10.0 Detention Practices

Definition: **Detention Practices are storage practices that are explicitly designed to provide stormwater detention for the Conveyance Event, Cv (10-year) and Flooding Event, Fv (100-year).**

Design variants include:

- 10-A **Dry Detention Pond**
- 10-B **Dry Extended Detention (ED) Basin**
- 10-C **Underground Detention Facilities**

Dry Detention Ponds and Dry ED Basins are widely applicable for most land uses and are best suited for larger drainage areas. An outlet structure restricts stormwater flow, so it backs up and is stored within the basin. The temporary ponding reduces the maximum peak discharge to the downstream channel, thereby reducing the effective shear stress on the bed and banks of the receiving stream. Dry Detention Ponds receive some credit for pollutant removal, while Dry ED Basins receive both runoff reduction and pollutant removal credits.

The key difference between Dry Detention Ponds and Dry ED Basins is that, in addition to management of the Cv and Fv, a Dry ED Basin provides 48-hour detention of the Resource Protection Volume (RPv). An under-sized outlet structure restricts stormwater flow so it backs up, is stored within the basin, and released at a slower rate. The temporary ponding enables 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. Unlike the Dry Detention Pond's stormwater detention, extended detention is designed to achieve a minimum drawdown time, rather than a maximum peak rate of flow. Dry Detention Ponds, which are designed only to manage the larger Cv and Fv will often detain smaller storm events for only a few minutes or hours.

Underground Detention Facilities include vaults and tanks. Underground Detention Vaults are box-shaped underground stormwater storage facilities typically constructed with reinforced concrete. Underground Detention Tanks are underground storage facilities typically constructed

with large diameter metal or plastic pipe. Both serve as an alternative to surface dry detention for stormwater quantity control, particularly for space-limited areas where there is not adequate land for a dry detention basin or multi-purpose detention area. Prefabricated concrete vaults are available from commercial vendors. In addition, several pipe manufacturers have developed packaged detention systems. Unless they provide 48-hour extended detention, underground detention vaults do not receive any runoff reduction or pollutant removal credit and should be considered only for management of larger storm events.

