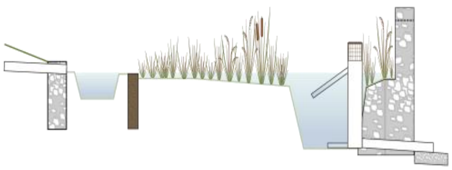
9.2 STANDARD CONSTRUCTED WETLANDS



Standard constructed wetlands are stormwater management systems designed to maximize the removal of pollutants from stormwater runoff. Flow is directed through an engineered, open marsh system where pollutants are removed through settling and vegetative uptake/filtration. The total suspended solids (TSS) removal rate is 90%.

N.J.A.C. 7:8 Stormwater Management Rules - Design and Performance Standards		
	Nonstructural Strategy	Assist with Strategy #7; See Page 2
	Water Quantity	When designed to receive runoff from all storm events (on-line)
GR	Groundwater Recharge	Not Allowed
%	Water Quality	90% TSS

Water Quality Mechanisms and Corresponding Criteria	
Settling	
Minimum Length to Width Ratio	1:1
Sinuous Flow Pathway	Recommended
Presence of a Permanent Pool	Required
Vegetative Uptake and Filtration	
Minimum Density of Vegetation	85%
Appropriate Species Selection	See *Chapter 7: Landscaping*
Minimum Inflow Drainage Area	Pond Category: 25 acres Marsh Category: 25 acres Extended Detention: 10 acres

Introduction

Standard constructed wetlands are engineered wetland systems used to remove a wide range of pollutants from land development sites; stormwater runoff is directed through the open, marsh system where pollutants are removed through settling and both uptake and filtration by the vegetation. Standard constructed wetlands can also be used to reduce peak runoff rates when designed as an on-line system. On-line systems receive upstream runoff from all storm events; they provide treatment for the Water Quality Design Storm and convey the runoff from larger storms through an outlet or overflow. In off-line systems, most or all of the runoff from storms larger than the Water Quality Design Storm bypass the constructed wetland system through an upstream diversion.

In addition to pollutant removal and volume control, standard constructed wetlands can also be used to provide wildlife habitat and to enhance the aesthetics of a site; however, these systems are designed primarily for stormwater treatment, so they should not be, and in most cases may not be, constructed within natural wetlands because they will not have the same full range of ecological functions. For more information on wetland regulations, refer to N.J.A.C. 7:7A Freshwater Wetlands Protection Act Rules.

There are three categories of standard constructed wetlands: **pond constructed wetlands, marsh constructed wetlands and extended detention constructed wetlands**; the category into which a standard constructed wetland system falls depends on the allocation of the Water Quality Design Storm volume in its different components. Standard constructed wetlands consist of a **pre-treatment zone**, and a combination of two or more of the following components: **pool zone, marsh zone and semi-wet zone**. The category of standard constructed wetlands selected will be driven largely by site conditions; for more information, refer to page 14, *How Site Characteristics Shape the Design* section under the *Considerations* section later in this chapter.

Standard constructed wetlands must have a maintenance plan and should be protected by easement, deed restriction, ordinance or other legal measures that prevent its neglect, adverse alteration or removal.

Applications

The nonstructural stormwater management strategies design standard in the Stormwater Management rules must be addressed for all major developments, pursuant to N.J.A.C. 7:8 -5.3(a). The site evaluation for nonstructural strategies should consider all nine strategies. The design of a standard constructed wetland system can assist in maximizing the following strategy:

- Strategy #7: The provision of low maintenance landscaping, which encourages retention, the planting of native vegetation, and minimizes the use of lawns, fertilizers and pesticides.

Standard constructed wetlands may be designed to reduce peak runoff rates when designed as an on-line system. Regardless of the design storm chosen, standard constructed wetlands must be designed for stability and capacity in accordance with the *Standards for Soil Erosion and Sediment Control in New Jersey,* as required by N.J.A.C. 7:8 Stormwater Management rules.

To receive credit for a TSS removal rate of 90%, standard constructed wetlands must be designed to treat the runoff generated by the Water Quality Design Storm and in accordance with all of the criteria below.

Design Criteria

Basic Requirements

There are three categories of standard constructed wetlands; the following design criteria apply to all categories and must be met in order to receive the 90% TSS removal rate for this BMP. It is critical that all standard constructed wetlands 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 7.

Minimum Inflow Drainage Area

- In order to sustain the vegetation and support the flow velocity, each of the three categories of standard constructed wetlands has a minimum drainage area requirement. Smaller drainage areas may be permissible if detailed analysis indicates that sufficient base or groundwater flow is available; a water budget must be included in this analysis. For more information on how to complete a water budget see the Water Budget Manual at: http://www.nj.gov/dep/landuse/download/mit_011.pdf.

Pretreatment

- Pretreatment is required in any type of standard constructed wetland system. Pretreatment reduces the velocity of incoming flows and captures coarser sediments and debris.

- 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.

Soils and Vegetation

- The character, diversity and hardiness of the wetland vegetation must be sufficient to provide adequate pollutant removal; see *Chapter 7: Landscaping* for specific information on vegetation for standard constructed wetlands.

- The soils must be sufficiently impermeable to maintain the hydrology of the system and to support the vegetation; otherwise, soil modifications or an impermeable liner may be necessary.

