Stormwater Wetland

Stormwater BMP Type

Pretreatment BMP	☐
Infiltration BMP	☐
Filtering BMP	☐
Stormwater Pond BMP	☐
Stormwater Wetland BMP	■
Water Quality Conveyance BMP	☐
Stormwater Reuse BMP	☐
Proprietary BMP	☐
Other BMPs and Accessories	☐

Stormwater Management Suitability

Retention	☐
Treatment	■
Pretreatment	☐
Peak Runoff Attenuation*	■

*On-line systems only

Pollutant Removal

Sediment**	**High**
Phosphorus	**Moderate**
Nitrogen	**Moderate**
Bacteria	**Moderate**

**Includes sediment-bound pollutants and floatables (with pretreatment)

Implementation

Capital Cost	**Medium**
Maintenance Burden	**Medium**
Land Requirement	**High**

Description

Stormwater wetlands are man-made wetland systems that incorporate marsh areas and permanent pools to provide treatment and attenuation of stormwater flows. Stormwater wetlands differ from stormwater ponds in that wetland vegetation is a major element of the overall treatment mechanism as opposed to a supplementary component. This section addresses four types of stormwater wetlands:

- Subsurface Gravel Wetland
- Shallow Wetland
- Extended Detention Shallow Wetland
- Pond/Wetland System

While stormwater wetlands can provide some of the ecological benefits associated with natural wetlands, these benefits are secondary to the function of the system to treat stormwater. Particulate and soluble pollutants are removed as stormwater runoff flows through the open marsh system. The primary pollutant removal mechanisms include sedimentation and filtration/uptake by wetland vegetation.

Subsurface gravel wetlands are a more recent stormwater wetland design variant that combines a surface marsh and subsurface gravel bed. Pollutants are removed through settling and filtration/uptake by wetland vegetation and by the process of denitrification in the subsurface gravel bed. Subsurface gravel wetlands are particularly effective for nitrogen removal.

The key to maximizing pollutant removal effectiveness in stormwater wetlands is maintaining wet conditions adequate to support wetland vegetation and saturated conditions in the subsurface gravel bed of subsurface gravel wetlands. Stormwater wetlands should either intercept the groundwater table or should be lined with an impermeable liner if located in permeable soils and should have a watershed large enough to supply storm flows that will maintain wetness even during dry periods.

Stormwater wetland systems are designed to operate on the plug flow principle where the "new" polluted incoming runoff displaces the "old" treated water held in the system from the previous storm event. This is accomplished by maximizing length versus width ratios and/or by creating distinct cells along the treatment path. Stormwater wetlands are designed to treat the Water Quality Volume (WQV). When designed in an on-line configuration, stormwater wetlands can also be sized to treat and provide peak runoff attenuation for storms larger than the water quality storm event.

Stormwater wetlands do not provide sufficient retention or runoff volume reduction through infiltration or other processes and therefore cannot be used to meet the Standard 1 retention performance criterion of this Manual.

Advantages

- Effective for removal of particulate and soluble pollutants. Subsurface gravel wetlands are particularly effective at removing nitrogen.
- Can provide aesthetic benefits.
- Can provide wildlife habitat with appropriate design elements.
- Can provide peak runoff attenuation.
- Subsurface gravel wetlands are well-suited for retrofitting existing stormwater detention and retention ponds to enhance pollutant removal.

Limitations

- Do not provide infiltration or sufficient runoff volume reduction, and therefore cannot be used to meet the Standard 1 retention performance criterion.

- Require a relatively large land area.

- Very sensitive to the ability to maintain wet conditions especially during extended dry weather when there may be significant evaporative losses.

- May cause thermal impacts to receiving waters and therefore should not discharge directly to coldwater streams or other receiving water environments that are sensitive to thermal loads.

- Stormwater wetlands with steep side slopes and/or deep wet pools may present a safety risk in residential areas and areas with public access.

- Stormwater wetlands can serve as decoy wetlands, intercepting breeding amphibians moving toward vernal pools. If amphibians deposit their eggs in these artificial wetlands, they rarely survive due to the sediment and pollutant loads, as well as fluctuations in water quality, quantity, and temperature.

Siting Considerations

- **Drainage Area:** Stormwater wetlands that utilize a liner system should have a contributing drainage area that is adequate to maintain minimum water levels. Typically, the minimum contributing drainage area for lined wetlands is 10 acres (5 acres for subsurface gravel wetlands). Smaller drainage areas may be suitable if intercepting groundwater or with sufficient surface runoff to support wetlands and a submerged gravel bed for subsurface gravel wetlands. A water budget analysis should be performed to demonstrate that sufficient groundwater flow and/or surface runoff is available to maintain the required water elevations in the various zones of the stormwater wetland.

- **Groundwater:** Stormwater wetlands should intercept groundwater or have an impermeable liner to maintain a permanent pool if located in permeable soils. The elevations of unlined wetlands should be established such that the groundwater elevation is equal to the desired permanent pool elevation. Seasonal variations of groundwater elevations should be considered.

- **Land Uses:** Land uses will dictate potential pollutants-of-concern and potential safety risks. A liner is required for stormwater wetlands that receive runoff from Land Uses with Higher Potential Pollutant Loads (LUHPPLs) (see Chapter 10) or on contaminated sites. The wetland's standing water may pose a safety risk in residential areas and areas with public access, sometimes requiring fencing to limit access to the wetland.

- **Baseflow:** A small amount of baseflow is desirable to maintain circulation and reduce the potential for low dissolved oxygen levels during late summer. This baseflow can be provided by groundwater discharge to the wetland or the drainage system that feeds the wetland.

- **Site Slopes:** Site slopes greater than 6% may result in the need for an embankment greater than 4 feet above existing grade to provide the desired storage volume, which would be subject to CT DEEP dam safety regulatory requirements. Steep slopes may also present design and construction challenges, and significantly increase the cost of earthwork.

- **Receiving Waters:** Stormwater wetlands should not be used for sites that discharge within 200 feet of coldwater streams, 200 feet from a public water supply reservoir, or 100 feet from streams tributary to a public water supply reservoir.

- **Natural Wetlands/Vernal Pools:** Natural wetlands and vernal pool depressions should not be used, either temporarily or permanently, as a stormwater wetland. Stormwater wetlands should be located at least 750 feet from a vernal pool. They should not be sited between vernal pools, or in areas that are known primary amphibian overland migration routes.