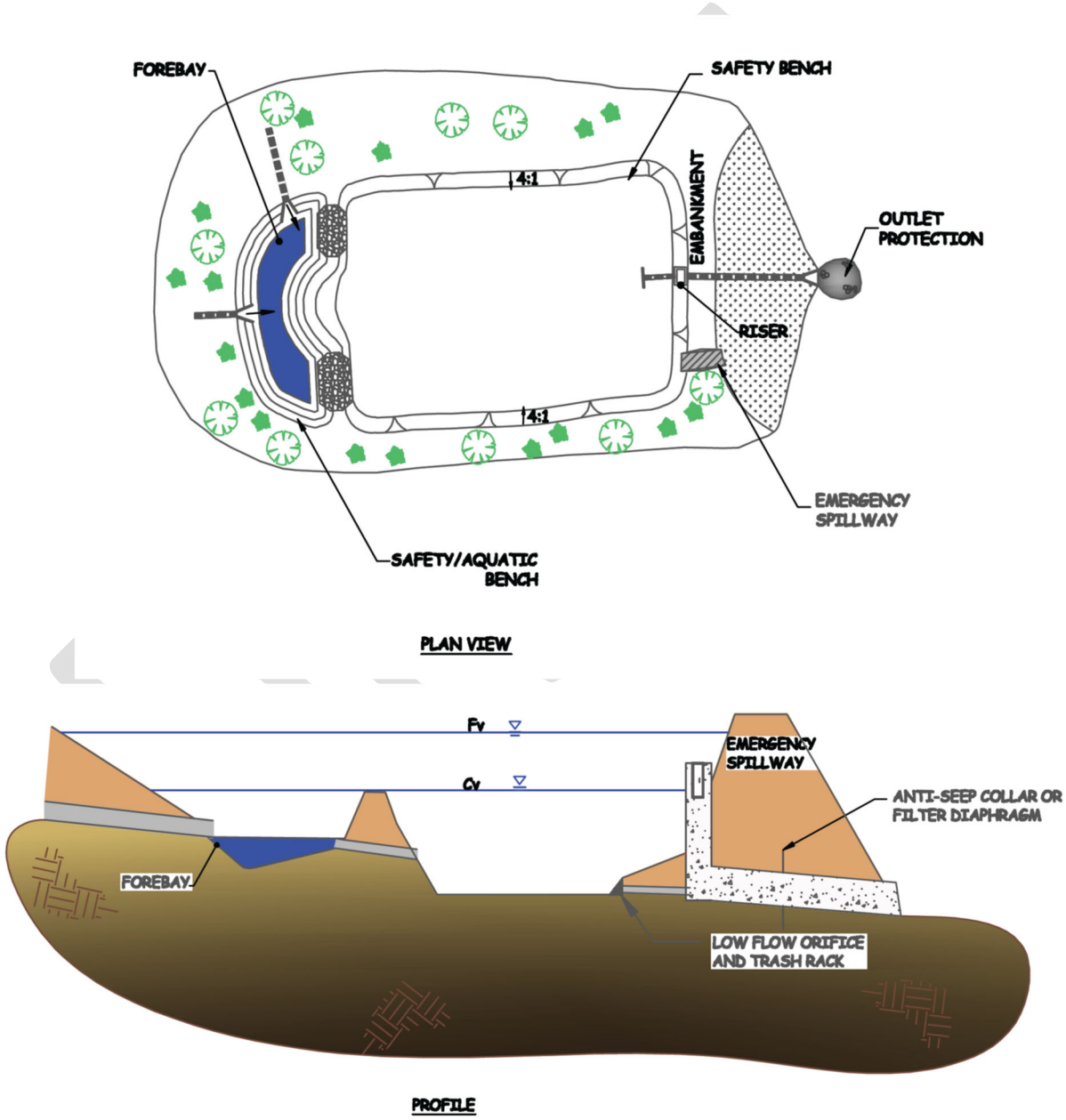

Figure 10.1. Example of a Dry Detention Pond (10-A)

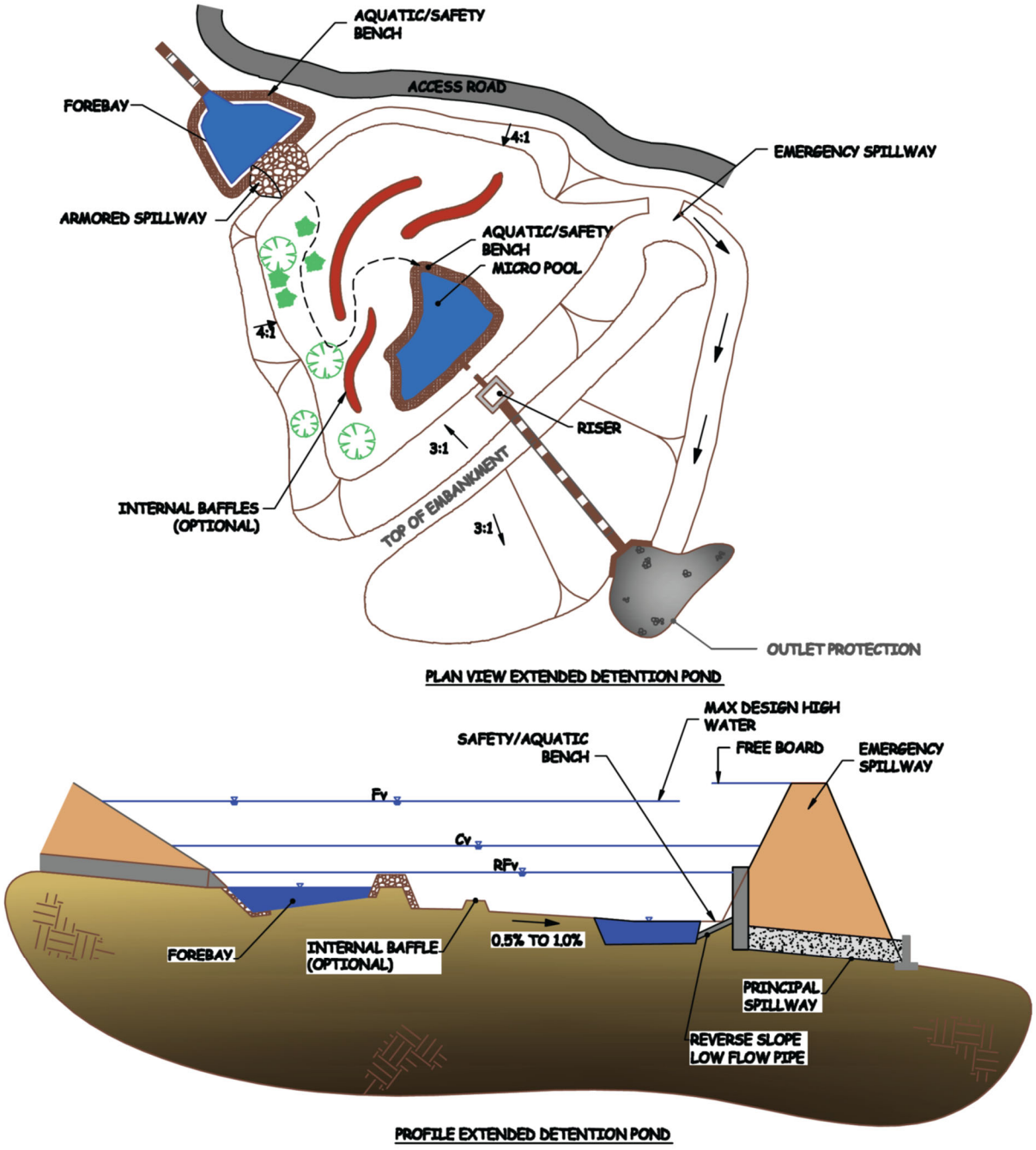

Figure 10.2. Example of a Dry Extended Detention Basin (10-B)