Hydraulics

- The flow velocity through the various components must be non-erosive but sufficient to carry runoff through to the final component, the pool zone, where particulate settling occurs.

Safety

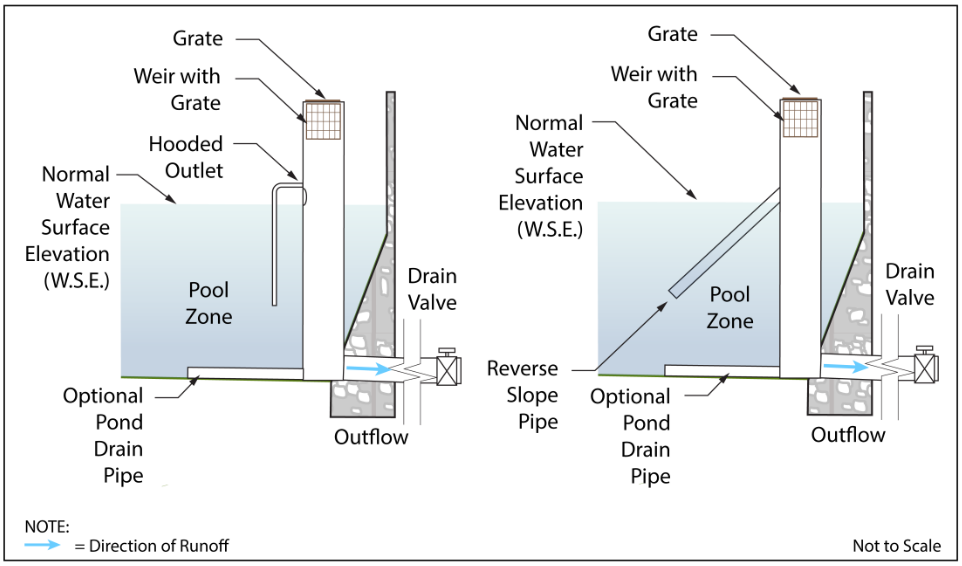
- Safety ledges must be constructed on all sides of the pool zone, as required by N.J.A.C. 7:8 Stormwater Management rules. Two ledges must be constructed, each 4 to 6 feet in width; the upper ledge must be located between 1 to 1.5 feet above the normal water surface elevation. The lower ledge must be located approximately 2.5 feet below the normal water surface elevation.

Outlet Structure

- The minimum diameter of any outlet orifice in a standard constructed wetland system 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.

- During the summer months, the pool zone can act as a heat sink between storm events, and runoff discharged from this zone may be as much as 10°F warmer than the naturally occurring baseflow in the downstream waterway, which can adversely impact these waterbodies. Thermal impacts can be mitigated through the use of either a hooded outlet or a reverse-slope pipe attached to the outlet riser, for which examples are shown below. These types of outlets discharge cooler bottom waters. If using a hooded outlet, the invert or crest elevation of the hooded outlet should be at least 1 foot below the normal water surface elevation.

Hooded and Reverse-Slope Outlet Structures



- The invert of the lowest stormwater quantity control outlet must be set at or above the normal water surface elevation in on-line systems.

- 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 of 1 inch, for elevations in excess of the Water Quality Design Storm;
  - Maximum bar spacing of1/3 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 of 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.

- Standard constructed wetlands must have drains that allow draindown or backflush when necessary for the removal of accumulated sediment. These drains must be controlled by a lockable valve that is readily accessible from the outlet structure.

- The design of all hydraulic outlets must consider any significant tailwater effects of downstream waterways or facilities, including instances where the lowest invert of the outlet or overflow structure is below the flood hazard area design flood elevation of a receiving stream.

- All standard constructed wetlands must be able to convey overflows to downstream drainage systems in a safe and stable manner. 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.* Standard constructed wetlands classified as dams under the NJDEP Dam Safety Standards at N.J.A.C. 7:20 must also meet the overflow standards therein.

Standard Constructed Wetland Categories

There are three categories of standard constructed wetlands:

1. Pond constructed wetlands
2. Marsh constructed wetlands
3. Extended detention constructed wetlands

The categories of standard constructed wetlands can be differentiated primarily by the allocation of the Water Quality Design Storm volume in each of their components; these volume allocations are shown in the table below.

Design Component	Required Size, as a Percentage of the Water Quality Design Storm Volume, By Category		
	Pond Wetlands	**Marsh Wetlands**	**Extended Detention Wetlands**
Pretreatment Zone*	10	10	10
Semi-wet Zone	Not Applicable	Not Applicable	50
High Marsh Zone	10	25	10
Low Marsh Zone	20	45	20
Pool Zone	60	20	10

