13.0 Wet Ponds

Definition: **Wet Ponds are stormwater storage practices that consist of a combination of a permanent pool, micropool, or shallow marsh that promote a good environment for gravitational settling, biological uptake and microbial activity. Wet Ponds are widely applicable for most land uses and are best suited for larger drainage areas. Runoff from each new storm enters the wet pond and partially displaces pool water from previous storms. The pool also acts as a barrier to re-suspension of sediments and other pollutants deposited during prior storms. When sized properly, Wet Ponds have a residence time that ranges from many days to several weeks, which allows numerous pollutant removal mechanisms to operate. Wet Ponds can also provide storage above the permanent pool to help meet stormwater management requirements for larger storms. Design variants include:**

- 13-A **Wet Quantity Management Pond**
- 13-B **Wet Extended Detention (ED) Pond**

A Wet ED Pond differs from a typical Wet Quantity Management Pond in that a Wet ED Pond provides 48-hour detention of all or a portion of the Resource Protection Volume (RPv). Optional internal baffles in the Wet ED Pond extend the flow path through the pond from the inflow point to the outlet. In addition, an undersized outlet structure restricts stormwater flow so it backs up and is stored within the Wet ED Pond. The temporary ponding enhances the ability of particulate pollutants to settle out and reduces the maximum peak discharge to the downstream channel, thereby reducing the effective shear stress on banks of the receiving stream.

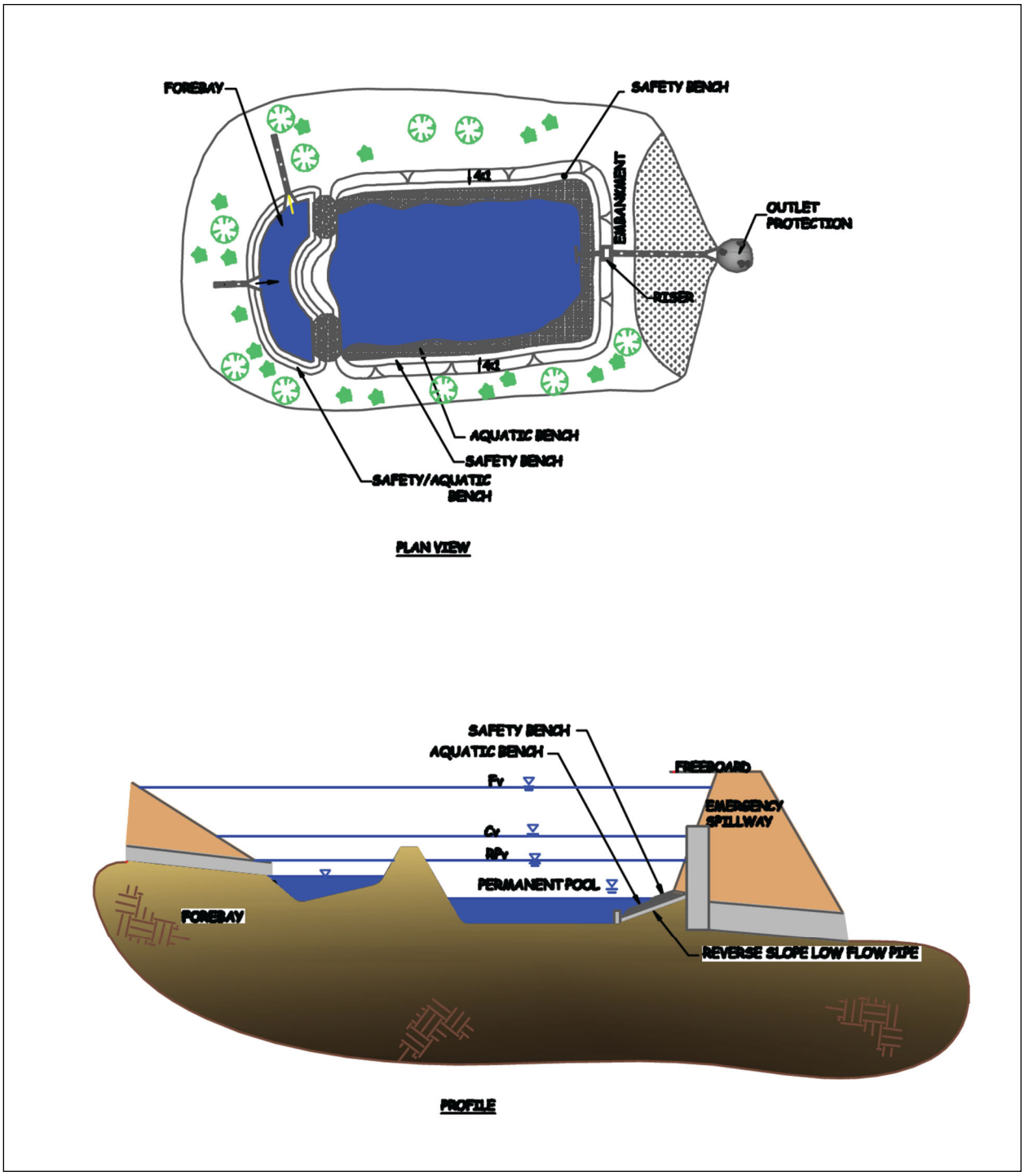

Figure 13.1. Wet Quantity Management Pond (13-A) and Wet ED Pond (13-B) Design Schematics.

13.1 Wet Pond Credit Calculations

Wet Quantity Management Ponds used solely for quantity management receive 0% retention credit (RPv) and 0% pollutant removal credit as outlined in Table 13.1a. Wet ED Ponds that provide 48-hour detention receive full credit for the portion of the RPv managed and pollutant reductions as outlined in Table 13.1b.