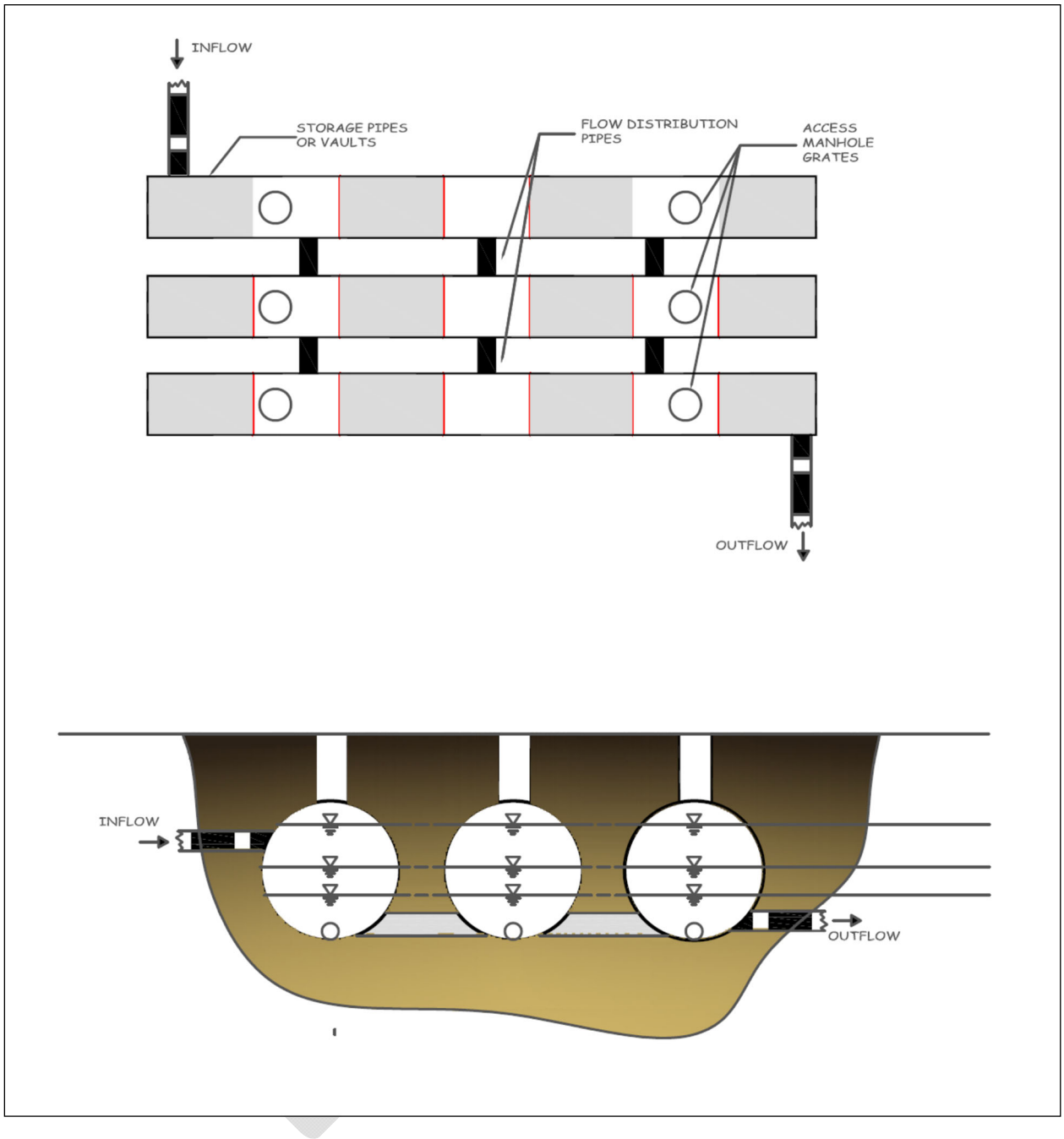

Figure 10.3. Example of an Underground Detention Facility (10-C)

10.1 Detention Practices Stormwater Credit

Dry Detention Ponds and Dry ED Basins constructed to meet regulatory stormwater management requirements in the State of Delaware shall be designed and constructed in accordance with the USDA NRCS Delaware Pond Code 378 as amended. Dry Detention Ponds and Dry ED Basins receive pollutant removal credits as follows in Table 10.1 and 10.2. **Full runoff reduction credit is given for detention practices that provide 48-hour extended detention of the full RPv.**

Table 10.1 Dry Detention Pond and Underground Detention Facilities Performance Credits

Runoff Reduction	
Retention Allowance	**0%**
RPv -A/B Soil	**0%**
RPv - C/D Soil	**0%**
Cv	**0%**
Fv	**0%**
Pollutant Reduction	
TN Reduction	**Not less than 5%**
TP Reduction	**Not less than 10%**
TSS Reduction	**Not less than 10%**

Table 10.2 Dry 48-hour ED Basin and Underground Detention Facilities with 48-hour ED Performance Credits

Runoff Reduction	
RPv – Detention Allowance	**100%**
Cv	**1%**
Fv	**0%**
Pollutant Reduction	
TN Reduction	**Not less than 20%**
TP Reduction	**Not less than 20%**
TSS Reduction	**Not less than 60%**

Because Detention Practices are designed for larger storm events, rather than the RPv, the credits above are “fixed” credits. They are not based on the relative size of the practice.