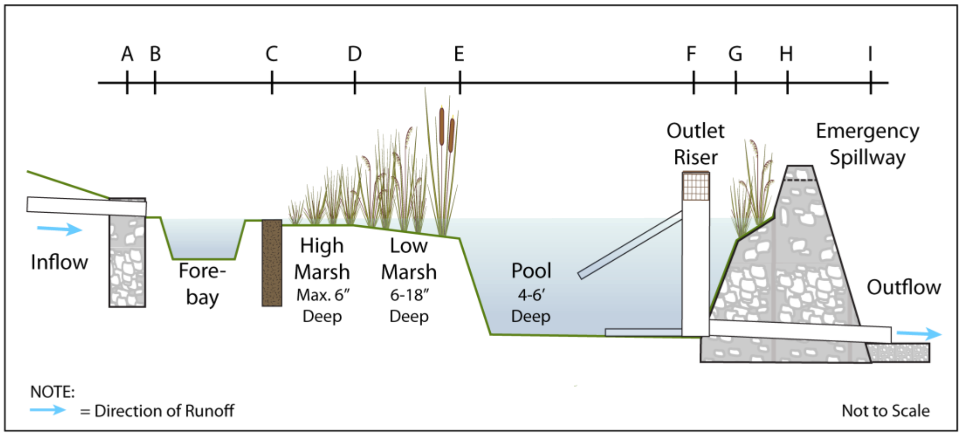
*The 10% Water Quality Design Storm volume allocation for this component is only applicable to those systems that utilize a forebay in the pretreatment zone; all other pretreatment options must be sized separately from the remainder of the system. For more information, see the examples below.

Individual Standard Constructed Wetland Categories

The following section provides detailed design criteria for each standard constructed wetland category; all of these utilize a forebay in the pretreatment zone. As previously mentioned, a vegetative filter strip or a Department-approved MTD may be used instead. For each category of standard constructed wetland, the allocation of the Water Quality Design Storm runoff volume is shown. The illustrations depict possible configurations and flow paths and are not intended to limit the design.

Category 1: Pond Constructed Wetlands

Pond Constructed Wetlands - Profile View



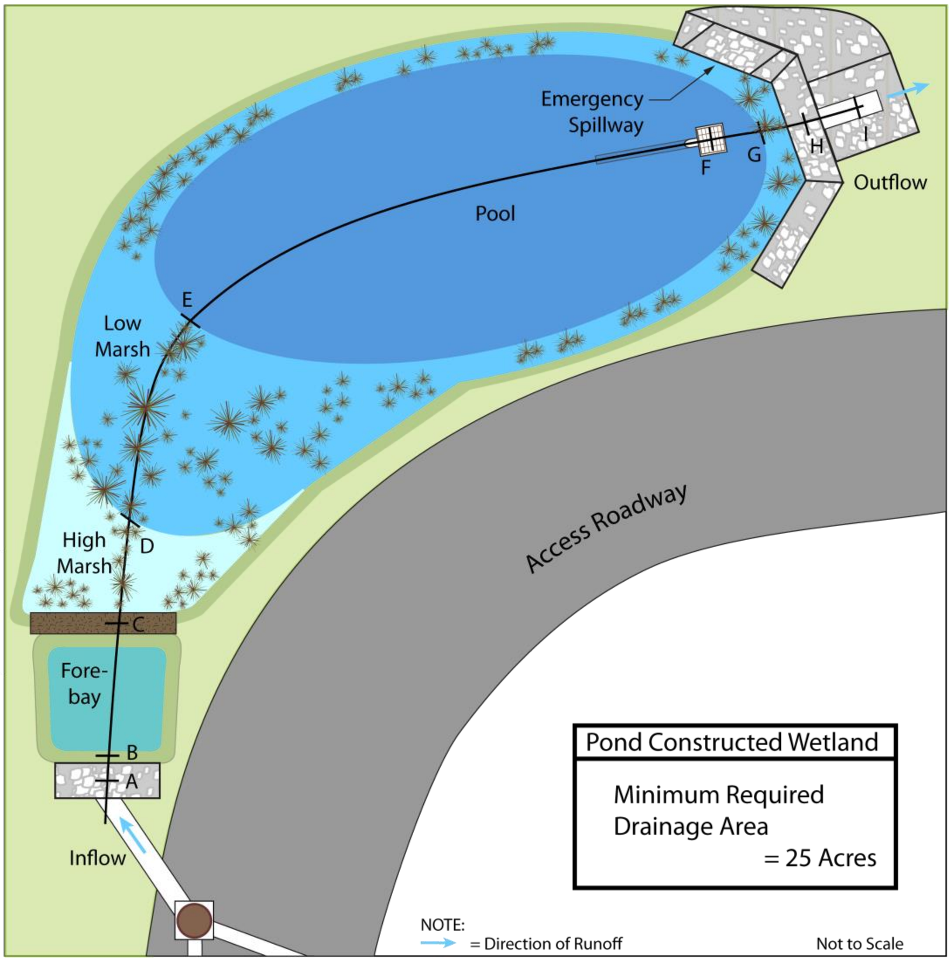
The illustration above shows the various components comprising a standard constructed wetland system from the pond category. Following the direction that runoff would take through the BMP; flow enters the system at A and then flows into the forebay spanning B to C. From the forebay, runoff flows over the spillway at C into the high marsh zone; it then enters the low marsh zone, which is depicted above from D to E. Runoff then exits the low marsh zone and flows into the pool zone, which extends from E to G, and ultimately out of the system through the outlet structure.

The standing water depths vary within each component, and as a result, the types of vegetation also vary within each component. The high marsh zone has shallow standing water depths and supports a large diversity of plant species; the deeper standing water depths in the low marsh zone support primarily emergent vegetation. The pool zone has the deepest standing water depths, and the plant community in this component is predominantly submerged and floating vegetation.