Soil Evaluation and Water Budget Analysis

- Conduct an evaluation of the soil characteristics and subsurface conditions at the location of the proposed system including soil type, depth to the seasonal high groundwater table, and depth to bedrock. Perform test pits or soil borings in accordance with the soil evaluation guidance in Chapter 10.

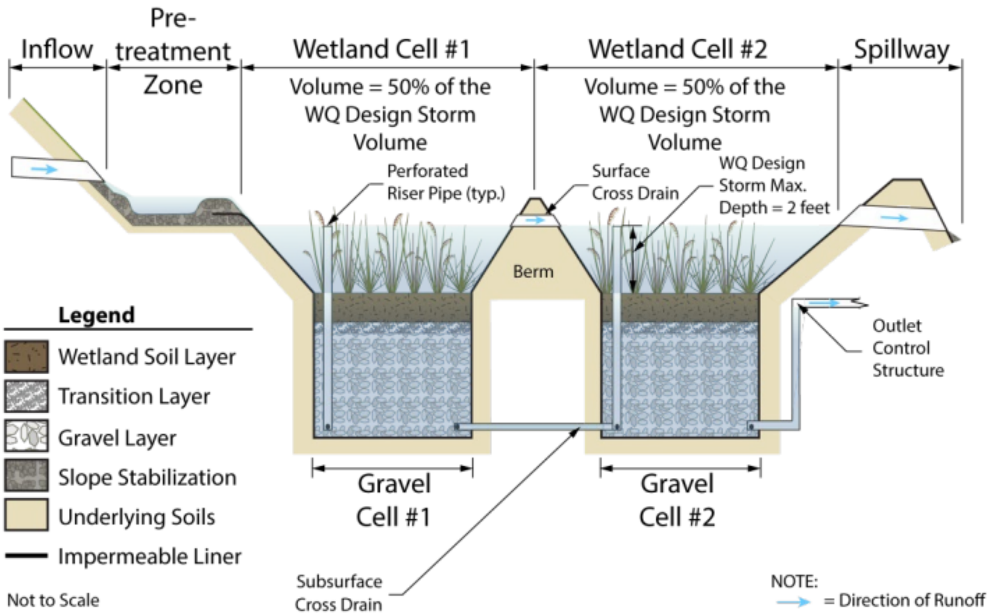
- A water budget analysis should be performed for stormwater wetland designs. The water budget consists of calculations, on a daily basis, of the inflows to and outflows from the wetland to show that the required depth of water in the wetland is maintained throughout the year. The analysis should be performed for a wet year, a dry year, and an average year. The analysis should demonstrate that the depths of water in the various zones of the stormwater wetland meet the minimum requirements of this section for all of the days in each of the three analyses. All of the inputs to and outputs from the wetland should be considered, including direct precipitation, runoff, flooding, groundwater inflow, evapotranspiration, groundwater outflow.

Design Recommendations – Subsurface Gravel Wetland

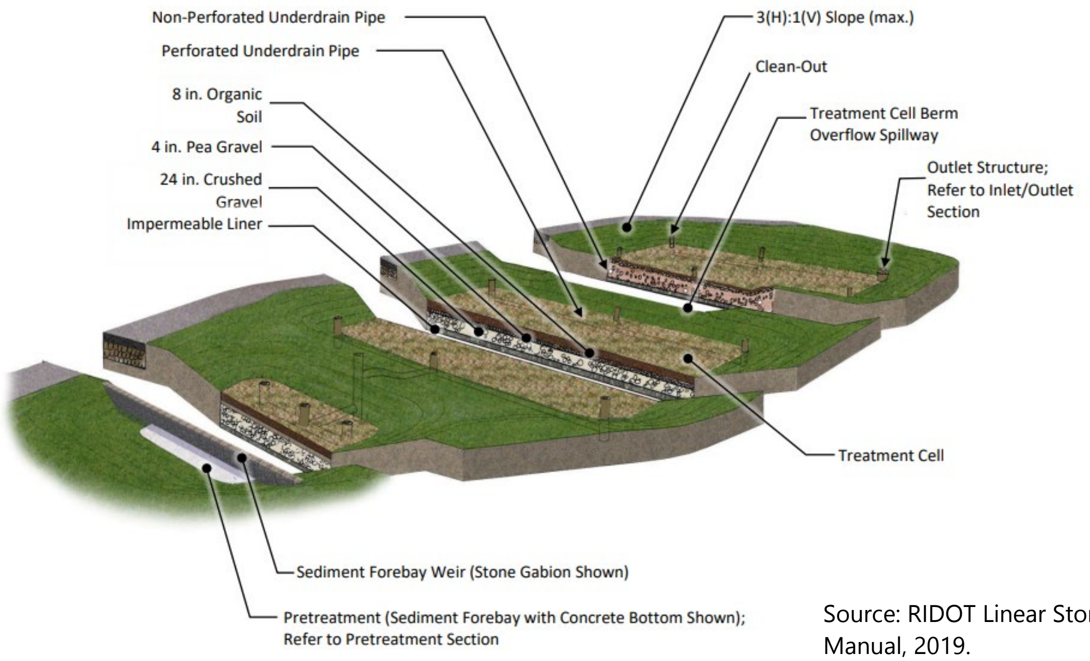
Subsurface gravel wetlands combine a surface marsh and a subsurface gravel bed. In the surface marsh, pollutants are treated through filtration and biological uptake by the marsh vegetation and through sedimentation. Stormwater runoff flows vertically from the surface marsh through perforated pipe into the saturated gravel bed, located directly below the surface marsh. Runoff then flows horizontally through the gravel where additional treatment occurs via denitrification, which is a microbially-facilitated process whereby nitrogen compounds in stormwater runoff are transformed to nitrogen gas. The nitrogen gas is then permanently removed from the system via the soil into the atmosphere. The subsurface gravel bed must always be completely filled with stormwater runoff in order to provide the anoxic environment necessary for denitrification to occur.

A subsurface gravel wetland consists of the following basic components:

- Pretreatment
- Two surface wetland treatment cells connected by a cross drain
- Transition layer located below each surface wetland cell
- Two subsurface gravel cells connected by a subsurface cross drain
- Two perforated riser pipes connecting each of the wetland treatment cells to the gravel cells below them
- Outlet structure.



Source: Adapted from NJDEP, 2021.



Source: RIDOT Linear Stormwater Manual, 2019.