10.2 Detention Practices Summary

Table 10.3 summarizes feasibility, design, construction and maintenance criteria for Detention Practices. For more detail, consult Sections 10.3 through 10.97.

Table 10.3 Detention Practices Summary

Feasibility Criteria (Section 10.3)	• 1%-3% of CDA for footprint • Recommended minimum CDA = 10 acres • Refer to Appendix A-8 for setback requirements. • **Dry Detention Ponds or Dry ED Basins shall not be allowed if the seasonal high water table or bedrock will be within 1 foot of the floor of the pond.** • **Non-watertight Underground Detention Facilities shall be no lower than the seasonal high water table and 2 feet above bedrock.** • **For watertight Underground Detention Facilities, an anti-flotation analysis is required to check for buoyancy problems in seasonal high water table areas** • **Soil Investigation Procedures shall be followed for testing.** • **Underground Detention Facilities must meet structural requirements for bearing capacity, overburden support, and traffic loading as determined by a licensed design professional, and based upon manufacturer's recommendations where applicable.**
Conveyance Criteria (Section 10.4)	• **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.** • **A structure-pipe spillway shall be designed with anti-flotation, anti-vortex and trash rack devices on the structure.** • **A structure-pipe spillway shall be designed with anti-flotation, anti-vortex and trash rack devices on the structure.** • **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.** • **For Dry ED Basins, the control structure must include an outlet that will slowly release the RPv over a 48-hour period.** • **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.** • **Dry Detention Ponds and Dry ED Basins must be designed to pass the maximum design storm event (Fv) if the Fv is being routed through the Dry Detention Ponds and Dry ED Basins rather than bypassing.** • **Inflow points into the Dry Detention Ponds and Dry ED Basins 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 Dry Detention Ponds and Dry ED Basins.**

Conveyance Criteria (Section 10.4) *cont.*	• **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.** • **For Underground Detention Facilities, an internal or external high flow bypass or overflow shall be included in the design to safely pass the Fv.**
Pretreatment Criteria (Section 10.5)	• Forebays maintain the longevity of all Dry Detention Ponds and Dry ED Basins • **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:** o **A major inlet is defined as an individual storm drain inlet pipe or open channel conveying at least 10% of the Dry Detention Pond's and Dry ED Basin's contributing RPv runoff volume.** o **The forebay shall be no deeper 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.** • **Every underground detention practice shall have pretreatment mechanisms to protect the long term integrity of the practice.**
Design Criteria (Section 10.6)	• **Dry Detention Ponds and Dry ED Basins constructed to meet regulatory stormwater management requirements in the State of Delaware shall be designed and constructed in accordance with the USDA NRCS Delaware Pond Code 378 as amended.** • **In order to simulate a baseflow condition to the extent practicable, the peak discharge for the outflow hydrograph shall not exceed five times the average discharge rate.** • **Earthen side slopes shall be designed and constructed no steeper than 3H:1V.** • **Retaining walls around Dry Detention Ponds and Dry ED Basins 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:** o **The retaining wall shall have a maximum height of 3 feet.** o **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.** • **Any opening 12 inches or greater discharging to a closed drainage system shall include safety grates.** • **The emergency spillway must be located so that downstream structures will not be impacted by spillway discharges.** • **The emergency spillway exit channel must be designed to direct runoff to a point of discharge without impact to downstream structures.** • **Maintenance access must meet the following criteria:** o **Minimum width of 15 feet.** o **Profile grade that does not exceed 10H:1V.** o **Minimum 10H:1V cross slope** • **Maintenance Set-Aside Area:** o **The maintenance set-aside area shall accommodate the volume of 50% of the collective forebay volume.** o **The maximum depth of the set aside volume shall be one foot.** o **The slope of the set aside area shall not exceed 5%.**

Design Criteria (Section 10.6) *cont.*	• **Detention Vault and Tank Materials:**
	  o **All construction joints and pipe joints shall be water tight.**
	  o **Cast-in-place wall sections must be designed as retaining walls.**
	• **For watertight Underground Detention Facilities, anti-flotation analysis is required to check for buoyancy problems in the high water table areas. Anchors shall be designed to counter the pipe and structure buoyancy by at least a 1.2 factor of safety.**

Landscaping Criteria (Section 10.7)	• **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.** • **For Dry Detention Ponds and Dry ED Basins, a planting plan shall be provided that indicates the methods used to establish and maintain vegetative coverage within the Detention Practice and its vegetated perimeter area.** • **Minimum elements of a plan include seed mixes by botanical and common names as well as percentages by weight or volume.**