The majority of particulate settling occurs in the pool zone. When flow enters this component, there is a sharp decrease in velocity, which allows suspended sediment to settle out of the runoff. The decrease in velocity is affected by surface area of the pool zone. Therefore, to ensure proper settling, the pool zone must be designed with a minimum length to width ratio of 1:1. The pool zone comprises the largest portion of a pond constructed wetland system; it is generally located immediately upstream of the outlet in order to protect the outlet from clogging.

The illustration below shows the same pond constructed wetland system in plan view. This example depicts a low marsh zone around the perimeter of the pool zone; however, instead of this configuration, the high marsh zone may also extend around the edge.

Pond Constructed Wetlands - Plan View

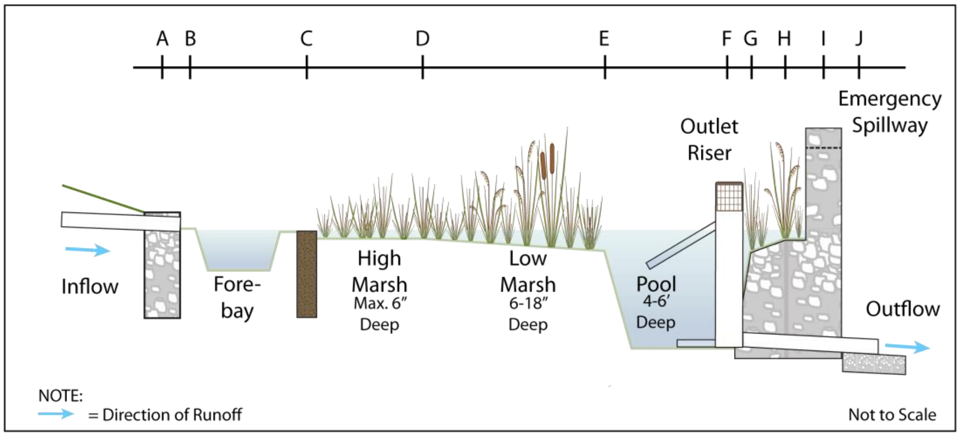


The table below shows the design criteria specific to pond constructed wetlands; for additional design criteria, refer to the *Basic Requirements* section of this chapter, beginning on page 3.

Pond Constructed Wetlands Design Criteria	
Minimum Drainage Area	25 Acres
Standing Water Depth: High Marsh Zone	Maximum 6 Inches
Standing Water Depth: Low Marsh Zone	6 – 18 Inches
Standing Water Depth: Pool Zone	4 – 6 Feet
Minimum Length to Width Ratio	1:1