Pretreatment – Sediment Forebay

- A sediment forebay is recommended for subsurface gravel wetlands, although other forms of pretreatment may be used at locations where runoff enters the system.
- The sediment forebay and other pretreatment measures should be designed in accordance with the Pretreatment BMPs section of this Manual.

- The sediment forebay should be a minimum of 3 feet deep and sized to contain at least 10% of the WQV. The forebay storage volume may be used to fulfill the WQV requirement of the overall stormwater wetland. The forebay should also include additional sediment storage volume that may not be used for WQV calculations.

Sizing and Dimensions

- Volume
  - Size the entire facility (including pretreatment, surface ponding in wetland treatment cells, and volume of voids in subsurface gravel beds) to hold 100% of the WQV and to drain the WQV over a 24 to 30 hour period after the end of a storm event.
  - Assume 40% void space when computing the amount of available storage within the gravel substrate.
  - WQV treatment should be equally distributed in each wetland treatment cell.
  - When used as an on-line treatment practice, the subsurface gravel wetland can be designed for extended detention for peak runoff control. In this case, the extended detention volume shall drain over a 24 to 48 hour period.

- Treatment Cell Ponding Depth and Freeboard
  - The maximum ponding depth in the surface wetland cells is 2 feet.
  - Provide at least 1 foot of freeboard above the WQV elevation (if designed to handle the WQV only).
  - Provide a maximum freeboard of 4 feet above the WQV elevation or 6 inches of freeboard above the 100-year storm elevation, whichever is less (if extended detention is provided).

- Treatment Cell Length, Width, and Slope
  - Minimum length: 15 feet (in the direction of flow) to provide sufficient travel time in the anoxic environment for denitrification to occur.
  - Maximum length: None; the length of the flow path in the gravel cell should be maximized to maximize treatment.
  - Minimum width: 1:1 length to width ratio
  - Bottom slope: the top and bottom of the treatment cell should be level.
  - Maximum side slope: 3(H):1(V) slopes or flatter

Berms

- The top of the berms separating treatment cells shall be set at or above the height of the WQV elevation.

- Construct berms of low permeability soils (hydraulic conductivity less than 0.03 feet per day), to prevent water seepage between cells and to maintain the structural integrity of the berm.

- Use solid (non-perforated) pipe sections and watertight joints to connect pipes through the base of the berm to promote flow of the WQV between treatment cells.

- Extended detention (optional) when designed as an on-line system:
  - If provided, extended detention occurs above the treatment cells. An overflow spillway or bypass pipe should be provided in the berm at the height of the WQV elevation.
  - The surface of the berm should be designed with materials to resist erosive velocities.
  - Provide stable and non-erosive energy dissipating devices between berms where overflow velocities are considered erosive.

Conveyance

- Stormwater should be conveyed to and from all stormwater management practices safely and to minimize erosion potential.

Inlet

- Design the inlet in accordance with the Inlet and Outlet Controls section of this Manual.

- The number of inlets should be minimized, and one inlet is preferable. The inlet should be located at the most hydraulically remote point from the outlet to minimize the potential for short-circuiting and should be located in a manner that meets or exceeds desired length to width ratios.

Outlet & Overflow

- Design the outlet and any overflows in accordance with the Inlet and Outlet Controls section of this Manual.

- The primary outlet control structure should be a riser with an orifice/outlet pipe for low flow. The WQV is conveyed into the outlet control structure through the underdrain.

- The WQV orifice/outlet should be located 4-8 inches below the elevation of the organic soil surface.

- The top of the structure should remain open with a grate for overflow. This configuration reduces the potential for creating siphoning.

- Extended detention (optional) when designed as an on-line system:
  - A weir should be provided in the center of the structure with a WQV orifice located in the weir. The elevation of the top of the weir should be set to provide control of lower frequency storm events, such as the 2-year or 10-year, 24-hour storm event.

  - If the outlet controls multiple storm events, additional orifices may be added to the structure.
  - The top of the structure should be set to allow the bypass of the 100-year event.

Underdrain and Risers

- Underdrains and risers are critical in subsurface gravel wetlands as they convey and distribute stormwater through the treatment cells as driven by the hydraulic head.

- Risers
  - Minimum central riser pipe diameter: 12 inches
  - Minimum end riser pipe diameter: 6 inches
  - Space perforated riser pipes across the width of the treatment cell with a maximum spacing of 15 feet.
  - Place inlet grates atop risers for an overflow when water levels exceed the WQV.

- Underdrains
  - Minimum diameter: 6 inches
  - Use solid (non-perforated) pipe sections and watertight joints wherever the underdrain system passes below berms, connects to a drainage structure and/or daylights.
  - Place the subsurface perforated distribution line at the upstream end of each treatment cell and the subsurface perforated collection drain at the downstream end. At a minimum, there should be 15 feet between both.
  - Provide a marking stake and an animal guard for underdrains that daylight at grade.

- Include an observation well/cleanout at each end of the underdrains. The cleanout should be highly visible.
  - Cleanouts should be at least 6 inches in diameter, should be perforated only within the gravel layer and solid within the organic soil and storage area.
  - Cap cleanouts with a watertight removable cap.

Liner

- Proper functioning of the system requires stormwater runoff to enter the subsurface gravel cells only from the surface wetland cells and only through the perforated riser pipes. It is also essential that discharges from the gravel cells occur only through the outlet structure and not into the underlying soil.

- An impermeable liner is required to prevent groundwater exchange with runoff in the subsurface gravel bed unless the underlying soils are sufficiently impermeable (soils with a field-verified infiltration rate of 0.05 in/hr or less), in which case the liner may be omitted provided that the system is above the seasonal high groundwater table (SHGT).

- A liner is also necessary to avoid impacts to groundwater quality for systems that receive runoff from Land Uses with Higher Potential Pollutant Loads (LUHPPLs) or on contaminated sites.

- Where SHGT is located at or above the bottom of the liner, complete a buoyancy analysis to verify buoyancy will not be an issue.

Materials

- Vegetation
    - Select vegetation and develop a planting plan in with guidance provided in Appendix F of this Manual.
    - Establish a dense vegetative cover or adequately stabilized landscaped surface across any upgradient areas disturbed by construction before runoff can be accepted into the facility.
    - The bottom of the subsurface gravel wetland should be planted to achieve a rigorous root mat with grasses, forbs, and shrubs with obligate and facultative wetland species, such as New England Wetland Plants Wet Mix.