Construction Criteria (Section 10.8)	• **Construction of proprietary Underground Detention Facilities must be in accordance with manufacturer's specifications.**
	• **Underground Detention Facilities must be inspected and cleaned of sediment after the site is stabilized.**
	• **Approval from the Department or the appropriate Delegated Agency must be obtained before any planned Dry Detention Ponds and Dry ED Basins can be used as a sediment basin. If a Dry Detention Pond or Dry ED Basin serves as a sediment basin during project construction, the volume of the sediment basin must be based on the more stringent sizing rule.**
	• **When the sediment basin is being converted into a Dry Detention Pond or Dry ED Basin, the sediment basin shall be dewatered in accordance with the approved plan and appropriate details from the Delaware Erosion and Sediment Control Handbook prior to removing accumulated sediment and regrading the pond bottom.**
	• **The Sediment and Stormwater Plan must include conversion steps from sediment basin to permanent Dry Detention Ponds and Dry ED Basins 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 Dry Detention Pond or Dry ED Basin.**
	• **Appropriate procedures must be implemented to prevent discharge of turbid waters when the sediment basin is being converted into a Dry Detention Pond or Dry ED Basin.**
	• **Construction reviews are required during the following stages of construction, and shall be noted on the plan in the sequence of construction:**
	  o **Pre-construction meeting**
	  o **Initial site preparation including installation of erosion and sediment controls**
	  o **Construction of the embankment, including installation of the principal spillway and the outlet structure**
	  o **For Dry Detention Pond and Dry ED Basin – excavation and grading including interim and final elevations**
	  o **For Underground Detention – subgrade, placement of stone, system components in accordance with manufacturer's recommendations and backfill**
	  o **Implementation of the planting plan and vegetative stabilization**
	  o **Final inspection including development of a punch list for facility acceptance**

Construction Criteria (Section 10.8) *cont.*	• **Upon facility completion, the owner shall submit post construction verification documents to demonstrate that the Detention Practice has been constructed within allowable tolerances and in accordance with the approved Sediment and Stormwater Management Plan and accepted by the approving agency.**
	• **Allowable tolerances for Dry Detention Pond and Dry ED Basin are as follows:**
	  o **The constructed top of bank elevation may be no lower than the design elevation for top of bank.**
	  o **The constructed volume of the dry pond surface storage shall be no less than 90% of the design volume.**
	  o **The constructed elevation of any structure shall be within 0.15 foot of the design.**
	• **Allowable tolerances for Underground Detention Facilities are as follows:**
	  o **Grate and invert elevations of all structures, including weirs shall be within 0.15 foot of the design.**
	  o **Diameter of all pipes or dimensions of chambers within underground detention facility shall be as shown on the plan.**
	  o **Dimension of any weirs shall be within 10% of the design.**
	• **When the allowable tolerances are exceeded for volume or structure elevations, supplemental calculations must be submitted to the approval agency to demonstrate that the Detention Practice, as constructed, meets the design requirements.**

Maintenance Criteria (Section 10.9)	• **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.** • **Sediment removal in the Dry Detention Pond or Dry ED Basin pretreatment practice 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.**

10.3 Detention Practices Feasibility Criteria

The following feasibility issues need to be evaluated when Detention Practices are considered:

EPA Requirements for Class V Injection Wells. Certain types of practices in this category, particularly Underground Detention Facilities, may be classified as Class V Injection Wells, which are subject to regulations under the Federal Underground Injection Control (UIC) program. In general, if the facility allows stormwater runoff to come in direct contact with groundwater it would meet this criterion. Facilities with a minimum 2-foot vadose zone separation from the groundwater table would not meet the criterion. Designers are advised to contact the DNREC Groundwater Discharges Section for additional information regarding UIC regulations and possible permitting requirements.

Space Required. A typical Detention Practice requires a footprint of 1% to 3% of its contributing

drainage area, depending on the depth of the Dry Detention Pond, Dry Extended Detention Basin, or Underground Detention Facility (i.e., the deeper the practice, the smaller footprint needed).

Dry Detention Ponds and Dry ED Basins can 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 Dry Detention Ponds and Dry ED Basins is less than 10 acres, alternative outlet configurations should be used to eliminate the possibility of clogging of the outlet.

Underground Detention Systems can be located downstream of other structural stormwater controls providing treatment of the design storm. For treatment train designs where upland practices are used for treatment of the RPv, designers can use a site-adjusted curve number (CN) that reflects the volume reduction of upland practices and likely reduce the size and cost of detention (see *Section 10.6. Detention Practice Design Criteria*).

Minimum Setbacks. Refer to Appendix A-8.

Depth-to-Water Table and Bedrock. Dry Detention Ponds or Dry ED Basins shall not be allowed if the seasonal high water table or bedrock will be within 1 foot of the floor of the pond. Non-watertight Underground Detention Facilities shall be no lower than the seasonal high water table and 2 feet above bedrock. For watertight Underground Detention Facilities, an anti-flotation analysis is required to check for buoyancy problems in seasonal high water table areas. Soil Investigation Procedures shall be followed for testing.

