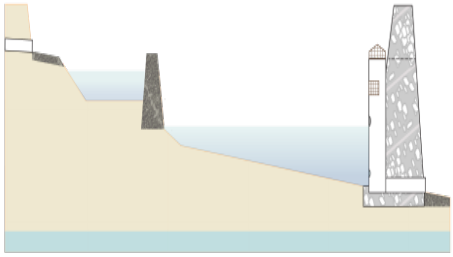
11.2 EXTENDED DETENTION BASINS (NON-GI)



An extended detention basin is a stormwater management system 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. However, extended detention basins can only be used to address the stormwater runoff quantity control aspects of development and stormwater runoff water quality when a waiver or variance from N.J.A.C. 7:8-5.3 is granted as they are not considered to be green infrastructure.

N.J.A.C. 7:8 Stormwater Management Rules – Applicable Design and Performance Standards		
	Green Infrastructure	Not Allowed
	Stormwater Runoff Quantity	Only with a waiver or variance from N.J.A.C. 7:8-5.3
GR	Groundwater Recharge	Not Allowed
%	Stormwater Runoff Quality	Only with a waiver or variance from N.J.A.C. 7:8-5.3, 40 - 60% TSS Removal, depending on duration of detention

Stormwater Runoff 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 have been traditionally 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 (WQDS) promoting pollutant removal through settling. The higher stages of the basin attenuate the peak rates of runoff from larger storm events.

Extended detention basins have been 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 limits their continued use for stormwater quality.

Only with a waiver or variance from N.J.A.C. 7:8-5.3 may an extended detention basin, designed in accordance with this chapter, be used to satisfy the standards for stormwater runoff quantity and/or quality, since this BMP does not meet the definition of green infrastructure.

Extended detention basins must have a maintenance plan andmust be reflected in a deed notice recorded in the county clerk's office to prevent alteration or removal.

Applications

Only if a waiver or variance form the green infrastructure requirements of N.J.A.C. 7:8-5.3 is obtained may extended detention basins that are designed to convey storm events larger than the Water Quality Design Storm be used to meet the stormwater runoff quantity requirements. Additionally, 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 and provided the aforementioned waiver or variance is approved.

Only if a waiver or variance from the green infrastructure requirements of N.J.A.C. 7:8-5.3 is obtained may extended detention basins be awarded a TSS removal rate of 40-60%. To merit the approved TSS removal rate of 40-60%, extended detention basins must also treat the Water Quality Design Storm (WQDS) and be designed in accordance with all of the design criteria below.

Design Criteria

Basic Requirements

There are two categories of extended detention basins; all of the following design criteria apply to all categories and must be incorporated into the design in order to merit 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 6.

Elevation Above Seasonal High Water Table

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 must not intercept the groundwater because doing so 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 12: Soil Testing Criteria* for more information on establishing the SHWT.

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

Storage Volume

- Extended detention basins may be constructed as either off-line or on-line systems. In off-line systems, most, or all, of the runoff from storms larger than the Water Quality Design Storm (WQDS) bypass the basin through an upgradient diversion; this reduces the size of the required basin storage volume, the system's long-term pollutant loading and associated maintenance. On-line systems receive runoff from all storms events; they provide treatment for the WQDS, and they convey the runoff from larger storms through an overflow. These on-line systems store and attenuate the larger storm events and provide stormwater runoff quantity control; in such systems, the invert of the lowest quantity control outlet is set at the water surface elevation of the WQDS.
- The system must have sufficient storage volume to contain the WQDS runoff volume without overflow.
- To enhance safety by minimizing standing water depths, the vertical distance between the basin bottom and the WQDS elevation should be no greater than 3 feet wherever practical.
- Take note that this type of system cannot be used to infiltrate stormwater runoff into the subsoil or provide groundwater recharge. Routing calculations may not include exfiltration as a form of discharge.

Detention Time

- The minimum detention time that must be provided is 12 hours. Detention time begins when the maximum storage volume is achieved and ends when only 10% of the maximum volume remains, and is discussed further, beginning on Page 9.
- 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.

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 stormwater quality and mosquito breeding issues.

