10% WQ Volume (hr)	Detention Time Used {12<=Td<=24} (hr)	% TSS Removal
1	3.5	1536.0	153.6			
2	2.4	584.5	58.5			
3	1	182.0	18.2			

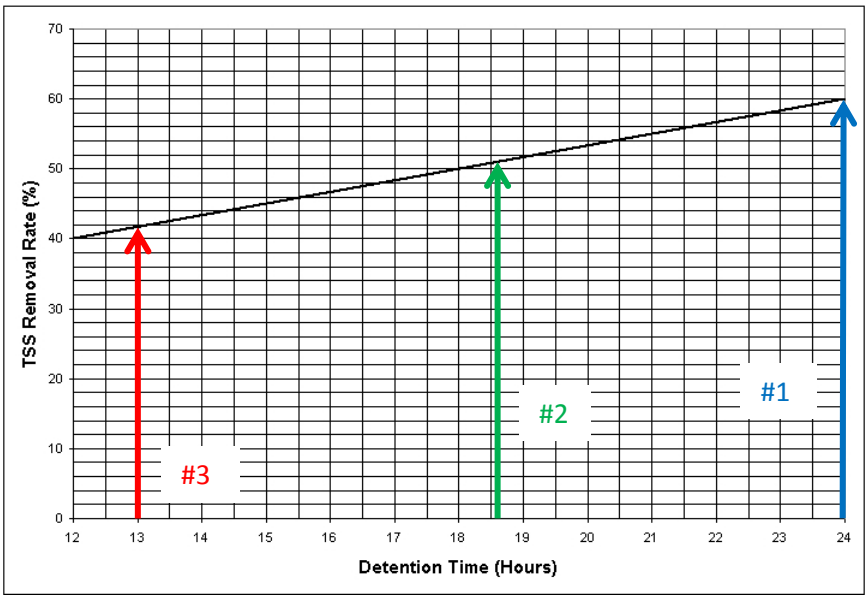
Step #2: For each design determine the time at which the outflow volume is reduced to 10%. For this example, they are as shown in the following table.

Design Number	Time to Peak Elevation (hr)	Peak Storage Volume for WQ Design Storm (cf)	10% Peak Storage Volume (cf)	Time to 10% WQ Volume (hr)	Detention Time Used {12<=Td<=24} (hr)	% TSS Removal
1	3.5	1536.0	153.6	>27.5		
2	2.4	584.5	58.5	21		
3	1	182.0	18.2	14		

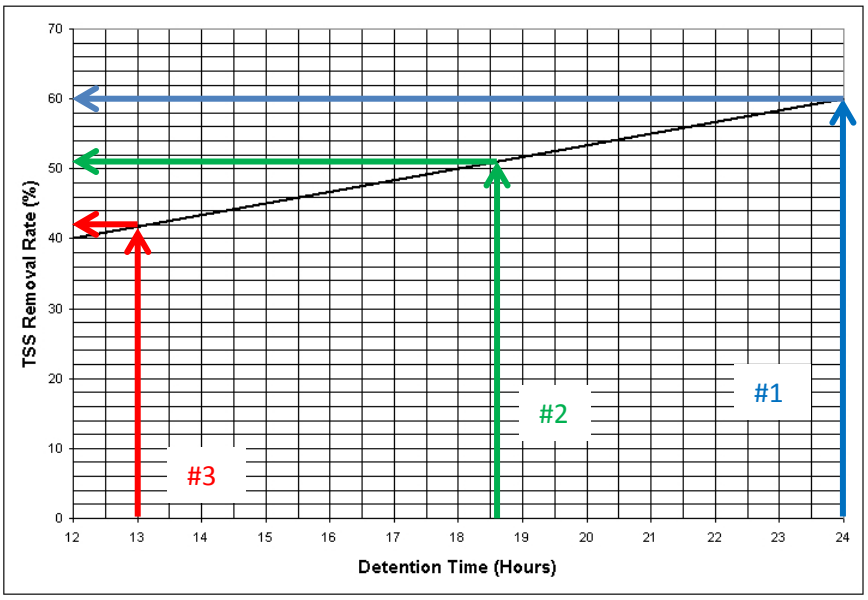
Step #3: For each design, the detention time is calculated by subtracting the value in the *time to Peak Elevation (hr)* column from the value in the *Time to 10% WQ Volume (hr)* column. A detention time less than 12 hours will result in a 0% TSS removal rating, and the maximum of 60% TSS rating is applied to all detention times of 24 or more hours.