Structural Stability. **Underground Detention Facilities must meet structural requirements for bearing capacity, overburden support, and traffic loading as determined by a licensed design professional, and based upon manufacturer's recommendations where applicable**.

10.4 Detention Practice Conveyance Criteria

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 USDA NRCS Delaware 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 Outlet. F**or Dry ED Basins, the control structure must include an outlet that will slowly release the RPv over a 48-hour period. 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 Dry Detention Pond and Dry ED Basin 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. Dry Detention Ponds and Dry ED Basins must be designed to pass the maximum design storm event (Fv) if the Fv is being routed through the Dry Detention Ponds and Dry ED Basins 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 Dry Detention Ponds and Dry ED Basins 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 Dry Detention Ponds and Dry ED Basins.** Additional information on forebays may be found in 10.5 Detention Practices 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.

Bypass. **For Underground Detention Facilities, an internal or external high flow bypass or overflow shall be included in the design to safely pass the Fv.**

10.5 Detention Practices Pretreatment Criteria

Pretreatment Forebay.

Sediment forebays are considered to be an integral design feature to maintain the longevity of all Dry Detention Ponds and Dry ED Basins. **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 Dry Detention Pond's and Dry ED Basin'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 shall be no deeper than 3 feet.**
- **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 Dry Detention Pond and Dry ED Basin. The storage volume within the forebay may be included in the calculated required storage volume for the Dry Detention Pond and Dry ED Basin.
- 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 Dry Detention Pond and Dry ED Basin.
- 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 Dry Detention Pond and Dry ED Basin 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.**

Underground Detention Pretreatment. **Every underground detention practice shall have pretreatment mechanisms to protect the long term integrity of the practice.** Recommended

techniques to pretreat 100% of the inflow in every practice include but are not limited to:

- Practices capable of removing floatables such as oils and greases
- Practices capable of removing gross pollutants such as trash and debris
- Proprietary Practices that can achieve a 50% reduction in suspended solids (see Specification 15. Proprietary Practices)
- Catch Basin Sumps (applicable for perforated pipe systems for residential streets and site drainage only, minimum 2')

10.6 Detention Practices Design Criteria

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

Detention Practice Sizing. In order to receive the credits outlined in Tables 10.1 and 10.2, **for RPv compliance, a Dry ED Basin or Underground Detention Facility 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 baseflow condition to the extent practicable, the peak discharge for the outflow hydrograph shall not exceed five times the average discharge rate.**

Detention Practices can be designed to capture and treat the remaining stormwater discharged from upstream practices to improve water quality. Detention Practices should be sized to control peak flow rates from the Conveyance Event and Flooding Event as required in accordance with the Delaware Sediment and Stormwater Regulations and accompanying Technical Specifications.

For treatment train designs where upland practices are used for treatment of the RPv, designers can use a site-adjusted CN that reflects the volume reduction of upland practices to compute the Cv and Fv that must be treated by the Detention Practice.

Dry Detention Pond and Dry ED Basin Internal Design Features. The following apply to Dry Detention Pond and Dry ED Basin design:

- *Flow Distribution.* Dry Detention Ponds and Dry ED Basin should be constructed in a manner whereby flows are evenly distributed across the pond bottom, to avoid scour, promote attenuation, filtering, and, where possible, infiltration.
- *Internal Slope.* The minimum recommended longitudinal slope through a pond should be 1%.
- *Side Slopes.* Side slopes within the Dry Detention Pond or Dry ED Basin should have a

gradient of 3H:1V to 4H:1V. The mild slopes promote better establishment and growth of vegetation and provide for easier maintenance and a more natural appearance. **Earthen side slopes shall be designed and constructed no steeper than 3H:1V.**

- *Long Flow Path.* Dry Detention Pond and Dry ED Basin designs should have an irregular shape and a long flow path from inlet to outlet to increase water residence time, treatment pathways, and pond performance and to eliminate short-cutting. In terms of flow path geometry, there are two design considerations: (1) the overall flow path through the pond and (2) the length of the shortest flow path (Hirschman et al., 2009):
    - The *overall flow path* can be represented as the length-to-width ratio *OR* the flow path ratio. These ratios should be at least 2L:1W (3L:1W preferred). Internal berms, baffles, or topography can be used to extend flow paths and/or create multiple pond cells.
    - The *shortest flow path* represents the distance from the closest inlet to the outlet. The ratio of the shortest flow to the overall length should be at least 0.4. In some cases – due to site geometry, storm sewer infrastructure, or other factors – some inlets may not be able to meet these ratios. However, the drainage area served by these "closer" inlets should constitute no more than 20% of the total contributing drainage area.