Table 13.1a Wet Quantity Management Pond Performance Credits

Runoff Reduction	
Retention Allowance	**0%**
RPv	**0%**
Cv	**0%**
Fv	**0%**
Pollutant Reduction	
TN Reduction	**Not less than 0%**
TP Reduction	**Not less than 0%**
TSS Reduction	**Not less than 0%**

Table 13.1b Wet ED Pond Performance Credits

Runoff Reduction	
RPv – 48-HR Detention Allowance	**100%**
Cv	**1%**
Fv	**0%**
Pollutant Reduction	
TN Reduction	**Not less than 30%**
TP Reduction	**Not less than 55%**
TSS Reduction	**Not less than 60%**

13.2 Wet Pond Practice Summary

Wet Ponds constructed to meet regulatory stormwater management requirements in the State of Delaware shall be designed and constructed in accordance with the USDA NRCS Pond Code 378 as amended. Table 13.2 summarizes the various criteria for Wet Ponds. For more detail on design criteria, consult Sections 13.3 through 13.7. Sections 13.8 describes practice construction and and Section 13.9 describes maintenance criteria.

Table 13.2 Wet Pond Practice Summary

Feasibility Criteria (Section 13.3)	• Adequate groundwater, runoff or baseflow to support permanent pool • Recommended minimum contributory drainage area (CDA) of 10 to 25 acres • Wet Pond surface area size allowance of 1% to 3% of CDA • Contributing slopes <15% • Wet Pond discharge point allows for gravity discharge • Setbacks in accordance with local codes and Appendix 8 • Utilities should not cross the embankment • Seasonal high water table < design permanent pool elevation • HSG C and D soils; HSG A and some HSG B soils may require a liner • **Soil investigations must be conducted to determine suitability of the soils to meet recommended embankment and permanent pool criteria.** • **Locating Wet Ponds within perennial streams will require all appropriate state and federal permits.**
Conveyance Criteria (Section 13.4)	• **Designed and constructed in accordance with USDA NRCS Pond Code 378 as amended** • **Principal spillway must be accessible from dry land.** • **A structure-pipe spillway shall be designed with anti-flotation, anti-vortex and trash rack devices on the structure.** • **The outfall pipe and all connections to the outfall structure shall be made watertight. Soil tight only joints are not acceptable.** • **Anti-seep collars shall be used in accordance with Pond Code 378, as amended.** • **When the principal spillway is composed of a weir wall discharging to a channel, the channel below the weir must be reinforced with riprap or other acceptable material to prevent scour.** • **When a low flow orifice is specified, it must be adequately protected from clogging by either an acceptable external trash rack or by internal orifice protection. Orifice diameters shall not be less than 3 inches unless internal orifice control is provided.** • **The design shall specify an outfall that can discharge the maximum design storm event in a non-erosive manner at the project point of discharge.** • **Wet Ponds must be designed to pass the maximum design storm event (Fv) if the Fv is being routed through the Wet Pond rather than bypassing.** • **An earthen emergency spillway designed to convey the Fv shall be cut in natural ground or, if cut in fill, shall be constructed and stabilized with methods to prevent erosion and structural failure.** • **Inflow points into the Wet Pond must be stabilized to ensure that non-erosive conditions exist during storm events up to the conveyance event (Cv).** • **A forebay shall be provided at each inflow location that provides 10% or greater of the total RPv inflow to the Wet Pond.** • **In the event that the embankment is a regulated dam, the designer must verify that the appropriate Dam Safety Permit has been approved by the Department's Dam Safety Program.**
Pretreatment Criteria	• **A forebay must be located at each major inlet to trap sediment and preserve the capacity of the main treatment cell.**

(Section 13.5)	• **The following criteria apply to forebay design:**
	  o **A major inlet is defined as an individual storm drain inlet pipe or open channel conveying at least 10% of the Wet Pond's contributing RPv runoff volume.**
	  o **A safety bench is required at the pond shoreline for forebay depths greater than 3 feet.**
	  o **The forebay must be sized to contain 10% of the volume of runoff from the contributing drainage area for the Resource Protection event.**
	  o **Discharge from the forebay shall be non-erosive.**

Design Criteria Storage (Section 13.6)	• **For RPv compliance, a Wet ED Pond must provide 48 hours extended detention for the RPv runoff volume.** • **Detention time shall be based on the time of initial inflow to time of final outflow from the facility.** • **In order to simulate a base flow condition to the extent practicable, the peak discharge for the outflow hydrograph shall not exceed five times the average discharge rate.**

Design Criteria Geometry (Section 13.6)	• **Minimum depth = 4'; maximum depth = 8'**
	• **Side slopes no steeper than 3H:1V for earthen side slopes**
	• **Ten foot wide safety bench constructed 1' above permanent pool when side slopes are steeper than 4:1 excluding areas containing retaining walls**
	• **Maximum safety bench slope = 5%**
	• **Ten foot wide aquatic bench constructed 1' below permanent pool**
	• **Retaining walls limited to 50% of perimeter based on the Cv pool elevation and configured as follows:**
	  o **Maximum 3' height above the aquatic bench for a wall at the permanent pool**
	  o **Maximum 2' height for any additional wall and minimum 10' wide terrace from lower wall**