Category 2: Marsh Constructed Wetlands

Marsh Constructed Wetlands - Profile View

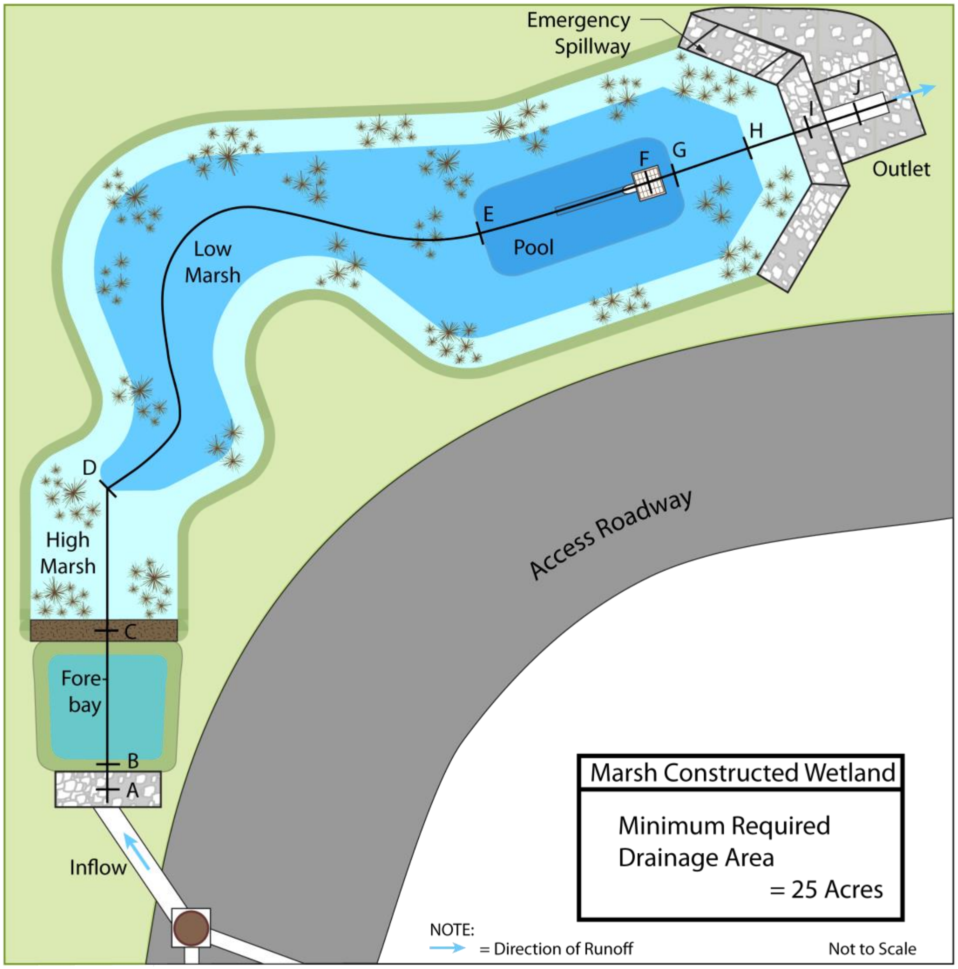


The illustration above shows the various components comprising a standard constructed wetland system from the marsh category. As with pond constructed wetlands, the minimum inflow drainage area is 25 acres. In this illustration, again, stormwater runoff enters the system at A and then flows into the forebay spanning B to C. From the forebay, runoff flows over the spillway at C into the high marsh zone; it then enters the low marsh zone, which in this illustration is found from D to E. Runoff then exits the low marsh zone and flows into the pool zone, which extends from E to F, and ultimately out of the system through the outlet structure.

While the constructed wetlands in these two categories have the same components, the surface area of these components differs. The pool zone in marsh constructed wetlands is smaller than the pool zone in pond constructed wetlands, and the marsh zone in marsh constructed wetland system is larger than the marsh zone in pond constructed wetlands. These differences are important because the majority of particulate settling occurs in the pool zone; to compensate for any loss of settling that results from the decreased pool component, sinuous pathways through the marsh zone should be constructed in marsh constructed wetlands. Longer flow paths increase detention time and contact area, allowing for increased settling of particulates in the marsh zone. Flow paths can be increased by including above-ground berms or high marsh wedges in the design; these structures should be placed at intervals of approximately 50 feet and at right angles to the direction of flow.

The following illustration depicts the same marsh constructed wetland system in plan view. This plan view illustrates the differences in size of both the pool zone and the marsh zone in this category in relation to these same components in the plan view of the pond constructed wetlands.

Marsh Constructed Wetlands - Plan View

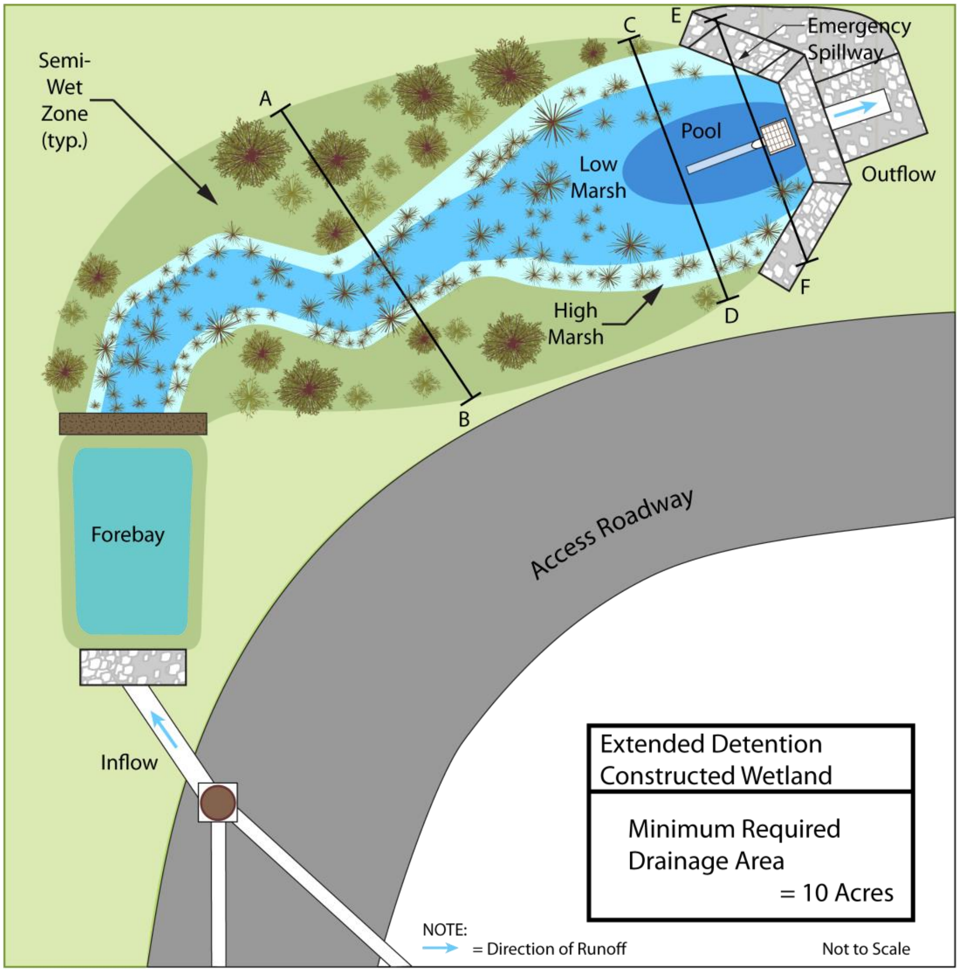


The table below shows the design criteria specific to marsh constructed wetlands; for additional design criteria, refer to the *Basic Requirements* section of this chapter, beginning on page 3.