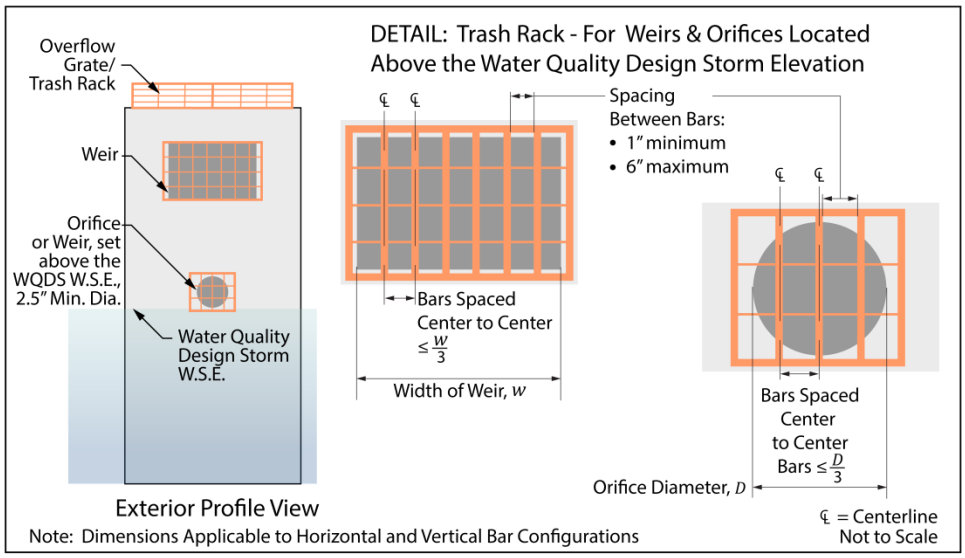
- **Under no circumstances may a drain-down valve or other dewatering measure be included in the design of the extended detention basin, even if it was intended to remain closed or unused during normal operation.**

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. 7:8-5.2(i)5; 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 all of the following criteria, as required by N.J.A.C. 7:8-5.2(i)2 and 6.2(a):

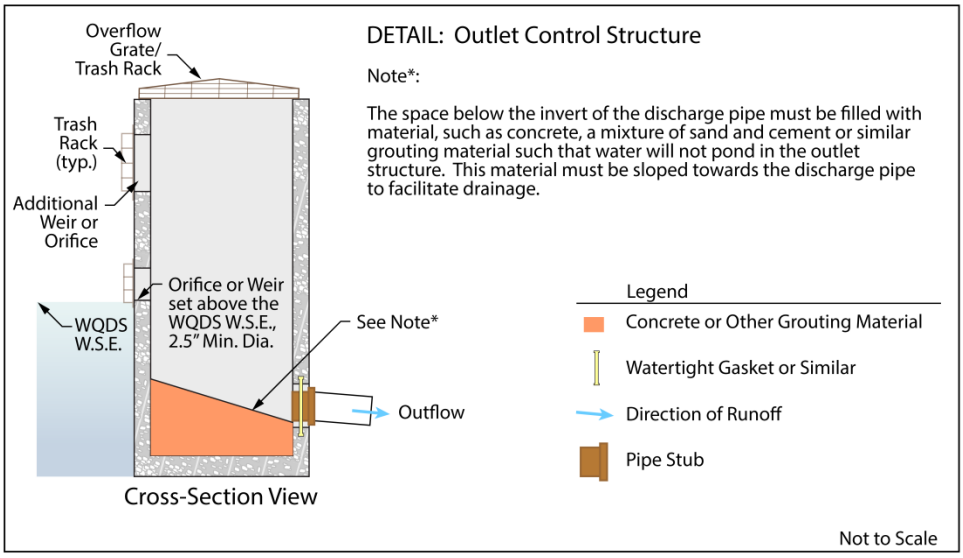
  - □ Parallel bars with 1-inch spacing between the bars up to the elevation of the WQDS;
  - □ Parallel bars higher than the elevation of the WQDS must be spaced no greater than one-third the width of the diameter of the orifice or one-third the width of the weir, with minimum spacing between bars of 1 inch and a maximum spacing between the bars of six inches;
  - □ The trash rack must be designed so as not to adversely affect the hydraulic performance of the outlet pipe or structure;
  - □ Constructed of rigid, durable and corrosion-resistant material; and
  - □ Designed to withstand a perpendicular live loading of 300 lbs/sf.