Design Criteria Appurtenances (Section 13.6)	• **A pond liner shall be required when recommended by a licensed, professional geotechnical engineer or geologist.**
	• **When the geotechnical engineer recommends a liner, acceptable options include the following:**
	  o **a clay liner having a minimum compacted thickness of 12 inches with an additional 12 inch layer of compacted soil above it. Clay used as a pond liner must meet the following specifications:**
	  ▪ **Permeability of $1x10^{-6}$ cm/sec using ASTM D-2434 procedure**
	  ▪ **Plasticity index of not less than 15% using ASTM D-423/424 procedures**
	  ▪ **Liquid limit of not less than 30% using ASTM D-2216 procedure**
	  ▪ **Clay particles passing not less than 30% using ASTM D-422 procedure**
	  ▪ **Compaction of 95% of standard proctor density using ASTM D-2216 procedure**
	  o **A 30 mil poly-liner; or**
	  o **Other acceptable measures as recommended by a qualified geotechnical professional.**
	• **Trash racks shall be provided for low-flow pipes and for all riser structure openings.**
	• **All metal trash racks shall be coated with a rust inhibitor to increase longevity of the device.**
	• **The low flow extended detention orifice shall be protected from clogging by an external trash rack.**
	• **Riser structure must be accessible for maintenance**
	• **The Department or the Delegated Agency shall be notified before a Wet Pond is drained.**
	• **Materials meet Pond Code 378 specifications**

Design Criteria Safety (Section 13.6)	• **Safety grates on openings 12" or greater** • **The emergency spillway and exit channel must be designed to direct runoff to a point of discharge without adversely impacting downstream structures** • ~~Fencing of the pond perimeter is discouraged~~
Design Criteria Maintenance Access (Section 13.6)	• **Provide access to forebays, safety bench, riser and outlet structure** • **Maintenance ROW or easement to the Wet Pond from a public or private road** • **Minimum width of access roads = 15', profile grade < 10H:1V with 10H:1V cross slope** • Top of bank should be set back at least 15 feet from property lines • **Maintenance set aside area provided to accommodate 50% of the collective forebay volume** • **Set aside area depth max.1 foot and slope not to exceed 5%**

Landscaping Criteria (Section 13.7)	• **No woody vegetation within 15' of the embankment and 10' on either side of principal spillway or inflow pipes**
	• **A planting plan must be provided that indicates the methods used to establish and maintain vegetative coverage in the Wet Pond and its vegetated perimeter.**
	• **Minimum elements of a planting plan include the following:**
	  ○ **Delineation of zones within both the Wet Pond and vegetated perimeter area**
	  ○ **Selection of corresponding plant species**
	  ○ **Size and spacing of plant material and/or application rate of seed mixes**
	  ▪ **Native plant material shall be specified by botanical and common name**
	  ▪ **Seed mixes shall be specified by botanical and common names as well as percentages by weight or volume**

Construction Criteria (Section 13.8)	• **Approval from the Department or the appropriate Delegated Agency must be obtained before any planned Wet Quantity Management Pond or Wet ED Pond can be used as a sediment basin.**
	• **If a Wet Pond serves as a sediment basin during project construction, the volume of the sediment basin must be based on the more stringent sizing rule**
	• **The Sediment and Stormwater Plan must include conversion steps from sediment basin to permanent Wet Pond in the construction sequence.**
	• **The Department or Delegated Agency must be notified and provide approval prior to conversion from sediment basin to the final configuration of the Wet Quantity Management Pond or Wet ED Pond.**
	• **Appropriate procedures must be implemented to prevent discharge of turbid waters when the sediment basin is being converted into a Wet Pond**
	• **Construction reviews are required during the following stages of construction, and shall be noted on the plan in the sequence of construction:**
	  ○ **Pre-construction meeting**
	  ○ **Initial site preparation including installation of erosion and sediment controls**
	  ○ **Construction of the embankment, including installation of the principal spillway and the outlet structure**
	  ○ **Excavation and grading including interim and final elevations**
	  ○ **Implementation of the planting plan and vegetative stabilization**
	  ○ **Final inspection including development of a punch list for facility acceptance**
	• **All areas surrounding the Wet Pond that are graded or denuded during construction must be planted with turf grass, native plantings, or other approved methods of soil stabilization**
	• **Upon project completion, the owner shall submit Post Construction verification documents to demonstrate that the wet pond has been constructed within allowable tolerances in accordance with the approved Sediment and Stormwater Management Plan and accepted by the approving agency.**
	• **Allowable tolerances for wet pond practices are as follows:**

	○ **The constructed top of bank elevation may be no lower than the design elevation for top of bank.** ○ **The constructed volume of the wet pond surface storage shall be no less than 90% of the design volume.** ○ **The constructed elevation of any structure shall be within 0.15 foot of the design.** • **When the allowable tolerances are exceeded for wet pond surface area or volume or structure elevations, supplemental calculations must be submitted to the approval agency to determine if the wet pond, as constructed, meets the design requirements.**
Maintenance Criteria (Section 1.9)	• **Repair of critical structural features such as embankments and risers shall be performed by responsible personnel that have successfully completed the Department Contractor Training Program** • **The Department or the Delegated Agency shall be notified before a Wet Pond is drained** • **Sediment removal in the Wet Pond pretreatment forebay must occur when 50% of total forebay capacity has been lost** • **Before project completion the Owner shall submit a final post construction stormwater management Operation and Maintenance Plan for the entire stormwater management system. Operation and Maintenance Plans remain valid for the life of the stormwater management system.**

13.3 **Wet Pond Feasibility Criteria**

The following feasibility issues need to be considered when Wet Ponds are considered as a final storm water management practice of the treatment train.

Adequate Water Balance. Wet Ponds should have enough water supplied from groundwater, runoff or baseflow to provide a permanent pool. A simple water balance calculation using the Equations 13.1 and 13.2 provided in Water Balance Testing can help determine the feasibility of the site to support a wet pond.