Marsh Constructed Wetland Design Criteria	
Minimum Drainage Area	25 Acres
Standing Water Depth: High Marsh Zone	Maximum 6 inches
Standing Water Depth: Low Marsh Zone	6 – 18 inches
Standing Water Depth: Pool Zone	4 – 6 Feet
Minimum Length to Width Ratio	1:1

Category 3: Extended Detention Constructed Wetlands

Extended Detention Constructed Wetlands - Plan View



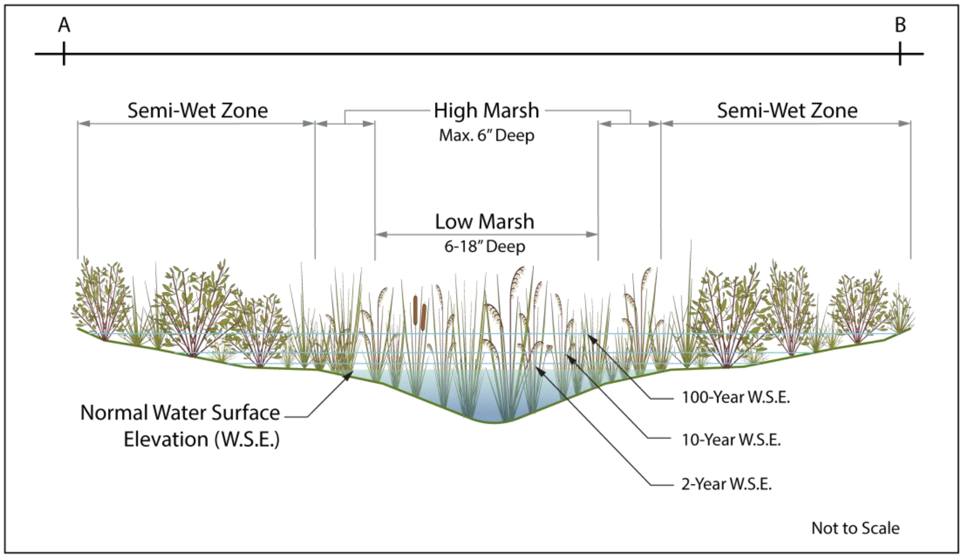
The illustration above shows the various components comprising a standard constructed wetland system from the extended detention category, for which a profile view taken along the centerline would look almost the same as a marsh constructed wetlands. Following the direction that stormwater runoff would take through the BMP; runoff enters the forebay and then flows over the spillway into the low and high marsh zones.

Unlike the previous two categories, extended detention standard constructed wetlands have an additional component, the semi-wet zone. Runoff from both the Water Quality Design Storm and storm events in excess of the Water Quality Design Storm are temporarily stored and attenuated in this component. The semi-wet zone is located above the system's normal water surface elevation; in this example, the semi-wet zone is depicted as the area outside of the high marsh zone, which extends to the perimeter of the system, represented by the darker green shading. The detention time of the Water Quality Design Storm volume stored in the semi-wet zone must be at least 24 hours; which means that the maximum volume of this storm event will drain to at least 10% of that same maximum volume in 24 hours. The runoff that is temporarily stored in this zone must be released in a manner similar to that in an extended detention basin; for more information on the release of this runoff, see *Chapter 9.4: Extended Detention Basins*.

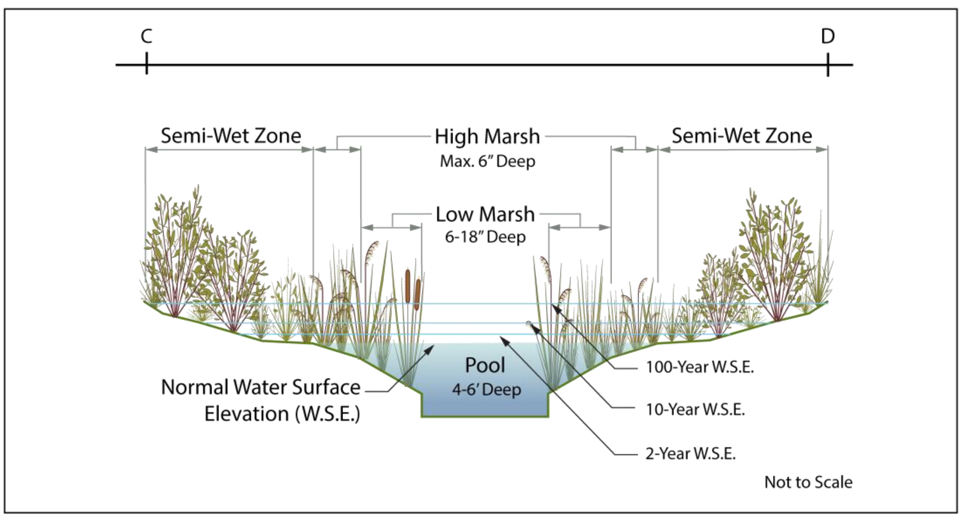
Due to the use of the semi-wet zone, water levels during storm events in an extended detention constructed wetland system may expand beyond the normal standing water limits occupied by the pool and marsh zones; therefore, wetland vegetation that can tolerate intermittent flooding and extended dry periods should be selected for this area.

The following illustrations are cross-sections showing the difference between a channelized area A-B and the area containing the pool C-D. An additional cross-section E-F depicts the view taken at the front face of the outlet riser structure. In these illustrations, the semi-wet zone has been sized to contain the volume of runoff generated by the 100-year design storm.