Design Number	Time to Peak Elevation (hr)	Peak Storage Volume for WQ Design Storm (cf)	10% Peak Storage Volume (cf)	Time to 10% WQ Volume (hr)	Detention Time Used {12<=Td<=24} (hr)	% TSS Removal
1	3.5	1536.0	153.6	>27.5	24	
2	2.4	584.5	58.5	21	18.6	
3	1	182.0	18.2	14	13	

Step #4: For each design, find the respective detention time along the horizontal axis of the chart found on page 5 and draw a vertical line up to the curve on the chart.



Step #5: For each design, next draw a horizontal line from the point on the curve identified in Step #4 to the vertical axis to obtain the corresponding TSS Removal Rate.



The resulting percent TSS Removal Rates appear in the last column of this table.

Design Number	Time to Peak Elevation (hr)	Peak Storage Volume for WQ Design Storm (cf)	10% Peak Storage Volume (cf)	Time to 10% WQ Volume (hr)	Detention Time Used {12<=Td<=24} (hr)	% TSS Removal
1	3.5	1536.0	153.6	>27.5	24	60%
2	2.4	584.5	58.5	21	18.6	51%
3	1	182.0	18.2	14	13	42%

TSS Removal Rates for BMPs in Series

The adopted TSS removal rates for extended detention basins is less than the 80% TSS removal rate typically required in the Stormwater Management rules at N.J.A.C. 7:8. Therefore, it may be necessary to use a series of BMPs to achieve the required TSS removal.

A simplified equation to calculate the total TSS removal rate for two BMPs in series can be found at N.J.A.C. 7:8-5.5(c). This equation may not be used for two of the same BMPs in series to increase the adopted TSS removal rate of that BMP. For more information on BMP in series, see *Chapter 4: Stormwater Pollutant Removal Criteria* and the *Pretreatment* Section below.

Considerations

A number of factors should be considered when utilizing an extended detention basin to treat stormwater runoff.

Pretreatment

For subsurface extended detention basins, pretreatment is a design requirement. For surface extended detention basin systems, as with all other best management practices, pretreatment can extend the functional life and increase the pollutant removal capability by reducing incoming velocities and capturing coarser sediments.

- Pretreatment may consist of a forebay or any of the structural BMPs found in *Chapter 9: Structural Stormwater Management Measures*.
- There is no adopted TSS removal rate associated with forebays; therefore, their inclusion in any design should be solely for the purpose of facilitating maintenance. Forebays can be earthen, constructed of riprap, or made of concrete, and must comply with the following requirements:
    - The forebay must be designed to prevent scour of the receiving basin by outflow from the forebay.
    - The forebay should provide a minimum storage volume of 10% of the Water Quality Design Storm and be sized to hold the sediment volume expected between clean-outs.
    - It should fully drain within nine hours in order to facilitate maintenance and to prevent mosquito issues. Under no circumstances should there be any standing water in the forebay 72 hours after a precipitation event.
    - Surface forebays must meet or exceed the sizing for preformed scour holes in the *Standard for Conduit Outlet Protection* in the *Standards for Soil Erosion and Sediment Control in New Jersey* for a surface forebay.
- If a concrete forebay is utilized, it must have at least two weep holes to facilitate low level drainage.
- When using a structural BMP for pretreatment, it must be designed in accordance with the design requirements outlined in the respective chapter. For additional information on the design requirements of each structural BMP, refer to the appropriate chapter in this manual.

Groundwater

A typical extended detention basin will range from 3 to 12 feet in depth; however, depth is often limited by groundwater conditions or the need for positive drainage from excavated basins. The basin may not intercept the groundwater because it may result in a loss of runoff storage volume, the creation of an environment suitable for mosquito breeding, and/or difficulty maintaining the basin bottom. Therefore, it is important to accurately determine the depth to the seasonal high water table (SHWT). Refer to *Chapter 6: Groundwater Recharge* for more information on establishing the SHWT.