- Gravel Substrate
    - Do not use geotextiles between subsurface layers as they will clog and prevent root growth.
    - Organic Soil
        - Similar to a low permeability wetland soil made up of compost, sand and fine soils blended to have an organic matter content > 15%. Avoid using clay contents in excess of 15%, as the fines could migrate into the subsurface crushed stone (gravel) layer.
    - Pea Gravel
        - Provide a 4-inch layer of pea gravel to provide separation between the organic soil layer and the crushed gravel layer.
        - Should consist of 3/8" AASHTO No. 8 stone. Pea gravel should be clean (washed and free from dirt and debris) and rounded in shape.
    - Crushed Gravel
        - Minimum Thickness: 24 inches
        - Should consist of 3/4" AASHTO No. 5 stone. Gravel should be clean (washed and free from dirt and debris), crushed, and angular.

- Underdrain/Riser (perforated and non-perforated sections)
    - Polyethylene or polyvinyl pipe.

- Liner
    - should consist of a 30 mil (minimum) HDPE or PVC liner, or one of the alternative liner systems described in Chapter 10 with the approval of the review authority.

- Turf Reinforcement Matting (TRM)
  - Stabilize the side slopes with a TRM to limit erosion in locations where flow velocities exceed 3 to 5 feet per second (depending on soil and vegetation types) for the 1-year, 24-hour storm event.
  - If used, shall be a woven material included on the CTDOT Qualified Products List that exceeds the design velocity of the design storm and allows for the growth of the proposed vegetative species.

Winter Operations

- Subsurface gravel wetlands should not be used as dedicated snow storage areas. To the extent feasible, locate and design the system to avoid snow storage areas and potential damage from snow plowing activities. Refer to Chapter 7 for general design considerations related to winter operations.

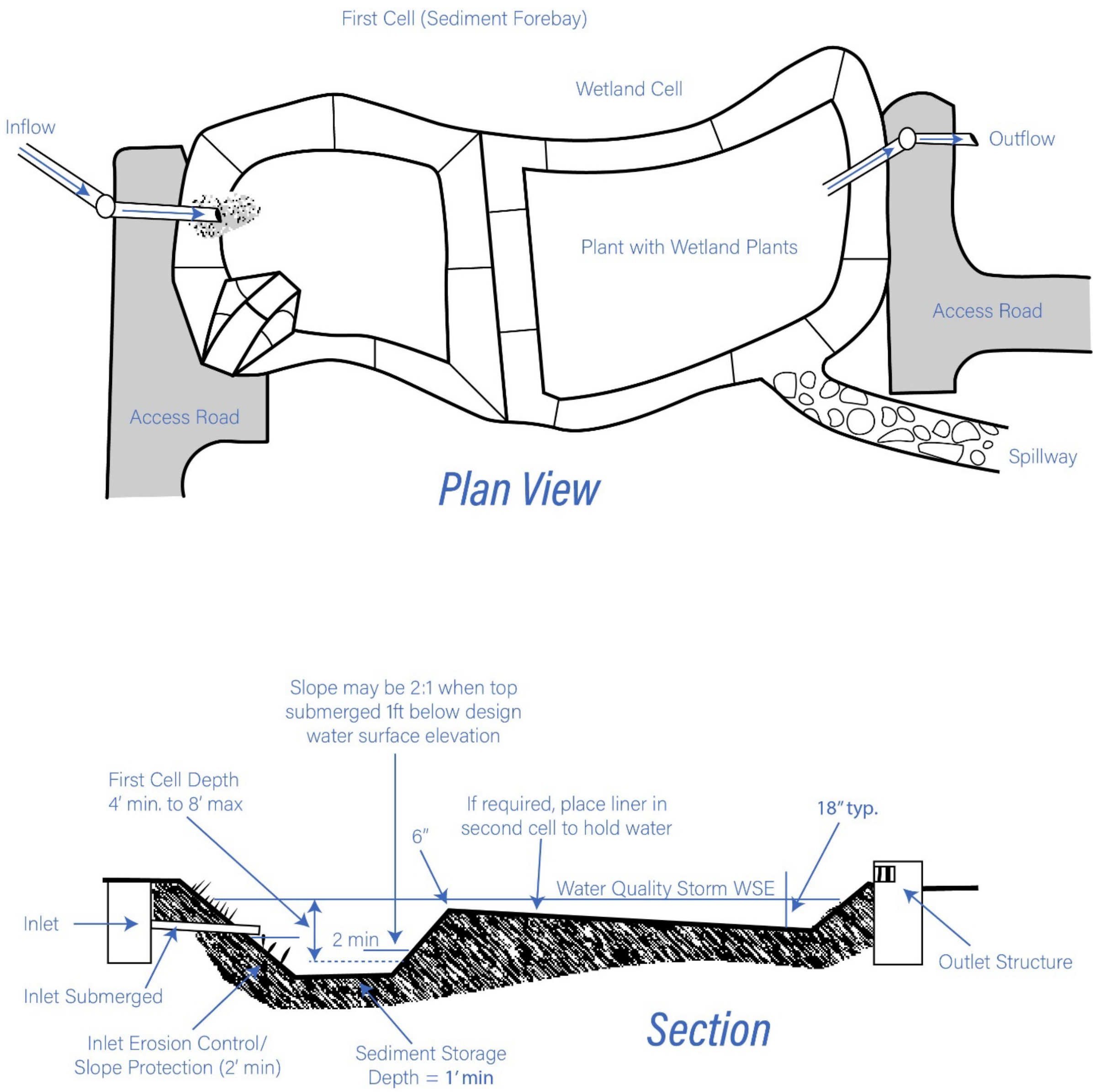
Design Recommendations – Conventional Stormwater Wetlands

The following conventional stormwater wetland design variants are characterized by the volume of the wetland in the deep pool, high marsh, and low marsh zones, and whether the design allows for detention of larger storms above the permanent pool (extended detention).

- **Shallow Wetland:** Shallow wetland systems, also referred to as shallow marsh wetlands, consist of aquatic vegetation with a permanent pool ranging from 6 to 18 inches during normal conditions. Shallow wetlands are designed such that flow through the wetlands is conveyed uniformly across the treatment area. While pathways, channels, or other varied water depths could enhance the aesthetic or ecosystem value of the wetland, they could also cause short-circuiting through the wetland thereby reducing the overall treatment effectiveness. A uniformly sloped system is recommended to maximize treatment performance. Individual wetland cells can be separated by weirs to enhance plug flow conditions across the wetland. Figure 13-27 is a typical schematic design of a shallow wetland.