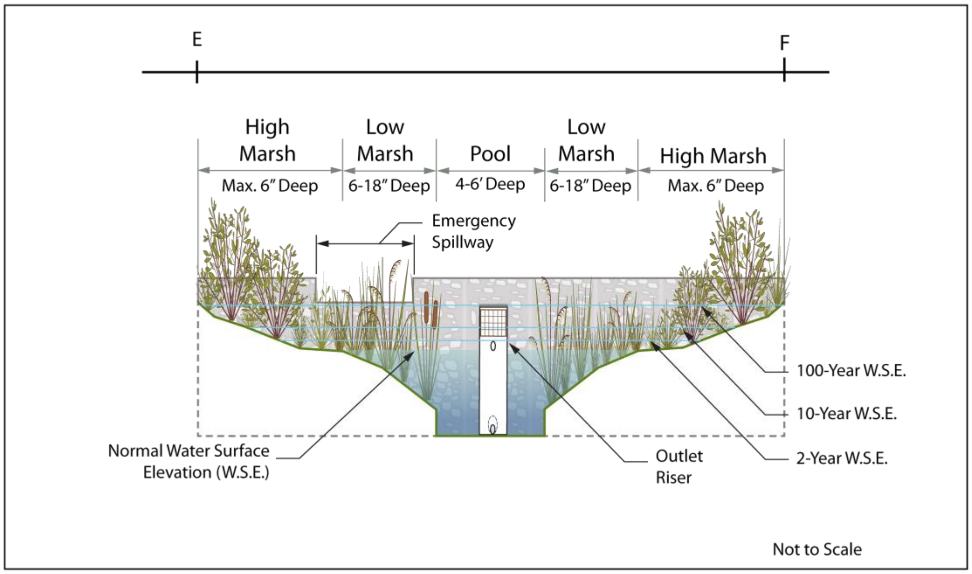
Extended Detention Constructed Wetlands – Cross-section View A-B



Extended Detention Constructed Wetlands – Cross-section View C-D



Extended Detention Constructed Wetlands – Cross-section View E-F



The table below shows the design criteria specific to marsh constructed wetlands; for additional design criteria, refer to the *Basic Requirements* section of this chapter, beginning on page 3.

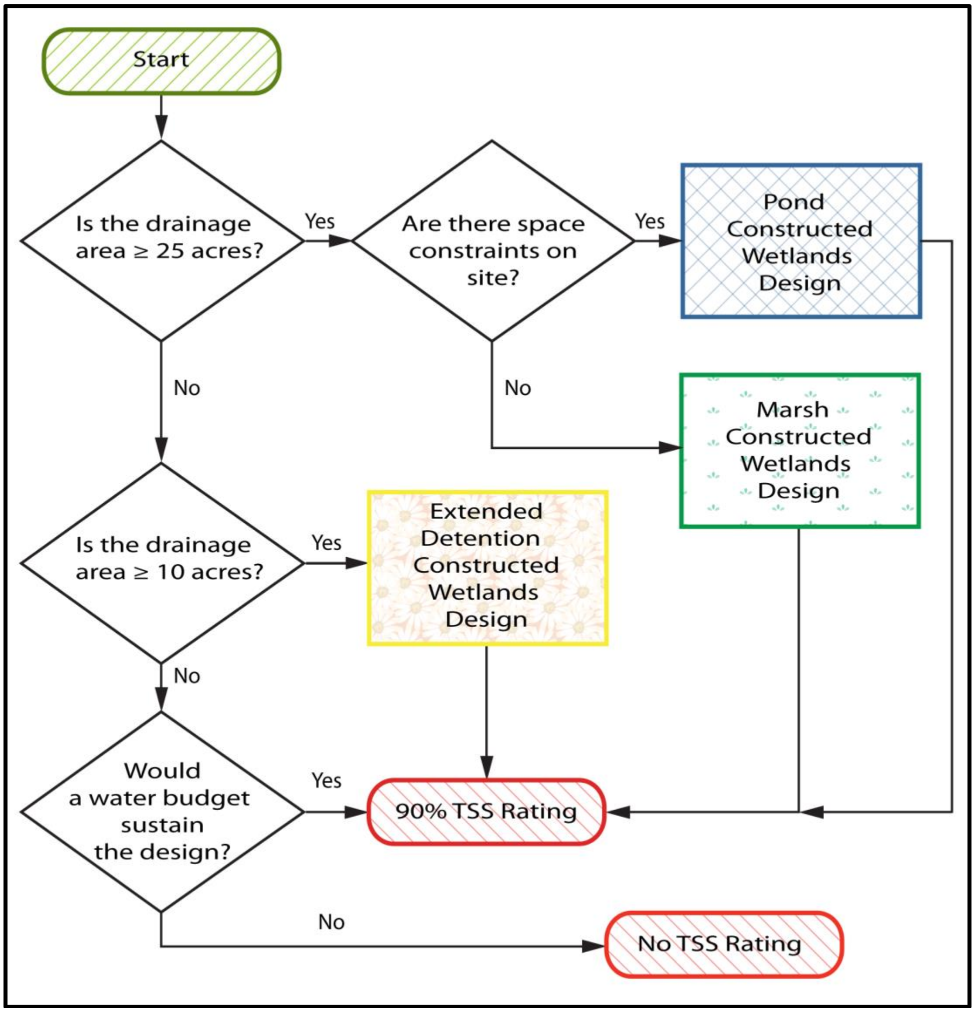
Extended Detention Constructed Wetland Design Criteria	
Minimum Drainage Area	10 Acres
Standing Water Depth: High Marsh Zone	Maximum 6 Inches
Standing Water Depth: Low Marsh Zone	6 – 18 Inches
Standing Water Depth: Pool Zone	4 – 6 Feet
Standing Water Depth: Semi-Wet Zone	Only inundated during storm events
Minimum Length to Width Ratio	1:1

Considerations

A number of factors should be considered when utilizing standard constructed wetlands to treat stormwater runoff.