Geology

Soil permeability is an important consideration when designing a combination extended detention-infiltration basin. If soils have low infiltration rates, the system may exhibit problems with standing water; conversely, if soils have high infiltration rates, runoff could migrate into the existing groundwater table. When designing a combination system, the design criteria for infiltration basins must also be met in addition to the design criteria specified in this chapter. For more information on infiltration basins, see *Chapter 9.5: Standard for Infiltration Basins.*

The underlying geology of an area is another factor that can affect the design of an extended detention basin. The existence of bedrock close to the surface of the soil can make the excavation necessary for sufficient storage volume costly and difficult. Also, the type of bedrock present on-site is another important consideration, specifically, in areas of the State with Karst topography. Any infiltration of runoff into this highly soluble bedrock can lead to subsidence and sink holes; therefore, in areas with this type of bedrock, where on-site soils are not sufficiently impermeable to prevent infiltration of runoff, extended detention basins should be lined with impermeable material.

Flow Paths

An extended detention basin relies on the process of sedimentation for removal of runoff pollutants. Therefore, the basin should be designed to maximize the degree of sedimentation. Flow path lengths should be maximized, and long, narrow basin configurations with length to width ratios from 2:1 to 3:1 should be utilized. However, when designing a basin to maximize flow path length, inflow velocities should be considered to ensure the stability of the flow path. Basins that are shallow and have larger surface area to depth ratios will provide better pollutant removal efficiencies than smaller, deeper basins.

Additional Pollutant Removal

The lower stages of an extended detention basin can be designed to create a wetland area or provide a permanent pool to provide additional pollutant removal. If this option is selected, the design must comply with all of the requirements specified in chapter 9.2 *Standard Constructed Wetlands* or 9.11 *Wet Ponds.*

Water Depth

To enhance safety by minimizing standing water depths, the vertical distance between the basin bottom and the elevation of the first stormwater quantity control outlet (normally set equal to the maximum stormwater quality design storm water surface) should be no greater than 3 feet wherever practical.

Sediment Accumulation

A properly designed extended detention basin will accumulate considerable amounts of sediment over time, leading to the loss of the detention volume, which leads to a loss in both runoff quality and quantity control effectiveness. Therefore, depending on the clean-out intervals, an increase in an extended detention basin's maximum design storm storage volume should be considered to compensate for this expected loss of storage volume. See the above section referring to the design criteria for Subsurface Extended Detention Basins for more information on required volume increases in subsurface basins. Additionally, when designing an extended detention basin, consideration should be given to the frequency of sediment inspection and removal.

Maintenance

Regular and effective maintenance is crucial to ensure effective extended detention performance; in addition, maintenance plans are required for all stormwater management facilities associated with a major development. There are a number of required elements in all maintenance plans, pursuant to N.J.A.C. 7:8-5.8; these are discussed in more detail in *Chapter 8: Maintenance of Stormwater Management Measures*. Furthermore, maintenance activities are required through various regulations, including the New Jersey Pollutant Discharge Elimination System (NJPDES) Rules, N.J.A.C. 7:14A. Specific maintenance requirements for extended detention basins are presented below; these requirements must be included in the extended detention basin's maintenance plan.

General Maintenance

- All structural components must be inspected, at least once annually, for cracking, subsidence, spalling, erosion and deterioration.
- Components expected to receive and/or trap debris must be inspected for clogging at least twice annually.
- Sediment removal should take place when the basin is thoroughly dry.
- Disposal of debris, trash, sediment and other waste material must be done at suitable disposal/recycling sites and in compliance with all applicable local, state and federal waste regulations.

Vegetated Areas

- Bi-weekly inspections are required when establishing/restoring vegetation.
- A minimum of one inspection during the growing season and one inspection during the non-growing season is required to ensure the health, density and diversity of the vegetation.
- Vegetative cover must be maintained at 85%; damage in excess of 50% must be addressed through replanting in accordance with the original specifications.
- Vegetated areas must be inspected at least once annually for erosion, scour and unwanted growth; any unwanted growth should be removed with minimum disruption to the remaining vegetation.
- All use of fertilizers, pesticides, mechanical treatments and other means to ensure optimum vegetation health must not compromise the intended purpose of the extended detention basin.

Drain Time

- The approximate time it would normally take for the extended detention basin to drain the maximum design storm runoff volume and begin to dry must be indicated in the maintenance manual.
- If the actual drain time is significantly different than the design drain time, the basin's outlet structure, underdrain system and both groundwater and tailwater levels must be evaluated and appropriate measures taken to return the basin to minimum and maximum drain time requirements.

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