Contributing Drainage Area. A contributing drainage area of 10 to 25 acres is typically recommended for Wet Ponds to provide a permanent pool. Wet Ponds can still function with drainage areas less than 10 acres, but designers should be aware that these "pocket" ponds will be prone to clogging, experience fluctuating water levels, and generate more nuisance conditions. When the contributing drainage area of the Wet Pond is less than 10 acres, alternative outlet configurations should be used to eliminate the possibility of clogging of the outlet.

Space Requirements. The surface area of a Wet Pond will normally be at least 1% to 3% of its contributing drainage area, depending on the pond's depth.

Site Topography. Wet Ponds are best applied when the grade of contributing slopes is less than 15%.

Available Hydraulic Head. The ultimate discharge point from the Wet Pond should be used to determine the minimum elevation of the permanent pool. The permanent pool elevation will be higher than the outlet elevation in order to have a gravity discharge. In situations where there is little relief on the parcel and the head differential between the permanent pool elevation and the discharge elevation is small, an option for the Wet Pond outlet is a weir and outlet channel

configuration.

Minimum Setbacks. See Appendix 8 Stormwater Facility Setbacks for recommended setbacks.

Proximity to Utilities. Wet Ponds should not be sited such that utility lines would cross any part of the embankment.

Depth-to-Water Table. The depth to the seasonal high water table is an important consideration in planning of a Wet Pond. When the seasonal high water table elevation exceeds the proposed permanent pool elevation of the Wet Pond, the capacity planned for management of the Cv and Fv in the Wet Pond may be taken up by groundwater. Further, if the water table is close to the surface, it may make excavation difficult and expensive.

Soils. Highly permeable soils will make it difficult to maintain a healthy permanent pool. Underlying soils of Hydrologic Soil Group (HSG) C or D should be adequate to maintain a permanent pool. Most HSG A and B soils will not support a permanent pool without the use of a liner (Refer to Liners in 13.6 Wet Pond Design Criteria and Table 13.3.) **Soil investigations must be conducted in accordance with Soil Investigation Procedures to determine the suitability of the soils to meet recommended embankment and permanent pool criteria.** When soil borings confirm HSG A/B soils, an infiltration test should be conducted. If the infiltration test results in an infiltration rate greater than 1.0 inch/hour at the proposed Wet Pond invert, and the seasonal high groundwater table is two feet or more below the proposed Wet Pond invert, a stormwater management BMP other than a Wet Pond or Wet ED Pond should be designed.

Use of or Discharges to Natural Wetlands. Wet Ponds may not be located within jurisdictional waters, including wetlands, without obtaining all appropriate state or federal permits. In addition, the designer should investigate the wetland status of adjacent areas to determine if the discharge from the Wet Pond will change the hydroperiod of a downstream natural wetland (see Cappiella et al., 2006, for guidance on minimizing stormwater discharges to existing wetlands).

Perennial Streams. **Locating Wet Ponds within perennial streams will require all appropriate state or federal permits.**

13.4 Wet Pond Conveyance Criteria

Wet Ponds constructed to meet regulatory stormwater management requirements in the State of Delaware shall be designed and constructed in accordance with the USDA NRCS Pond Code 378 as amended.

Internal Slope. The longitudinal slope of the Wet Pond bottom should be at least 0.5% to facilitate maintenance.

Principal Spillway. The principal spillway may be composed of a structure-pipe configuration or a weir-channel configuration. **The principal spillway must be accessible from dry land. A structure-pipe spillway shall be designed with anti-flotation, anti-vortex and trash rack devices on the structure. The outfall pipe and all connections to the outfall structure shall be made watertight. Soil tight only joints are not acceptable. Anti-seep collars shall be used in accordance with Pond Code 378, as amended. When the principal spillway is composed of a weir wall discharging to a channel, the channel below the weir must be reinforced with riprap or other acceptable material to prevent scour.**

Non-Clogging Low Flow Orifice. **When a low flow orifice is specified, it must be adequately protected from clogging by either an acceptable external trash rack or by internal orifice protection. Orifice diameters shall not be less than 3 inches unless internal orifice control is provided.**

Outfall Protection. **The design shall specify an outfall that can discharge the maximum design storm event in a non-erosive manner at the project point of discharge.** If necessary, the channel immediately below the Wet Pond outfall may be modified to prevent erosion and conform to natural dimensions in the shortest possible distance. This can be accomplished by placing appropriately sized riprap over stabilization geotextile in accordance with HEC-14 Hydraulic Design of Energy Dissipators for Culverts and Channels and Delaware Erosion and Sediment Control Handbook Specification 3.3.10 Riprap Outlet Protection or 3.3.11 Riprap Stilling Basin, which can reduce flow velocities from the principal spillway to non-erosive levels (3.5 to 5.0 fps) based upon the channel lining material. Flared pipe sections, which discharge at or near the stream invert or into a step pool arrangement, should be used at the spillway outlet.

When the discharge is to a manmade pipe or channel system, the system should be adequate to convey the required design storm peak discharge in a non-erosive manner. Care should be taken to minimize tree clearing along the downstream channel, and to reestablish a forested riparian zone in the shortest possible distance. Excessive use of rip-rap should be avoided. The final release rate of the facility should be modified if any increase in flooding or stream channel erosion would result at a downstream structure, highway, or natural point of restricted streamflow unless downstream improvements are made to accommodate the increase.

Emergency Spillway. **Wet Ponds must be designed to pass the maximum design storm event (Fv) if the Fv is being routed through the Wet Pond rather than bypassing. An earthen emergency spillway designed to convey the Fv shall be cut in natural ground or, if cut in fill, shall be constructed and stabilized with methods to prevent erosion and structural failure.**

Inflow Points. **Inflow points into the Wet Pond must be stabilized to ensure that non-erosive conditions exist during storm events up to the conveyance event (Cv).** Inlet pipe inverts should generally be located at the permanent pool elevation. **A forebay shall be provided at each inflow location that provides 10% or greater of the total RPv inflow to the Wet Pond.** Additional information on forebays may be found in 13.5 Wet Pond Pretreatment Criteria.