How Site Characteristics Shape the Design

The flowchart below is an example of the types of questions a designer should be considering when determining the category of standard constructed wetlands that is appropriate for a particular site; the outcomes shown in this flowchart are not all-inclusive. As previously mentioned, smaller drainage areas may be permissible if detailed analysis indicates that sufficient base or groundwater flow is available; a water budget must be included in this analysis. For more information on how to complete a water budget see the Water Budget Manual at http://www.nj.gov/dep/landuse/download/mit_011.pdf.



Site Constraints

Standard constructed wetlands may be limited by a number of site constraints, including soil types, depths to groundwater or bedrock, contributing drainage area and available land area on-site. Medium-fine textured soils (such as loams or silt-loams) are best to establish vegetation, retain surface water, permit groundwater discharge and capture pollutants. At sites where the soil permeability rate is too high or where there is potential for groundwater contamination, the use of an impermeable liner should be considered. When designing a standard constructed wetland system with an impermeable liner, proper installation is critical to ensure long term functioning. For more information on the installation of impermeable liners, refer to N.J.A.C. 7:26 Solid and Hazardous Waste Rules.

Setback requirements for standard constructed wetlands vary; ensure compliance with any applicable federal, state or local requirements.

Design Approach

A pondscaping plan should be developed for each standard constructed wetland system. The plan should include hydrologic calculations (or a water budget), elevations and grades, a site/soil analysis, estimated depths, wetland design/configuration, vegetation plan, site preparation requirements, maintenance requirements and a maintenance schedule.

Regulatory Issues

A standard constructed wetland system, once constructed, may be regulated by the Freshwater Wetlands Protection Act and require additional permits for maintenance or modification. Standard constructed wetlands classified as dams under the NJDEP Dam Safety Standards at N.J.A.C. 7:20 must also meet the overflow standards therein.

Vegetation

Establishing and maintaining wetland vegetation is an important consideration when planning a standard constructed wetland system.

- Native species are preferred, but it is best when choosing plants to consider the prospects of establishing a healthy plant community. See *Chapter 7: Landscaping* for more information.
- Selected species must be able to adapt to a broad range of conditions, including wide variations in water depth and inundation; additionally, when designing an off-line standard constructed wetland system, the potential effects of the diversion of larger storm events on the wetland vegetation should be considered.
- A variety of plants should be selected; diversity will minimize the risk of loss from pest and disease that is common in monocultures.
- Plant communities develop best through the use of wetland mulch, which is enriched with plant roots and seeds. Wetland mulch enhances the diversity of the plant community and speeds establishment; however, the content is often unpredictable and undesirable species may be introduced. If wetland mulch is used, it should be collected at the end of the growing season and kept moist until installation.

- The planting of shade trees around the perimeter of a standard constructed wetland system should be considered to help reduce the discharge of heated water by reducing the solar warming of the pool zone.

- Wildlife access to the standard constructed wetland system must be prohibited during the initial planting phase; in addition, precautions, such as deer fencing, muskrat trapping and planting after seasonal bird migrations should be considered.

Maintenance

Regular and effective maintenance is crucial to ensure effective standard constructed wetlands 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 standard constructed wetlands are presented below; these requirements must be included in the standard constructed wetland system's maintenance plan.

General Maintenance

- All 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.

- If a forebay is used in the pretreatment zone, it must be cleaned when it accumulates either 6 inches of sediment, there is a 10% loss of forebay volume, or if it remains wet 9 hours after the end of a storm event.

- If using the optional bottom drain pipe, it must be sized to drain the permanent pool within 40 hours to allow excess sediments to be removed when necessary.

- 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.

- All valves for maintenance must be clearly shown in the Operations and Maintenance Manual; additionally, it must also be conspicuously stated that all valves are to remain closed except when necessary to perform specific activities, such as temporary drawdown or backflush.

- Drains with lockable valves are required to allow the drawdown or backflush of wetland cells; these drains must be readily accessible.

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.
- Pruning within the standard constructed wetlands must be performed on a regular schedule based on specific site conditions; perimeter grass should be mowed at least once a month during growing season.
- 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.

  The types and distribution of dominant plants must be assessed during the semi-annual wetland inspections, and an appropriate balance between original and volunteer species must be achieved in accordance with the intent of the system's original design.
- All use of fertilizers, pesticides, mechanical treatments and other means to ensure optimum vegetation must not compromise the intended purpose of the standard constructed wetland.

Drain Time

- The approximate drain time for the various wetland pools to their normal standing water levels must be indicated in the maintenance manual.
- If the actual drain time is significantly different from the design drain time, the components that could provide hydraulic control must be evaluated and appropriate measures taken to return the wetland system to the design drain time.

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