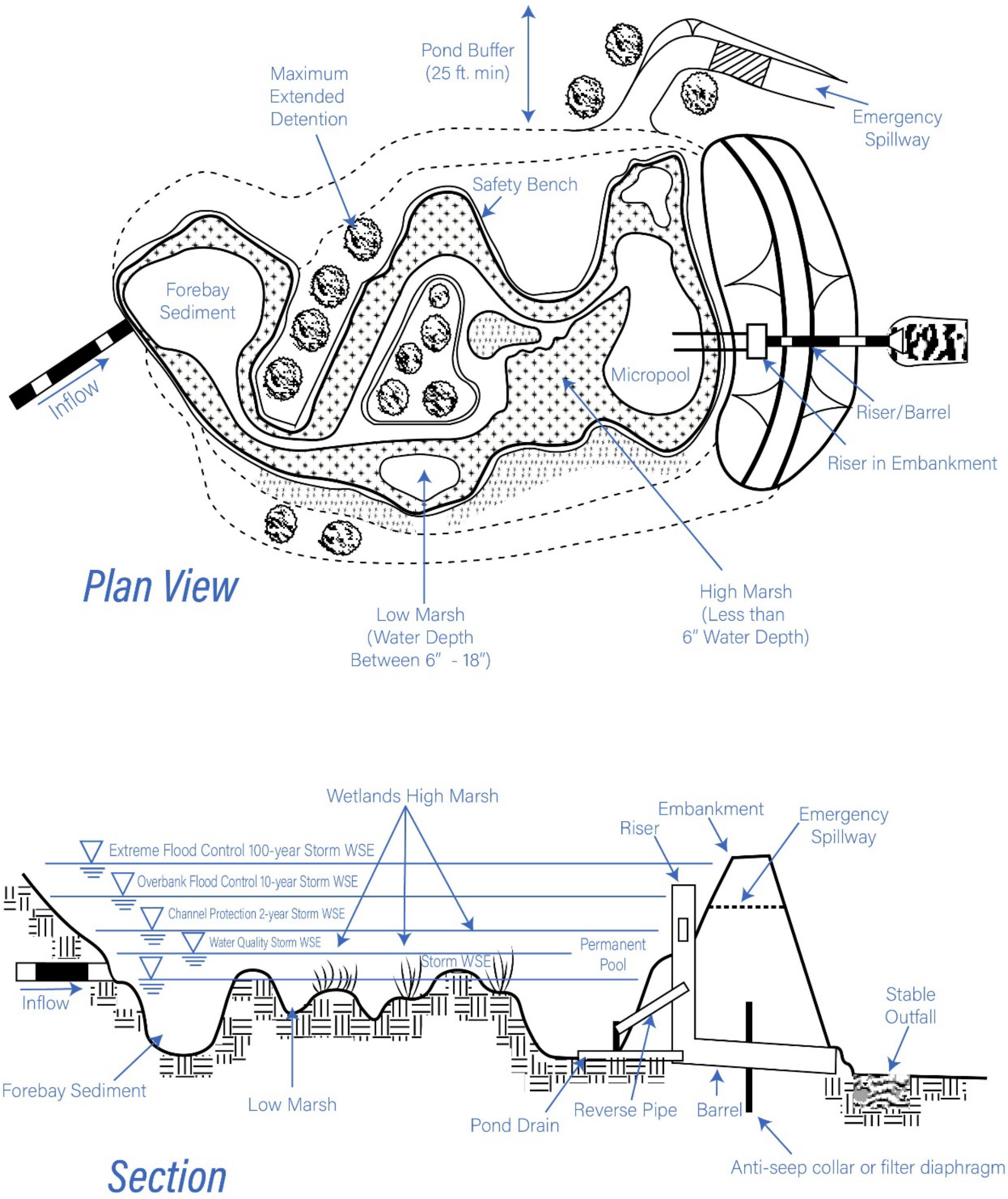
  Shallow wetlands are typically designed as off-line systems to provide treatment of the Water Quality Volume (WQV) but not to provide stormwater quantity control for larger storms.

Figure 13-27. Shallow Wetland Schematic



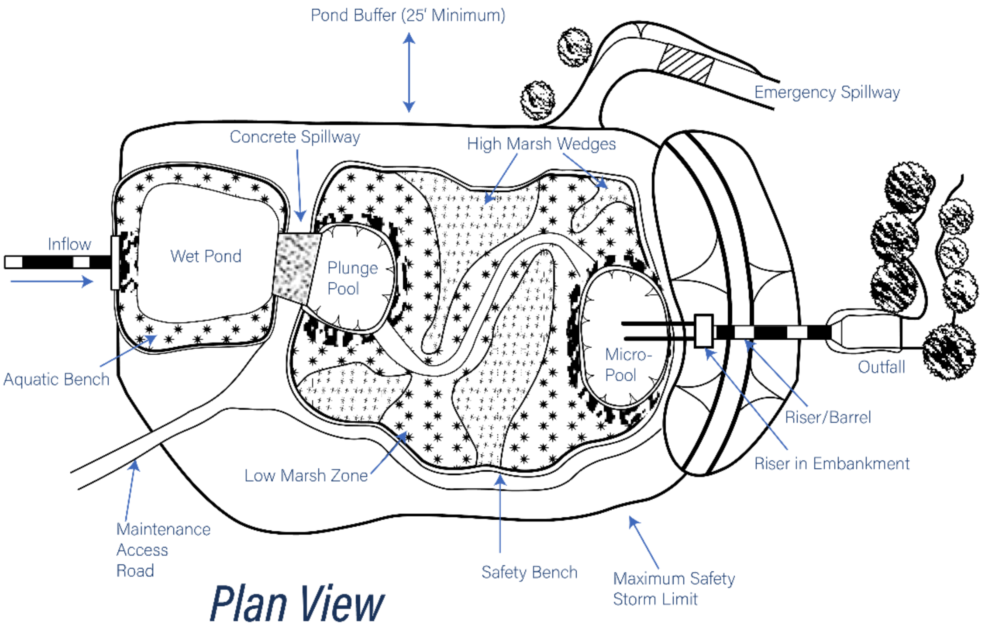
- **Extended Detention Shallow Wetland:** Extended detention shallow wetlands provide a greater degree of stormwater quantity control as they are designed with more vertical storage capacity. The additional vertical storage volume also provides extra runoff detention above the normal pool elevation. Water levels in the extended detention shallow wetland may increase by as much as 3 feet after a storm event and return gradually to pre-storm elevations within 24 hours of the storm event. The extended detention zone is the inundation area above the normal pool elevation up to the water quality storm elevation. Wetland plants that tolerate intermittent flooding and dry periods should be selected for the extended detention area above normal pool elevation. Figure 13-28 is a typical schematic design of an extended detention shallow wetland.