Dam Safety Permits. The designer should determine whether or not the embankment meets the criteria to be regulated as a dam by the Delaware Dam Safety Regulations. **In the event that the embankment is a regulated dam, the designer must verify that the appropriate Dam Safety Permit has been approved by the Department's Dam Safety Program.**

13.5 Wet Pond Pretreatment Criteria

Sediment forebays are considered to be an integral design feature to maintain the longevity of all Wet Ponds. **A forebay must be located at each major inlet to trap sediment and preserve the capacity of the main treatment cell. The following criteria apply to forebay design:**

- **A major inlet is defined as an individual storm drain inlet pipe or open channel conveying at least 10% of the Wet Pond's contributing RPv runoff volume.**
- The preferred forebay configuration consists of a separate cell, formed by an acceptable barrier such as a concrete weir, riprap berm, gabion baskets, etc. Riprap berms are the preferred barrier material.
- The forebay should be 3 to 4 feet deep. **A safety bench is required at the pond shoreline for forebay depths greater than 3 feet.** The safety bench need not continue around the entire forebay.
- **The forebay must be sized to contain 10% of the volume of runoff from the contributing drainage area for the Resource Protection event.** The relative size of individual forebays should be proportional to the percentage of the total inflow to the Wet Pond. The storage volume within the forebay may be included in the calculated required storage volume for the Wet Pond.
- The recommended minimum length of the forebay is 10 feet. The forebay should have a length to width ratio of 2:1 or greater. Length is measured with the direction of flow into the Wet Pond.
- The forebay should be equipped with a metered rod in the center of the pool (as measured lengthwise along the low flow water travel path) for long-term monitoring of sediment accumulation. Metered wooden stakes may need to be replaced frequently in Wet Pond forebays; alternative materials should be considered for longevity.
- Vegetation may be included within forebays to increase sedimentation and reduce resuspension and erosion of previously trapped sediment.
- **Discharge from the forebay shall be non-erosive.**

13.6 **Wet Pond Design Criteria**

Wet Pond Sizing: In order to receive the credits outlined in Table 13.1b, **for RPv compliance, a Wet ED Pond must provide 48 hours extended detention for the RPv runoff volume. Detention time shall be based on the time of initial inflow to time of final outflow from the facility. In order to simulate a base flow condition to the extent practicable, the peak discharge for the outflow hydrograph shall not exceed five times the average discharge rate.**

Additionally, Wet Quantity Management Ponds and Wet ED Ponds should be sized to manage the Conveyance Event and Flooding Event as required in accordance with the Delaware Sediment and Stormwater Regulations.

For treatment train designs where upland practices are utilized for treatment of the resource protection storm (RPv), designers can use a site-adjusted runoff curve number (RCN) that reflects the volume reduction of upland practices to compute the Cv and Fv that will be treated by the Wet Pond.

Water Balance Testing: A water balance calculation may be required to document that sufficient inflows to Wet Quantity Management Ponds and Wet ED Ponds exist to compensate for combined infiltration and evapo-transpiration losses during a 30-day summer drought without creating unacceptable drawdowns (see Equation 13.1, adapted from Hunt et al., 2007). The recommended minimum pool depth to avoid nuisance conditions may vary; however, it is generally recommended that the water balance maintain a minimum 24-inch reservoir.

Equation 13.1. Water Balance Equation for Acceptable Water Depth in a Wet Pond

$$DP > ET + INF + RES - MB$$

Where:

DP	=	Average design depth of the permanent pool (inches)
ET	=	Summer evapo-transpiration rate (inches) (assume 8 inches)
INF	=	Monthly infiltration loss (assume 7.2 @ 0.01 inch/hour)
RES	=	Reservoir of water for a factor of safety (assume 24 inches)
MB	=	Measured baseflow rate to the Wet Pond, if any (convert to inches)

Design factors that will alter this equation are the measurements of seasonal base flow and infiltration rate. The use of a liner could eliminate or greatly reduce the influence of infiltration. Similarly, land use changes in the upstream watershed could alter the base flow conditions over time (e.g., urbanization and increased impervious cover).

Translating the baseflow to inches refers to the depth within the Wet Pond. Therefore, Equation 13.2 can be used to convert the baseflow, measured in cubic feet per second (ft^3/s), to pond-inches:

Equation 13.2. Baseflow Conversion Equation

$$\text{Pond inches} = (\text{MB in } ft^3/s) * (2.592E6) * (12"/ft) / \text{SA of Pond } (ft^2)$$

Where:

2.592E6	=	Conversion factor: ft^3/s to ft^3/month.

SA = surface area of Wet Pond in ft^2

Wet Pond Storage Design: Volume storage may 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 [ED], and marsh).

A minimum of 50% of the pond area should have the minimum depth of 4 feet in order to prevent the pond from being overgrown by aquatic vegetation, allowing for a more balanced ecosystem to manage pest species.

Maximum Extended Detention Levels: The maximum extended detention volume associated with the Resource Protection volume should occur within the storage for the Conveyance storm (Cv). The total storage, including any ponding for larger flooding events (100-year storm) should not extend more than 5 feet above the permanent pool unless specific design enhancements to ensure side slope stability, safety, and maintenance are identified and approved.

Wet Pond Geometry: Wet Pond designs should have an irregular shape and a long flow path from inlet to outlet, to increase water residence time and Wet Pond performance. Greater flow paths and irregular shapes are recommended. The total length of the flow path compared to the linear length through the Wet Pond from inlet to outlet, should be a minimum ratio of 2:1. Internal berms, baffles, or vegetated peninsulas can be used to extend flow paths and/or create multiple pond cells.