Retaining Walls: **Retaining walls around Dry Detention Ponds and Dry ED Basins 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 shall have a maximum height of 3 feet.**
- **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.**

Safety Features. The following safety features apply to Detention Practices:

- **Any inflow opening 12 inches or greater discharging to a closed drainage system shall include safety grates.**
- **The emergency spillway must be located so that downstream structures will not be adversely impacted by spillway discharges.**
- **The emergency spillway exit channel must be designed to direct runoff to a point of discharge without adverse impact to 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 Dry Detention Ponds and Dry ED Basins is discouraged.~~ The preferred method to reduce risk is to manage the contours of the pond to eliminate drop-offs or other safety hazards.
- Maintenance access to Underground Detention Facilities should be locked at all times. The Operation and Maintenance Plan should specify how access to the Underground Detention Facility will be accomplished.

Maintenance Access. **All Detention Practices shall be designed so as to be accessible for maintenance. Adequate maintenance access must extend to the pretreatment, riser, and outlet structure. Adequate maintenance access must also be provided for all Underground Detention Facilities. A maintenance right-of-way or easement must extend to the Detention Practice 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 Dry Detention Ponds and Dry ED Basins 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 Dry Detention Pond or Dry ED Basin should be provided for in the Operation and Maintenance Plan as a location for disposal of sediment removed from the pond when maintenance is performed

- **The maintenance set-aside area shall accommodate the volume of 50% of the collective forebay volume.**
- **The maximum depth of the set aside volume 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.

Detention Vault and Tank Materials: Designers should consider longevity in selecting materials for construction of Underground Detention Facilities. **All construction joints and pipe joints shall be water tight. Cast-in-place wall sections must be designed as retaining walls.** The maximum depth from finished grade to the vault invert should be 20 feet. Manufacturer's specifications should be consulted for proprietary Underground Detention Facilities.

Anti-floatation Analysis for Underground Detention: **For watertight Underground Detention Facilities, anti-flotation analysis is required to check for buoyancy problems in the high**

water table areas. Anchors shall be designed to counter the pipe and structure buoyancy by at least a 1.2 factor of safety.

10.7 Detention Practices Landscaping Criteria

No landscaping criteria apply to Underground Detention Facilities.

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 Dry Detention Ponds and Dry ED Basins are constructed adjacent to existing forested areas.

Planting Plan. **For Dry Detention Ponds and Dry ED Basins, a planting plan shall be provided that indicates the methods used to establish and maintain vegetative coverage within the Detention Practice and its vegetated perimeter area.** The planting plan should allow the pond to mature into a native forest in the right places, but yet keep mowable turf along the embankment and all access areas. Avoid plant species that require full shade, or are prone to wind damage. **Minimum elements of a plan include seed mixes by botanical and common names as well as percentages by weight or volume.**

10.8 Detention Practices Construction

Underground Detention Facilities. **Construction of proprietary Underground Detention Facilities must be in accordance with manufacturer's specifications.** All runoff into the system should be blocked until the site is stabilized. **Underground Detention Facilities must be inspected and cleaned of sediment after the site is stabilized.**

Use of Dry Detention Pond or Dry ED Basin for Erosion and Sediment Control. A Dry Detention 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 Dry Detention Ponds and Dry ED Basins can be used as a sediment basin. If a Dry Detention Pond or Dry ED Basin serves as a sediment basin during project construction, the volume of the sediment basin must be based on the more stringent sizing rule.** Installation of the permanent riser 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 Dry Detention Pond or Dry ED Basin in mind. The bottom elevation of the temporary sediment basin should be a minimum of 6 inches higher than the proposed bottom elevation of the Dry Detention Pond or Dry ED Basin to allow for accumulated sediment to be removed with the remaining material during

conversion from sediment basin to permanent pond. **When the sediment basin is being converted into a Dry Detention Pond or Dry ED Basin, the sediment basin shall be dewatered in accordance with the approved plan and appropriate details from the Delaware Erosion and Sediment Control Handbook prior to removing accumulated sediment and regrading the pond bottom.**

The Sediment and Stormwater Plan must include conversion steps from sediment basin to permanent Dry Detention Ponds and Dry ED Basins 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 Dry Detention Pond or Dry ED Basin. Appropriate procedures must be implemented to prevent discharge of turbid waters when the sediment basin is being converted into a Dry Detention Pond or Dry ED Basin.

Dry Detention Pond, Dry ED Basin, and Underground Detention Construction Review. Multiple construction reviews are critical to ensure that Dry Detention Ponds and Dry ED Basins 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**
- **For Dry Detention Pond and Dry ED Basin – excavation and grading including interim and final elevations**
- **For Underground Detention – subgrade, placement of stone, system components in accordance with manufacturer's recommendations and backfill**
- **Implementation of the planting plan and vegetative stabilization**
- **Final inspection including development of a punch list for facility acceptance**

The following is a typical construction sequence to properly install a Dry Detention Pond or Dry ED Basin. The steps may be modified to reflect different designs, site conditions, and the size, complexity and configuration of the proposed facility.

Step 1: Stabilize the Drainage Area. Dry Detention Ponds or Dry ED Basins should be constructed after the contributing drainage area is stabilized. If the proposed Dry Detention Pond or Dry ED Basin 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 dewatered, 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 Dry Detention Ponds and Dry ED Basins 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 pond or basin that are graded or denuded during construction should 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 Core Trench and Install the Principal Spillway Pipe in accordance with construction specification of NRCS Small Pond Code 378.