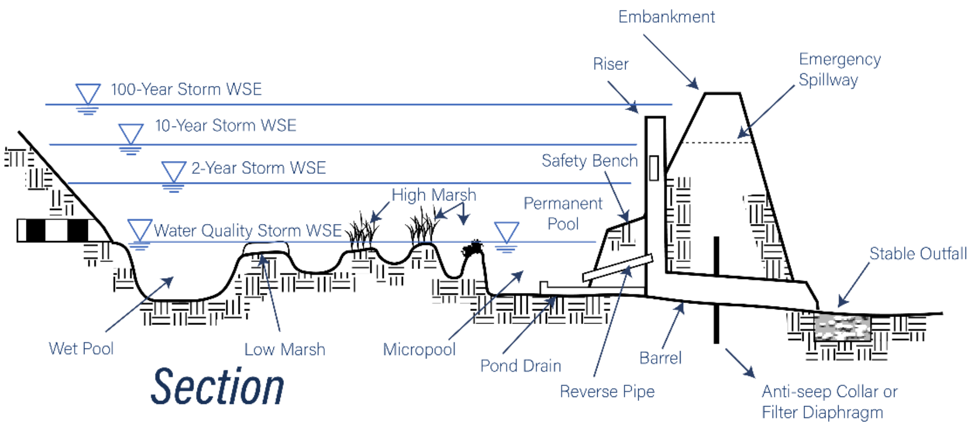
Figure 13-28. Extended Detention Shallow Wetland Schematic



- **Pond/Wetland System:** Multiple cell systems, such as pond/wetland systems, utilize at least one pond component in conjunction with a shallow marsh component. The first cell is typically a wet pond, which provides pretreatment of the runoff by removing particulate pollutants and reduce the velocity of the runoff entering the system. The shallow marsh then polishes the runoff, particularly for soluble pollutants, prior to discharge. These systems require less space than the shallow marsh systems since more of the water volume is stored in the deep pool which can be designed to reduce peak flows. Because of this system's ability to significantly reduce the velocity and volume of incoming peak flows (i.e., flow equalization or dampening), it can often achieve higher pollutant removal rates than other similarly sized stormwater wetland systems. Figure 13-29 is a typical schematic design of a pond/wetland system.

Figure 13-29. Pond/Wetland System Schematic





Source: Adapted from NYDEC, 2001.

Pretreatment – Sediment Forebay

- A sediment forebay is recommended for conventional stormwater wetlands, although other forms of pretreatment may be used at locations where runoff enters the system.
- The sediment forebay and other pretreatment measures should be designed in accordance with the Pretreatment BMPs section of this Manual.
- The sediment forebay should be a minimum of 3 feet deep and sized to contain at least 10% of the WQV. The forebay storage volume may be used to fulfill the WQV requirement of the overall stormwater wetland. The forebay should also include additional sediment storage volume that may not be used for WQV calculations.

Sizing and Dimensions

- The wetland volume, including the volume of the sediment forebay, the permanent pool volume (high marsh zone, low marsh zone, and pool zone), and the volume of the extended detention area (if any), should be equal to or exceed the WQV. Table 13-11 provides the recommended division of storage between these zones for each stormwater wetland design variant.

Table 13-8. Water Quality Volume Distribution in Stormwater Wetland Designs

Design Variant	Percent of Water Quality Volume (WQV)				
	Sediment Forebay	High Marsh Zone	Low Marsh Zone	Pool Zone	Extended Detention Zone
Water Depth	3 feet min (below permanent pool)	6 inches max (below permanent pool)	6-18 inches (below permanent pool)	4-6 feet (below permanent pool)	Varies (above permanent pool)
Shallow Wetland	10%	0%	90%	0%	0%
Extended Detention Shallow Wetland	10%	10%	20%	10%	50%
Pond/Wetland System	10%	10%	20%	60%	0%

Adapted from NYDEC, 2001 and NJDEP, 2021.

- Water quality storage can be provided in multiple cells. Performance is enhanced when multiple treatment pathways are provided by using multiple cells, longer flow paths, high surface area to volume ratios, complex microtopography, and/or redundant treatment methods (combinations of pool, extended detention, and marsh).
- For extended detention shallow wetlands, the extended detention storage volume (storage volume above the permanent pool provided for additional water quality and stormwater

quantity control) should drain out of the wetland over a minimum of 24 hours, after which the water surface elevation in the wetland will return to the permanent pool elevation.

- Thermal impacts of stormwater wetlands may be mitigated by implementing one or more of the following design measures:
    - Use of a smaller permanent pool with more extended detention storage and an extended detention time of 24 hours or less
    - Planting of shade trees around the perimeter of the wetland (but at least 25 feet away from inlet/outlet structures and the wetland embankment) to reduce solar warming of the pool
    - Designing the wetland with a series of pools, as opposed to a single pool, to allow cooling prior to discharge
    - Use of an outlet structure designed to draw water from near the bottom of the outlet pool where water temperatures may be cooler
    - Use of an underdrained gravel trench outlet.

- The wetland should have a curvilinear shape and a minimum length:width ratio of 3:1 from the wetland inlet to outlet.

- For extended detention shallow wetland and pond/wetland systems, the upper stages of the wetland should provide temporary storage of larger storms (2-year, 10-year, and 100-year, 24-hour events) to control peak discharge rates.

- Wetland Water Depths:
    - High Marsh Zone: 6 inches maximum (below permanent pool)
    - Low Marsh Zone: 6-18 inches (below permanent pool)
    - Pool Zone: 4-6 feet (below permanent pool), includes deeper pool at outlet structure (i.e., micropool)
    - Extended Detention Zone: varies (above permanent pool)

- Pumping of groundwater to maintain the permanent pool should not be allowed.

- The volume below the surface elevation of the permanent pool should not be included in storage calculations for peak flow management.