In addition, the ratio of the shortest flow path through the system (due to an inlet located near the outlet) to the overall length should be at least 0.5:1. The drainage area served by any inlets located less than a 0.5:1 ratio should constitute no more than 20% of the total contributing drainage area.

Permanent Pool Depth: **The minimum depth to prevent the permanent pool area from being overtaken by undesirable vegetation is 4 feet. The maximum depth of the permanent pool shall not exceed 8 feet for safety reasons.**

Earthen Side Slopes: **Earthen side slopes for Wet Ponds both above and below permanent pool shall be no steeper than 3H:1V.** Mild slopes promote better establishment and growth of vegetation and provide for easier maintenance and a more natural appearance.

Wet Pond Benches:

- Safety Bench. **Excluding areas containing retaining walls, when Wet Pond side slopes above permanent pool are steeper than 4H:1V, a 10 foot wide safety bench shall be constructed 1 foot above the permanent pool.** The safety bench allows for maintenance access and reduces safety risks. **The maximum slope of the safety bench shall be 5%.**
- Aquatic Bench. An aquatic bench is a shallow area below the permanent pool that promotes growth of aquatic and wetland plants. The bench also serves as a safety feature, reduces

shoreline erosion, and conceals floatable trash. **A 10 foot wide aquatic bench shall be provided 1 foot below permanent pool.**

Retaining Walls: Retaining walls around Wet Ponds shall be limited to no more than 50% of the pond perimeter based upon the peak elevation of the Cv. In order to maintain the safety requirements, retaining walls shall be configured as follows:

- **The retaining wall at the permanent pool shall have a maximum height of 3 feet above the aquatic bench.**
- **Any additional retaining walls shall have a maximum height of 2 feet and provide a minimum 10-foot level terrace from a lower retaining wall.**

Liners: Highly permeable soils will make it difficult to maintain a healthy permanent pool. **All wet ponds shall be evaluated for feasibility and ability to maintain permanent pool, including the need for a liner, by a qualified, licensed geotechnical engineer or geologist. If the pond designer chooses not to follow the recommendations of the geotechnical professional, a signed and sealed letter from the designer providing justification for the design shall be provided to DNREC or their delegated Agency.**

When the geotechnical engineer recommends a liner, acceptable options include the following:

(1) a clay liner having a minimum compacted thickness of 12 inches with an additional 12 inch layer of compacted soil above it. Clay used as a pond liner must meet the following specifications:

a. Permeability of $1x10^{-6}$ cm/sec using ASTM D-2434 procedure
b. Plasticity index of not less than 15% using ASTM D-423/424 procedures
c. Liquid limit of not less than 30% using ASTM D-2216 procedure
d. Clay particles passing not less than 30% using ASTM D-422 procedure
e. Compaction of 95% of standard proctor density using ASTM D-2216 procedure

(2) A 30 mil poly-liner; or

(3) **Other acceptable measures as recommended by a qualified geotechnical professional.**

Trash Racks: **Trash racks shall be provided for low-flow pipes and for all riser structure openings.** Open weirs that discharge to an open channel will not require trash racks. Synthetic trash rack materials options are available and should be considered. **All metal trash racks shall be coated with a rust inhibitor to increase longevity of the device.**

Non-clogging Low Flow (Extended Detention) Orifice: **The low flow extended detention orifice shall be protected from clogging by an external trash rack.** The preferred method is a hood apparatus over the orifice that reduces gross pollutants such as floatables and trash, as well as oil and grease and sediment.

Orifices less than 3 inches in diameter may require extra attention during design, to minimize the potential for clogging. As an alternative, internal orifice protection may be used (i.e., an orifice internal to a perforated vertical stand pipe with 0.5-inch perforations or slots that are protected by wire-cloth and a stone filtering jacket). Floating skimmers, seepage berms, French drains or other similar measures may be a better alternative to provide the 48-hour detention required for Wet ED Ponds if the orifice diameter is too small.

Riser: **When a riser is used, it must be located such that it is accessible from the pond side slope or safety bench for the purposes of inspection and maintenance.** The riser may be located within the embankment for maintenance access, safety, and aesthetics. Where appropriate, access to the riser may be provided by manhole covers and manhole steps within easy reach of valves and other controls.

Pond Drain: Wet Ponds should have a drain pipe that can completely or partially drain the permanent pool. In cases where a low level drain is not feasible (such as in an excavated Wet Pond), the Operation and Maintenance Plan should include requirements for dewatering the Wet Pond.

- The drain pipe should have an upturned elbow or protected intake within the Wet Pond to help keep it clear of sediment deposition, and a diameter capable of draining the Wet Pond within 24 hours.
- The Wet Pond drain should be equipped with an adjustable valve located within the riser, where it will not be normally inundated and can be operated in a safe manner.

Care should be exercised during Wet Pond drawdowns to prevent downstream discharge of sediments or anoxic water and rapid drawdown. **The Department or the Delegated Agency shall be notified before a Wet Pond is drained.**

Adjustable Gate Valve: If desired to adjust the pond permanent pool elevation, both the outlet pipe and the Wet Pond drain should be equipped with an adjustable gate valve (typically a hand wheel activated knife gate valve) or pump well and be sized one pipe size greater than the calculated design diameter. Valves should be located inside of the riser at a point where they (a) will not normally be inundated and (b) can be operated in a safe manner. To prevent vandalism, the hand wheel should be chained to a ringbolt, manhole step or other fixed object.