- An overflow grate is designed to prevent obstruction of the overflow structure. If an outlet structure has an overflow grate, the grate must comply with the following requirements:

- The overflow grate must be secured to the outlet structure but removable for emergencies and maintenance;
- The overflow grate spacing must be no greater than 2 inches across the smallest dimension; and
- The overflow grate must be constructed of rigid, durable, and corrosion resistant material and designed to withstand a perpendicular live loading of 300 lbs./sf.

- The space below the invert of the discharge pipe must be filled with material, such as concrete, a mixture of sand and cement, or similar grouting material, such that water will not pond in the outlet structure. This material must be sloped towards the discharge pipe to facilitate drainage, as shown in the detail below.



- The minimum diameter of any overflow orifice is 2.5 inches.

- Blind connections to down-gradient facilities are prohibited. Any connection to down-gradient stormwater management facilities must include access points such as inspections ports and manholes, for visual inspection and maintenance, as appropriate, to prevent blockage of flow and ensure operation as intended. All entrance points must adhere to all State, County and municipal safety standards such as those for confined space entry.

- In instances where the lowest invert in the outlet or overflow structure is below the flood hazard area design flood or tide elevation in a down-gradient waterway or stormwater collection system, the effects of tailwater on the hydraulic design of the underdrain and overflow systems, as well as any stormwater quantity control outlets must be analyzed. Two methods to analyze tailwater are:

  - A simple method entails inputting flood elevations for the 2-, 10-, and 100-year events as static tailwater during routing calculations for each storm event. These flood elevations are either obtained from a Department flood hazard area delineation or a FEMA flood hazard area delineation that includes the 100-year flood elevation or derived using a combination of NRCS

hydrologic methodology and a standard step backwater analysis or level pool routing, where applicable. In areas where the 2-year or 10-year flood elevation does not exist in a FEMA or Department delineation, it may be interpolated or extrapolated from the existing data. If this method demonstrates that the requirements of the regulations are met with the tailwater effect, then the design is acceptable. If the analysis shows that the requirements are not met with the tailwater effects, the detailed method below can be used or the BMP must be redesigned.

- □ A detailed method entails the calculation of hydrographs for the watercourse during the 2, 10, and 100-year events using NRCS hydrologic methodology. These hydrographs are input into a computer program to calculate rating curves for each event. Those rating curves are then input as a dynamic tailwater during the routing calculations for each of the 2, 10, and 100-year events. This method may be used in all circumstances; however, it may require more advanced computer programs. If this method demonstrates that the requirements of the regulations are met with the tailwater effect, then the design is acceptable. If the analysis shows that the requirements are not met with the tailwater effects, the BMP must be redesigned.

Safety

- All extended detention basins must be designed to safely convey system overflows to down-gradient drainage systems. The design of the overflow structure must be sufficient to provide safe, stable discharge of stormwater runoff 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.

- 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*.

Types of Extended Detention Basins

There are two types of extended detention basins:

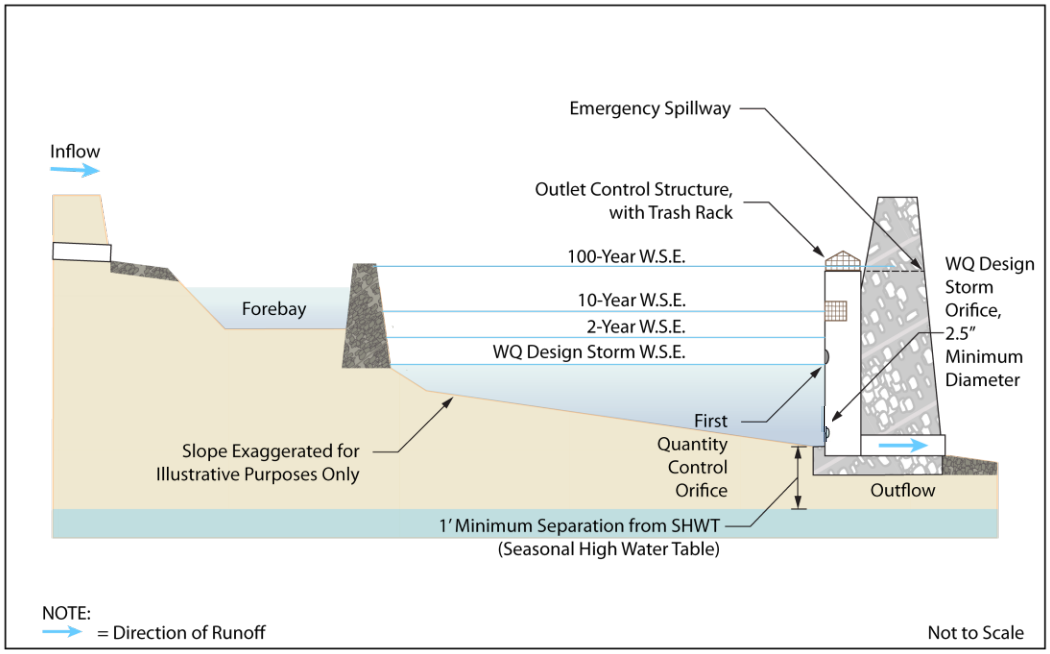
1. Surface Extended Detention Basins
2. Subsurface Extended Detention Basins

The following sections provide 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.