Side Slopes

- 3(H):1(V) slopes or flatter are preferred.

- The perimeter of permanent pool areas (sediment forebay and outlet pool) four feet or greater in depth should provide two benches:
    - Provide a flat safety bench that extends 10 feet outward from the normal water edge to the toe of the wetland side slope.
    - Provide a flat aquatic bench that extends 10 feet inward from the normal water edge at a depth of 12-18 inches below the normal pool water surface elevation.

Inlet

- Design the inlet in accordance with the Inlet and Outlet Controls section of this Manual.
- The number of inlets should be minimized, and one inlet is preferable. The inlet should be located at the most hydraulically remote point from the outlet to minimize the potential for short-circuiting and should be located in a manner that meets or exceeds desired length to width ratios.
- The ideal inlet configuration is above the permanent pool to prevent potential hydraulic constrictions due to freezing.

Outlet & Overflow

- Design the outlet and any overflows in accordance with the Inlet and Outlet Controls section of this Manual.
- Shallow wetlands should be designed as off-line systems and have an outlet structure sized to convey the water quality storm to the storm drainage system or stabilized channel. An emergency spillway is required to convey flows up to the 100-year, 24-hour storm event in the event that the primary outlet structure gets clogged.
- Extended detention shallow wetlands and pond/wetland systems should have an outlet structure sized to convey flows up to the 10-year, 24-hour storm event, at a minimum, to the storm drainage system or stabilized channel. An emergency spillway is required to convey the 100-year storm event if the outlet structure is not designed to pass the 100-year storm event.

Conveyance

- Stormwater should be conveyed to and from all stormwater management practices safely and to minimize erosion potential.
- Stabilize any portion of the stormwater wetland with Turf Reinforcement Matting (TRM) to limit erosion in locations where flow velocities exceed 3 to 5 feet per second (depending on soil and vegetation types) for the 1-year, 24-hour storm event.
- TRM should be a woven material included on the CTDOT Qualified Products List that exceeds the design velocity of the design storm and allows for the growth of the proposed vegetative species.

Liner

- When a stormwater wetland is located such that the bottom of the wetland does not intercept groundwater and the wetland is located in permeable soils, an impermeable liner is needed to maintain a permanent pool of water. A liner is also necessary to avoid impacts to groundwater quality for stormwater wetlands that receive runoff from Land Uses with Higher Potential Pollutant Loads (LUHPPLs) or on contaminated sites.

- If used, should consist of a 30 mil (minimum) HDPE or PVC liner, or one of the alternative liner systems described in Chapter 10 with the approval of the review authority.

Non-clogging Low-Flow Orifice

- A low-flow orifice should be provided, with the size of the orifice sufficient to avoid clogging (recommended minimum orifice diameter of 6 inches, although orifice diameters as small as 3 inches are allowed if required to provide the necessary hydraulic control). The low flow orifice should be protected from clogging using an external trash rack.
- A submerged reverse-slope pipe may also be used that extends downward from the riser to an inflow point one foot below the normal pool elevation.
- Alternative methods are to employ a broad crested rectangular, V-notch, or proportional weir, protected by a half-round pipe that extends at least 12 inches below the normal pool level.

Riser in Embankment

- The riser should be located within the embankment for maintenance access and safety.
- Lockable manhole covers and manhole steps within easy reach of valves and other controls should provide access to the riser.

Drain

- For stormwater wetlands that do not intercept groundwater, the design may include a drain pipe that can completely or partially drain the permanent pool. The drain pipe should have an elbow or protected intake within the outlet pool to prevent sediment deposition in the pipe, and a diameter capable of draining the pool within 24 hours.
- Care should be exercised during draining to prevent rapid drawdown and minimize downstream discharge of sediments or anoxic water. The review/approving authority should be notified before draining the system.

Adjustable Gate Valve

- Both the WQV extended detention pipe and the drain may be equipped with an adjustable gate valve, typically a handwheel activated knife gate valve.
- Valves should be located inside of the riser at a point where they will not normally be inundated and can be operated in a safe manner.

- Both the WQV extended detention pipe and the drain should be sized one pipe size greater than the calculated design diameter.

- To prevent vandalism, the handwheel should be chained to a ringbolt, manhole step, or other fixed object.

Vegetation

- Establishing and maintaining wetland vegetation is critical to the success of stormwater wetlands. Use plants that have high colonization and growth rates, can establish large surface areas that continue through the winter dormant season, have high potential for treating pollutants, and are very robust in flooded environments. Selected species must be able to adapt to a broad range of conditions, including large variations in water depth and inundation. Select vegetation and develop a planting plan in with guidance provided in Appendix F of this Manual.
    - The best depth for establishing emergent wetland plants, either through transplantation or volunteer colonization, is within approximately six inches of the normal pool elevation.
    - Soils should be modified (e.g., scarified or tilled) to mitigate compaction that occurs during construction around the proposed planting sites.
    - Avoid species that require full shade, are susceptible to winterkill, or are prone to wind damage.
    - Woody vegetation may not be planted or allowed to grow within 25 feet of the toe of the embankment and 25 feet from the principal spillway structure.
    - Existing trees should be preserved in the buffer area during construction. It is desirable to locate forest conservation areas adjacent to wetlands. To help discourage resident geese populations, the buffer can be planted with trees, shrubs, and native ground covers.
    - Annual mowing of the wetland buffer is only required along maintenance rights-of-way and the embankment. The remaining buffer can be managed as a meadow (mowing every other year) or forest.
    - Plant the wetland with salt-tolerant vegetation if the stormwater wetland receives road runoff.

Safety Features

- The principal spillway opening must not permit access by small children, and endwalls above pipe outfalls greater than 48 inches in diameter should be fenced to prevent a hazard.

- Both the safety bench and the aquatic bench may be landscaped to prevent access to the pool.

- Fencing around the perimeter of the wetland is generally not encouraged but may be required by some municipalities. The preferred method is to grade the wetland to eliminate dropoffs or other safety hazards.

Maintenance Reduction Features

- Wetlands should be designed with non-clogging outlets, such as a weir, or by incorporating trash racks for culverts and orifice openings.

- To prevent clogging from ice or floatables, a reverse slope outlet pipe can be used to draw water from below the permanent pool up to the outlet structure. The invert of the pipe drawing from the pool should be at least 18 inches from the bottom to prevent sediment discharge.