Material Specifications: **All materials used in construction of a Wet Quantity Management Pond or Wet ED Pond shall meet the material specifications in USDA NRCS Pond Code 378 as amended.**

Safety Features:

- **Any opening 12 inches or greater discharging to a closed drainage system shall include safety grates.**
- **The emergency spillway and exit channel must be designed to direct runoff to a point of discharge without adversely impacting downstream structures.**
- Stormwater management systems designed with a permanent pool that are reasonably accessible to the public should consider barriers around the system to restrict public access. The barrier should not inhibit facility function or maintenance access.
- ~~Fencing of the perimeter of Wet Ponds is discouraged.~~ The preferred method to reduce risk is to manage the contours of the Wet Pond to eliminate drop-offs or other safety hazards.
- Warning signs may be posted.

Maintenance Reduction Features: The following Wet Pond maintenance issues can be addressed during the design, in order to make on-going maintenance easier:

- Maintenance Access. **All Wet Ponds must be designed so as to be accessible for maintenance.** Good access is needed so crews can remove sediments, make repairs and preserve Wet Pond treatment capacity.
  - **Adequate maintenance access must extend to the pretreatment, safety bench, riser, and outlet structure.**
  - **A maintenance right-of-way or easement must extend to the Wet Pond from a public or private road.**
  - **Maintenance access must meet the following criteria:**
    - **Minimum width of 15 feet.**
    - **Profile grade that does not exceed 10H:1V.**
    - **Minimum 10H:1V cross slope.**
  - Local ordinances and design criteria should be consulted to determine minimum setbacks to property lines. When not specified in local code, the top of bank of Wet Ponds should be set back at least 15 feet from property lines to ensure maintenance access.

- **Maintenance Set-Aside Area**: Adequate land area adjacent to the Wet Pond should be provided for in the Operation and Maintenance Plan as a location for disposal of sediment removed from the Wet Pond when maintenance is performed. The maintenance set-aside area is necessary on all sites adjacent to the Wet Pond to adequately dewater sediment removed from the pond prior to spreading and seeding or transporting from the site.
  - **The maintenance set-aside area shall accommodate the volume of 50% of the collective forebay volume.**
  - **The maximum depth of the set aside area shall be one foot.**
  - **The slope of the set aside area shall not exceed 5%**.
  - The area and slope of the set aside area may be modified if an alternative area or method of disposal is approved by the Department or Delegated Agency.

13.7 Wet Pond Landscaping Criteria

Woody Vegetation: **Woody vegetation shall not be planted or allowed to grow within 15 feet of the embankment and 10 feet on either side of principal spillway or inflow pipes.** These recommendations may be relaxed in situations where Wet Ponds are constructed adjacent to existing forested areas.

Planting Plan: **A planting plan must be provided that indicates the methods used to establish and maintain vegetative coverage in the Wet Pond and its vegetated perimeter.** Avoid species that require full shade, or are prone to wind damage. Extra mulching around the base of trees and shrubs is strongly recommended as a means of conserving moisture and suppressing weeds. See Appendix 2. Landscaping Guidelines for additional information.

Minimum elements of a planting plan include the following:

- **Delineation of zones within both the Wet Pond and vegetated perimeter area**
- **Selection of corresponding plant species**
- **Size and spacing of plant material or application rate of seed mixes, as applicable**
    - **Native plant material shall be specified by botanical and common name**
    - **Seed mixes shall be specified by botanical and common names as well as percentages by weight or volume**

13.8 Wet Pond Construction

Use of Wet Ponds for Erosion and Sediment Control. A Wet Pond may serve as a sediment basin during project construction. **Approval from the Department or the appropriate Delegated Agency must be obtained before any planned Wet Quantity Management Pond or Wet ED Pond can be used as a sediment basin. If a Wet Pond serves as a sediment basin during project construction, the volume of the sediment basin must be based on the more stringent sizing rule** (erosion and sediment control requirement vs. storage volume requirement)**.** Installation of the permanent principal spillway should be initiated during the construction phase, and design elevations should be set with final cleanout of the sediment basin and conversion to the post-construction Wet Pond in mind.

The Sediment and Stormwater Plan must include conversion steps from sediment basin to permanent Wet Pond in the construction sequence. The Department or Delegated Agency must be notified and provide approval prior to conversion from sediment basin to the final configuration of the Wet Quantity Management Pond or Wet ED Pond. Appropriate procedures must be implemented to prevent discharge of turbid waters when the sediment basin is being converted into a Wet Pond.

Construction Review. Multiple construction reviews are critical to ensure that Wet Ponds are properly constructed. **Construction reviews are required during the following stages of**

construction, and shall be noted on the plan in the sequence of construction:

- **Pre-construction meeting**
- **Initial site preparation including installation of erosion and sediment controls**
- **Construction of the embankment, including installation of the principal spillway and the outlet structure**
- **Excavation and grading including interim and final elevations**
- **Implementation of the planting plan and vegetative stabilization**
- **Final inspection including development of a punch list for facility acceptance**

Construction Sequence. The following is a typical construction sequence to properly install a Wet Pond. The steps may be modified to reflect different Wet Pond designs, site conditions, and the size, complexity and configuration of the proposed facility.

Step 1: Stabilize the Drainage Area. If the proposed Wet Pond site will be used as a sediment trap or basin during the construction phase, the construction notes should clearly indicate that the facility will be de-watered, dredged and re-graded to design dimensions after the original site construction is complete.

Step 2: Assemble Construction Materials on-site, make sure they meet design specifications, and prepare any staging areas. Ensure that appropriate compaction and dewatering equipment is available. Locate the project benchmark and if necessary transfer a benchmark nearer to the Wet Pond location for use during construction.

Step 3: Install Erosion and Sediment Controls prior to construction, including temporary de-watering devices and stormwater diversion practices. **All areas surrounding the Wet Pond that are graded or denuded during construction must be planted with turf grass, native plantings, or other approved methods of soil stabilization.**

Step 4: Clear and Strip the embankment area to the desired sub-grade.