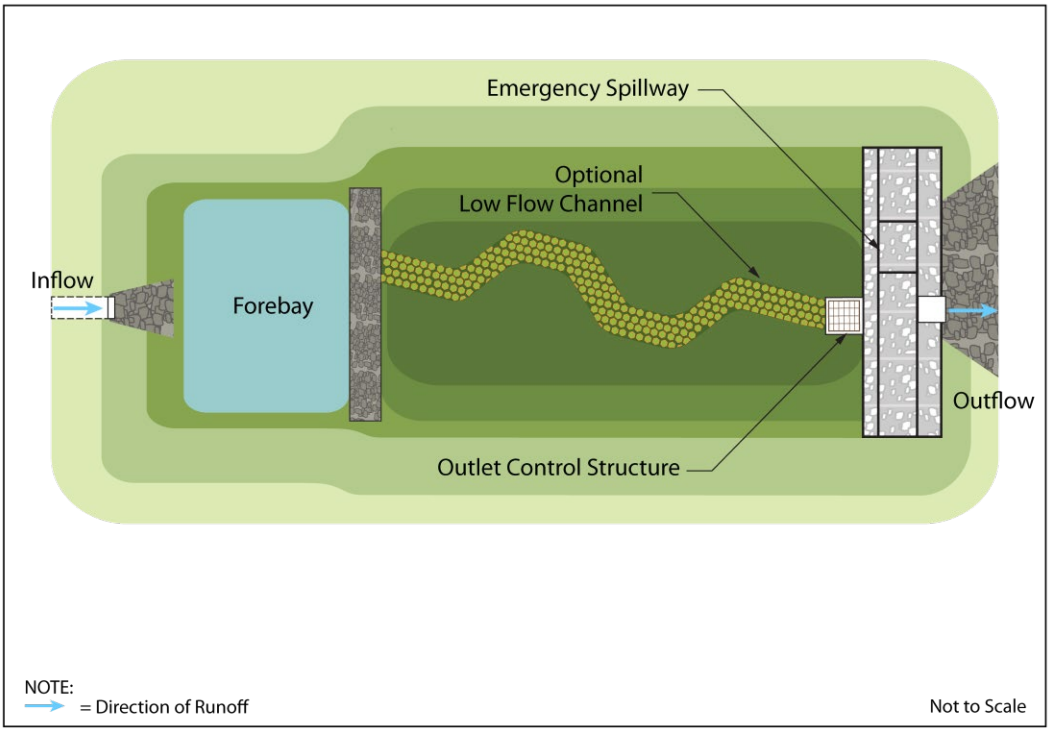
Surface Extended Detention Basins

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



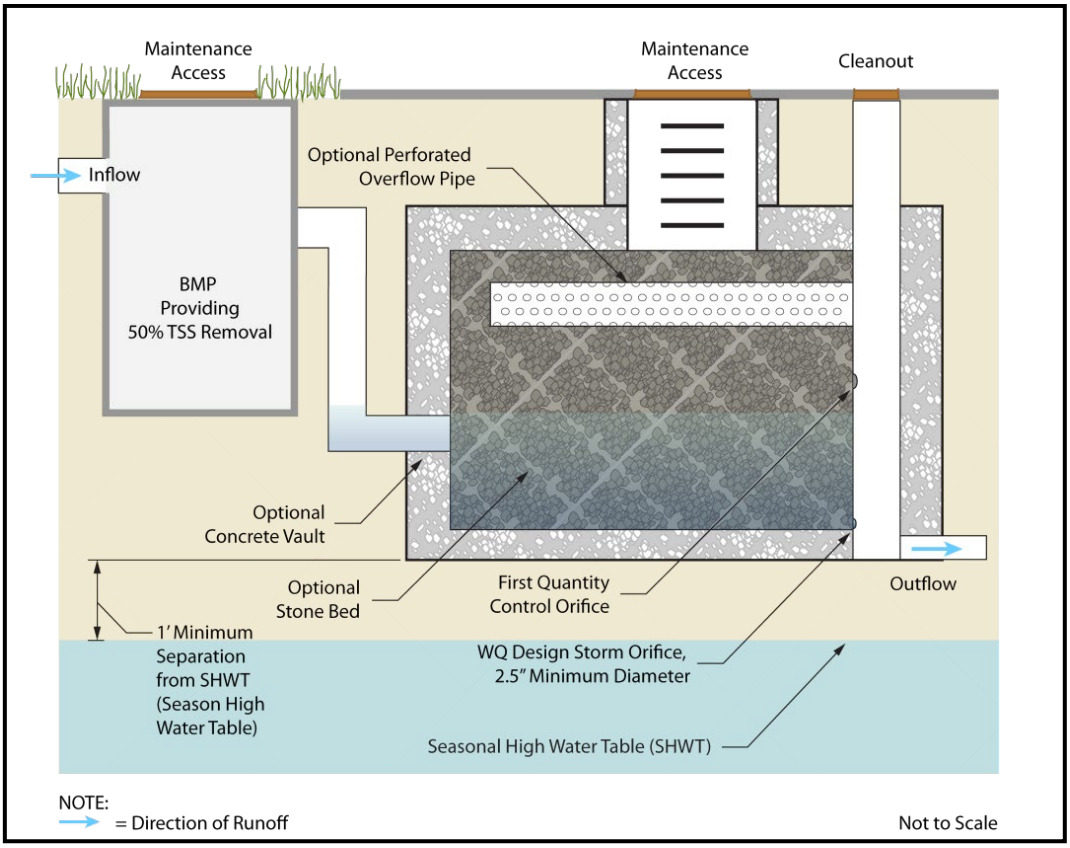
Surface Extended Detention Basin – Plan View



Subsurface Extended Detention Basins

A subsurface detention basin is located entirely below the ground surface. Runoff may be stored in one or more vaults or pipes. A system may include a gravel or stone bed for additional storage within the void spaces of the stone bed; however, it is difficult to remove accumulated sediment from these systems. Therefore, all runoff entering a system that includes a stone bed to provide additional storage must be pretreated to remove at least 50% of the TSS from the runoff volume of the system's maximum design storm. Additionally, the gravel or stone used must be clean and washed prior to installation. For additional information, see the discussion of pretreatment found on Page 12. The illustration below shows an example of a stone-filled vault type of subsurface extended detention basin.

Subsurface Extended Detention Basin – Profile View



Any roof runoff may be pretreated by leaf screens, first flush diverters or roof washers. For details of these pretreatment measures, see Pages 5 and 6 of *Chapter 9.1: Cisterns.*