- Orifices should be less than 6 inches in diameter with a trash rack to prevent clogging. Smaller orifice diameters (3 inches or larger) are allowed if required to provide the necessary hydraulic control.

- Metal components of outlet structures should be corrosion resistant, but not galvanized due to the contribution of zinc to water.

- Outlet structures should be resistant to frost heave and ice action in the wetland.

Cold Climate Design Considerations

The following design elements should be considered to minimize potential performance impacts caused by cold weather:

- Inlet pipes should not be submerged since this can result in freezing and upstream damage or flooding.

- Bury pipes below the frost line to prevent frost heave and pipe freezing. Bury pipes at the point furthest from the pond deeper than the frost line to minimize the length of pipe exposed.

- Increase the slope of inlet pipes to a minimum of 1 percent, if site conditions allow, to prevent standing water in the pipe and reduce the potential for ice formation.

- If perforated riser pipes are used, the minimum orifice diameter should be 0.5 inches. In addition, the pipe should have a diameter of at least 6 inches.

- When a standard weir is used, the minimum slot width should be 3 inches, especially when the slot is tall.

- Baffle weirs can prevent ice formation near the outlet by preventing surface ice from blocking the inlet, encouraging the movement of base flow through the system.

- Riser hoods and reverse slope pipes should draw from at least 6 inches below the typical ice layer. This design encourages circulation in the pond, preventing stratification and formation of ice at the outlet. Reverse slope pipes should not be used for off-line systems.

- Trash racks should be installed at a shallow angle to prevent ice formation.

- Additional storage should be provided to account for storage lost to ice buildup. Ice thickness may be estimated by consulting with local authorities (e.g., the fire department) with knowledge of the typical ice thickness in the area.

Winter Operations

- Stormwater wetlands should not be used as dedicated snow storage areas. To the extent feasible, locate and design the system to avoid snow storage areas and potential damage from snow plowing activities. Refer to Chapter 7 for general design considerations related to winter operations.

Construction Recommendations

- The design engineer should develop a detailed, site-specific construction sequence.

- The design engineer should inspect the installation during the following stages of construction, at a minimum:
    - After excavation of the wetland
    - After internal grading of microtopography, berms, safety benches, etc.
    - After installation of bypass, outlet/overflow, and inlet controls
    - After vegetation and wetland plants/seed mix has been installed

- The design engineer should provide an as-built plan of the completed system along with a certification that the system was designed in accordance with the guidance contained in this Manual and other local or state requirements and that the system was installed in accordance with the approved plans.

- The entire contributing drainage area should be completely stabilized prior to directing any flow to the system. Adequate vegetative cover must be established over any pervious area adjacent or contributing to the system before runoff can be accepted.

- Erosion and sediment controls should be in place during construction in accordance with the Connecticut Guidelines for Soil Erosion and Sediment Control and the Soil Erosion and Sediment Control (SESC) Plan developed for the project.

- Temporary dewatering may be required if excavation extends below the water table. Appropriate sedimentation controls will be required for any dewatering discharges.

- During clearing and grading of the site, measures should be taken to avoid soil compaction at the location of the proposed system to promote growth of vegetation.

- The system should be fenced off during the construction period to prevent disturbance of the soils.
- The system should be excavated to the dimensions, side slopes, and elevations shown on the plans. The method of excavation should avoid compaction of the bottom of the wetland. A hydraulic excavator or backhoe loader, operating outside the limits of the system, should be used to excavate the system. Excavation equipment should not be allowed within the limits of the system.
- Install vegetation in accordance with the planting plan and plant schedule on the plans. Water vegetation thoroughly immediately after planting and as necessary until fully established.
- Stormwater wetlands classified as dams under the CT DEEP dam safety program (generally those with embankments greater than 4 feet above existing grade) should be constructed, inspected, and maintained in accordance with applicable CT DEEP dam safety regulations and guidance.

Maintenance Needs

- Detailed inspection and maintenance requirements, inspection and maintenance schedules, and those parties responsible for maintenance should be identified on the plans and in the Stormwater Management Plan.
- Maintenance should be detailed in a legally binding maintenance agreement.
- Maintenance activities such as sediment removal, mowing, and repairs should be performed with rakes and light-weight equipment rather than heavy construction equipment to avoid soil compaction and damage to vegetation. Heavy equipment may be used for sediment removal and other maintenance activities if the equipment is positioned outside the limits of the system. Heavy construction equipment should not be allowed within the limits of the system for maintenance purposes.

Maintenance Access

- Stormwater wetlands should be designed with easy access to all components of the system for maintenance purposes. In addition to the maintenance reduction design factors described in this section, also refer to Chapter 7 for general design considerations to reduce and facilitate system maintenance.
- A maintenance right-of-way or easement should extend to the wetland from a public road.
- Maintenance access should be at least 12 feet wide, have a maximum slope of no more than 15 percent, and be appropriately stabilized to withstand maintenance equipment and vehicles.

- The maintenance access should extend to the forebay, safety bench, outlet pool, riser, and outlet and be designed to allow vehicles to turn around.
- The principal spillway should be equipped with a removable trash rack, and generally accessible from dry land.

Recommended Maintenance Activities

- Inspect after major storms (1 inch or more of precipitation) in the first few months following construction.
- Inspect sediment forebay twice per year and the rest of the system annually, including inlet and outlet control structures and the pond embankment.
- Refer to Appendix B for maintenance inspection checklists, including items to focus on during the inspections.
- Remove trash and organic debris (leaves) in the Spring and Fall.
- Remove sediment from the sediment forebay or other pretreatment area when it accumulates to a depth of more than 24 inches or 50% of the design depth.
- Remove sediment from the permanent pool when the pool volume has become reduced significantly, or when significant algal growth is observed.
- The vegetative cover should be maintained at 85%. If vegetation has damage, the area should be reestablished in accordance with the original specifications.
- Prune wetland vegetation on a regular schedule. Inspect wetland plants and manage/harvest dead or dying plants as necessary. Plant reinforcement plantings as necessary.
- Periodically mow perimeter grass during the growing season. Maintain perimeter grass at 6 inches or higher. High grass along the wetland edge will discourage waterfowl from taking up residence and serve to filter pollutants.
- Inspect and remove invasive vegetation as necessary.
- Remove trees and woody vegetation within 25 feet of all risers, pipe outlet structures, spillways, and downstream embankments that hold back water.
- Prune other woody vegetation where dead or dying branches are observed.

Other References

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