Step 5: Excavate the Cutoff Trench and Install the Principal Spillway Pipe in accordance with construction specification of USDA NRCS Pond Code 378 as amended.

Step 6: Install the Riser or Outflow Structure, and ensure the top invert of the overflow weir is constructed level at the design elevation.

Step 7: Construct the Embankment and Any Internal Berms using acceptable material in 8- to 12-inch lifts, compact the lifts with appropriate equipment. Construct the embankment allowing for 10% settlement of the embankment.

Step 8: Excavate/Grade until the appropriate elevation and desired contours are

achieved for the bottom and side slopes of the Wet Pond. Construct forebays at the proposed inflow points.

Step 9: Construct the Emergency Spillway in cut or structurally stabilized soils.

Step 10: Install Outlet Pipes, including any flared end sections, headwalls, and downstream rip-rap outlet protection underlain by stabilization geotextile.

Step 11: Stabilize Exposed Soils with the approved seed mixtures appropriate for the Wet Pond perimeter area. All areas above the permanent pool elevation should be permanently stabilized in accordance with the vegetative stabilization specifications on the approved Sediment and Stormwater Management Plan.

Step 12: Plant the Wet Pond Benches and Vegetated Perimeter Area, following the planting plan (see Section 13.7 Wet Pond Landscaping Criteria).

Post Construction Verification Documentation. **Upon project completion, the owner shall submit Post Construction verification documents to demonstrate that the wet pond has been constructed within allowable tolerances in accordance with the approved Sediment and Stormwater Management Plan and accepted by the approving agency.**
Allowable tolerances for wet pond practices are as follows:

- **The constructed top of bank elevation may be no lower than the design elevation for top of bank.**
- **The constructed volume of the wet pond surface storage shall be no less than 90% of the design volume.**
- **The constructed elevation of any structure shall be within 0.15 foot of the design.**

When the allowable tolerances are exceeded for wet pond surface area or volume or structure elevations, supplemental calculations must be submitted to the approval agency to determine if the wet pond, as constructed, meets the design requirements.

13.9 Wet Pond Maintenance Criteria

Maintenance is needed so Wet Ponds continue to operate as designed on a long-term basis. Wet Pond maintenance activities vary regarding the level of effort and expertise required to perform them. Routine Wet Pond maintenance, such as mowing and removing debris and trash, is needed several times each year (See Table 13.4).

More significant maintenance (e.g., removing accumulated sediment) is needed less frequently but requires more skilled labor and special equipment. Inspection of critical structural features such as embankments and risers should be performed by a Certified Construction Reviewer or licensed professional who has experience in the construction, inspection, and repair of these features**. Repair of critical structural features such as embankments and risers shall be performed by responsible personnel that have successfully completed the Department Contractor Training Program.**
The Department or the Delegated Agency shall be notified before a Wet Pond is drained.

Sediment removal in the Wet Pond pretreatment forebay must occur when 50% of total forebay capacity has been lost. The owner can plan for this maintenance activity to occur every 5 to 7 years.

Sediment removed from the Wet Pond should be deposited in the designated maintenance set aside area for dewatering, prior to leveling and stabilization or removal from the site. Sediments excavated from Wet Ponds are not usually considered toxic or hazardous. They can be safely disposed of by either land application or land filling. Sediment testing may be needed prior to sediment disposal if the Wet Pond serves a hotspot land use.

Community awareness can contribute to a properly maintained Wet Pond. Signs describing the function and/or minimum maintenance requirements for the Wet Pond may be posted at the Wet Pond location to increase community awareness.

Table 13.4. Typical Wet Pond Maintenance Items and Frequency

Frequency	Maintenance Items
During establishment, as needed (first year)	• Inspect the site after storm event that exceeds 0.5 inches of rainfall. • Stabilize any bare or eroding areas in the contributing drainage area including the Wet Pond perimeter area • Water trees and shrubs planted in the Wet Pond vegetated perimeter area during the first growing season. In general, water every 3 days for first month, and then weekly during the remainder of the first growing season (April - October), depending on rainfall.
Quarterly or after major storms (>1 inch of rainfall)	• Remove debris, trash and blockages • Repair undercut, eroded, and bare soil areas
Twice a year	• Mowing of the Wet Pond vegetated perimeter area and embankment
Annually	• Shoreline cleanup to remove trash, debris and floatables • A full maintenance review ▪ Open up the riser to access and test the valves ▪ Repair broken mechanical components, if needed
Every 5 to 7 years	• Forebay sediment removal
From 5 to 25 years	• Repair pipes, riser, spillway, and embankment as needed • Remove sediment from Wet Pond area outside of forebays

Before project completion the Owner shall submit a final post construction stormwater management Operation and Maintenance Plan for the entire stormwater management system. Operation and Maintenance Plans remain valid for the life of the stormwater management system. The Operation and Maintenance Plan will specify the property owner's primary maintenance responsibilities and authorize the Department or Delegated Agency staff to access the property for maintenance review or corrective action in the event that proper

maintenance is not performed.

Operation and Maintenance Plans should clearly outline how vegetation in the Wet Pond and its vegetated perimeter area will be managed or harvested in the future. Periodic mowing of the Wet Pond vegetated perimeter area is only required along the maintenance access and the embankment. The remaining Wet Pond perimeter can be managed as a meadow (mowing every other year) or forest. The maintenance plan should schedule a shoreline cleanup at least once a year to remove trash and floatables.

Maintenance of a Wet Pond is driven by annual maintenance reviews that evaluate the condition and performance of the Wet Pond. Based on maintenance review results, specific maintenance tasks may be required.

13.10 References

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