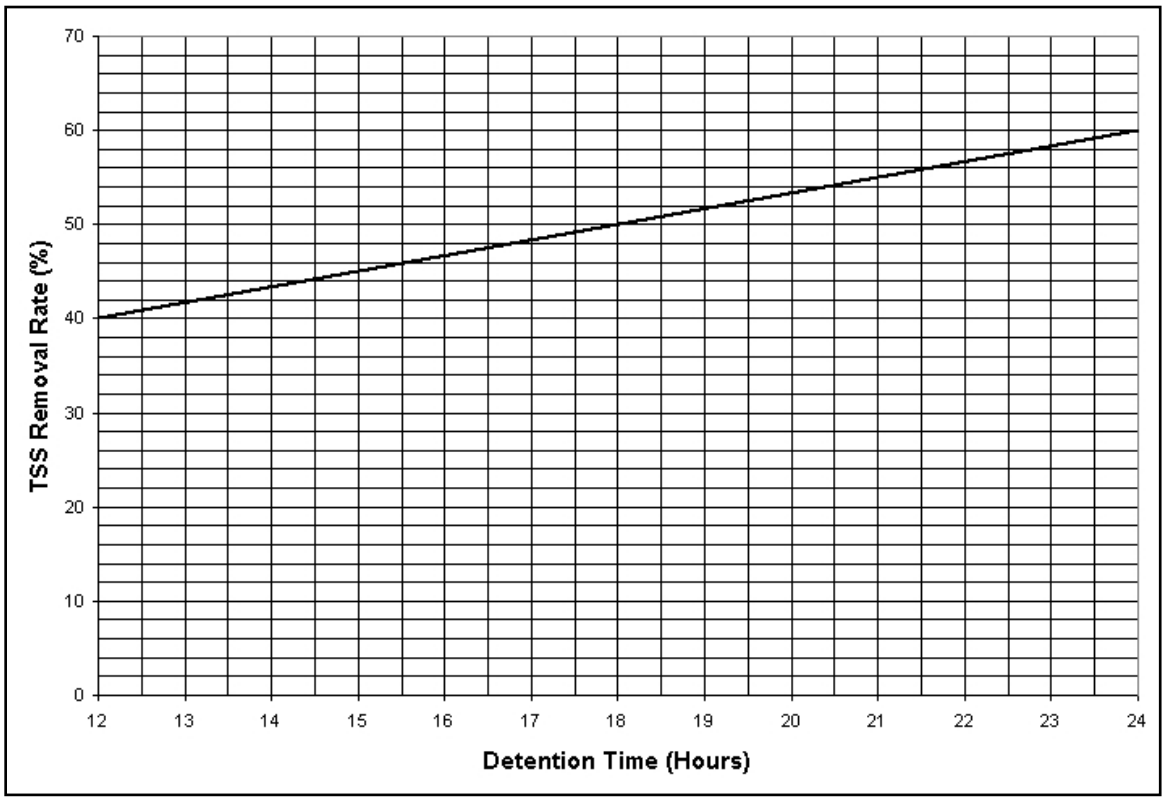
- This pretreatment requirement for roof runoff can be waived by the review agency if the building in question has no potential for debris and other vegetative material to be present in the roof runoff. For example, a building that is significantly taller than any surrounding trees and does not have vegetative roof should not need the pretreatment. However, in making this determination, the review agency must consider the mature height of any surrounding trees.

TSS Removal Rates for Extended Detention Basins

Extended detention basins are designed to provide treatment of runoff volume generated by the Water Quality Design Storm (WQDS). Techniques to compute this volume are discussed in *Chapter 5: Stormwater Management Quantity and Quality Standards and Computations.*

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. **Extrapolation beyond the minimum and maximum detention times of 12 and 24 hours, respectively, is not allowed.**

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:

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

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

The example located on the following page 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 of the designs, multiply the peak storage volume by 0.10 (10%). The result is located in the column below the red arrow symbol.