Step 6: Install the Riser or Outflow Structure and ensure that 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 and compact the lifts with appropriate equipment. Construct the embankment to allow 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 Dry Detention Pond or Dry ED Basin. Construct forebays at the proposed inflow points.

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

*Step 10: Install Outlet Pipe*s, including any flared end sections, headwalls, and downstream rip-rap apron protection underlain by stabilization geotextile.

Step 11: Stabilize Exposed Soils with the approved seed mixtures in accordance with the vegetative stabilization specifications on the approved Sediment and Stormwater Management Plan.

Step 12: Plant the Dry Detention Pond or Dry ED Basin.

Post Construction Verification.

Upon facility completion, the owner shall submit post construction verification documents to demonstrate that the Detention Practice has been constructed within allowable tolerances and in accordance with the approved Sediment and Stormwater Management Plan and accepted by the approving agency.

Allowable tolerances for Dry Detention Pond and Dry ED Basin 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 dry 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.**

Allowable tolerances for Underground Detention Facilities are as follows:

- **Grate and invert elevations of all structures, including weirs shall be within 0.15 foot of the design.**
- **Diameter of all pipes or dimensions of chambers within underground detention facility shall be as shown on the plan.**
- **Dimension of any weirs shall be within 10% of the design.**

When the allowable tolerances are exceeded for volume or structure elevations, supplemental calculations must be submitted to the approval agency to demonstrate that the Detention Practice, as constructed, meets the design requirements.

10.9 Detention Practices Maintenance Criteria

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.

Sediment removal in the Dry Detention Pond or Dry ED Basin pretreatment practice 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.

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.

Typical maintenance activities for Detention Practices are outlined in Table 10.5. Maintenance requirements for Underground Storage Facilities should include quarterly visual inspections from the manhole access points to verify that there is no standing water or excessive sediment buildup. Entry into the system for a full inspection of the system components (pipe or vault joints, general structural soundness, etc.) should be conducted annually. Confined space entry credentials may be required for this inspection.

Table 10.5 Typical maintenance items for Detention Practices

Frequency	Maintenance Items
During establishment, as needed (first year)	• Water Dry Detention Pond and Dry ED Basin side slopes and bottom area to promote vegetation growth and survival
Quarterly or after major storms (>1 inch of rainfall)	• Remove sediment and oil/grease from inlets, pre-treatment devices, flow diversion structures, storage practices and overflow structures. • Ensure that the contributing drainage area, inlets, and facility surface are clear of debris. • Ensure that the contributing drainage area is stabilized. Perform spot-reseeding where needed. • Repair undercut and eroded areas at inflow and outflow structures.
Annually	• Measure sediment accumulation levels in forebay. Remove sediment when 50% of the forebay capacity has been lost. • Inspect the condition of stormwater inlets for material damage, erosion or undercutting. Repair as necessary. • Inspect the banks of upstream and downstream channels for evidence of sloughing, animal burrows, boggy areas, woody growth, or gully erosion that may undermine pond embankment integrity. • Inspect outfall channels for erosion, undercutting, rip-rap displacement, woody growth, etc. • Inspect condition of principal spillway and riser for evidence of spalling, joint failure, leakage, corrosion, etc. • Inspect condition of all trash racks, flashboard risers, and other appurtenances for evidence of clogging, leakage, debris accumulation, etc. • Inspect maintenance access to ensure it is free of debris or woody vegetation, and check to see whether valves, manholes and locks can be opened and operated. • Inspect internal and external side slopes of Dry Detention Ponds for evidence of sparse vegetative cover, erosion, or slumping, and make needed repairs immediately. • Monitor the growth of trees and shrubs planted in Dry Detention Ponds. Remove invasive species and replant vegetation where necessary to ensure dense coverage.

Operation and Maintenance Plans should clearly outline how vegetation in the Dry Detention Pond or Dry ED Basin and its vegetated perimeter will be managed or harvested in the future. Periodic mowing of the vegetated perimeter area is only required within the maintenance access and the embankment. The remaining perimeter can be managed as a meadow (mowing every other year) or forest. The Operation and Maintenance Plan should schedule a shoreline cleanup at least once a year to remove trash and debris. Maintenance of Detention Practices is driven by annual maintenance reviews that evaluate the condition and performance of the Detention Practice. Based on maintenance review results, specific maintenance tasks may be required.

10.10 References

Cappiella, K., Schueler, T., and T. Wright. 2005. *Urban Watershed Forestry Manual. Part 1: Methods for Increasing Forest Cover in a Watershed*. NA-TP-04-05. USDA Forest Service, Northeastern Area State and Private Forestry. Newtown Square, PA.

Hirschman, D., L. Woodworth and S. Drescher. 2009. *Technical Report: Stormwater BMPs in Virginia's James River Basin: An Assessment of Field Conditions & Programs*. Center for Watershed Protection. Ellicott City, MD.