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			

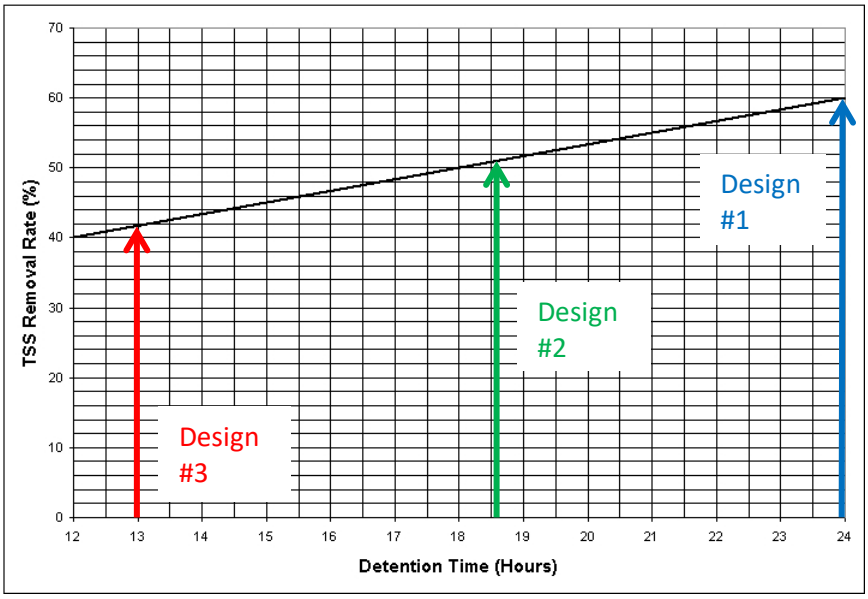
Step 2: For each of the designs, determine the time at which the outflow volume is reduced to 10%. For this example, they are as shown in the following table below the red arrow.

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		

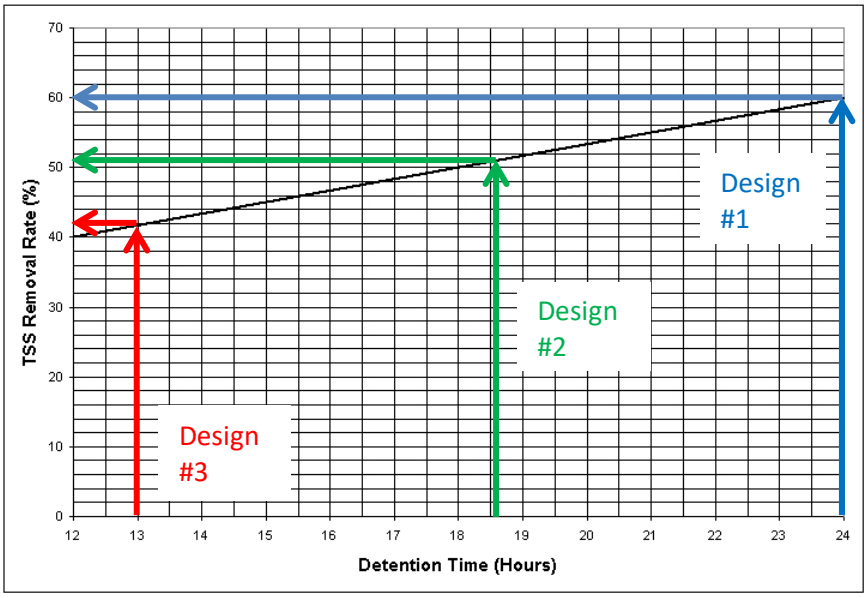
Step 3: For each of the designs, the detention time is calculated by subtracting the value in the *Time to Peak Elevation (hr)* column from the value in the *Time to 10% WQ Volume (hr)* column. A detention time less than 12 hours will result in a 0% TSS removal rating; the maximum allowable TSS rating of 60% 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 of the designs, 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 the table provided on the next page.

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%

Considerations

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

Pretreatment

For subsurface extended detention basins that use a stone bed for storage of stormwater runoff, 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: Green Infrastructure BMPs*.
- 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 constructed of earthen materials, riprap or concrete and, in each case, 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 volume generated by the WQDS and be sized to hold the sediment volume expected between clean-outs.
  - The forebay 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.

Geology

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, meaning 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.

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 and Retrofit 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, as well as after every storm exceeding 1 inch of rainfall.
- If accumulated sediment is detected during an inspection, it must be removed; otherewise, it can lead to loss of detention volume. 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.

- Access points for maintenance are required on all extended detention basins; these access points should be clearly identified in the maintenance plan. In addition, any special training required for maintenance personnel to perform specific tasks should be included in the plan.

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.
- If the extended detention basin fails to fully drain within 72 hours, corrective action must be taken and the maintenance manual revised accordingly to prevent similar failures in the future.

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