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 Basin
- 10-C Underground Detention Facilities

Dry Detention Ponds and Dry Extended Detention 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 Extended Detention Basins receive both runoff reduction and pollutant removal credits.

The key difference between Dry Detention Ponds and Dry Extended Detention Basins is that, in addition to management of the Cv and Fv, a Dry Extended Detention Basin provides up to a 24-hour detention of all or a portion of the Resource Protection Volume (RPv). An under-sized outlet structure restricts stormwater flow so it backs up and is stored within the basin. 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. Extended detention differs from a Dry Detention Pond’s stormwater detention, since it 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 Conveyance Event and Flooding Event 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 24- or 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 Calculations

Both Dry Detention Ponds and Dry Extended Detention Basins receive a pollutant removal credit, while Dry Extended Detention Basins that provide 24-hour extended detention receive partial runoff reduction credit as well. Underground Detention Facilities receive no credit for runoff reduction or pollutant removal.

Full runoff reduction credit is also given for detention practices that provide 48-hour detention of the full RPv runoff volume.

<table>
<thead>
<tr>
<th>Table 10.1 Dry Detention Pond Performance Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Runoff Reduction</td>
</tr>
<tr>
<td>Retention Allowance</td>
</tr>
<tr>
<td>RPv - A/B Soil</td>
</tr>
<tr>
<td>RPv - C/D Soil</td>
</tr>
<tr>
<td>Cv</td>
</tr>
<tr>
<td>Fv</td>
</tr>
<tr>
<td>Pollutant Reduction</td>
</tr>
<tr>
<td>TN Reduction</td>
</tr>
<tr>
<td>TP Reduction</td>
</tr>
<tr>
<td>TSS Reduction</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 10.2a Dry 24-hour Extended Detention Basin Performance Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Runoff Reduction</td>
</tr>
<tr>
<td>Retention Allowance</td>
</tr>
<tr>
<td>RPv - A/B Soil 24-hour ED Retention Allowance</td>
</tr>
<tr>
<td>RPv - C/D Soil 48 HR Hour ED Detention Allowance</td>
</tr>
<tr>
<td>Cv</td>
</tr>
<tr>
<td>Fv</td>
</tr>
<tr>
<td>Pollutant Reduction</td>
</tr>
<tr>
<td>TN Reduction</td>
</tr>
<tr>
<td>TP Reduction</td>
</tr>
<tr>
<td>TSS Reduction</td>
</tr>
</tbody>
</table>
Table 10.2b Dry 48-hour Extended Detention Basin Performance Credits

<table>
<thead>
<tr>
<th>Runoff Reduction</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>RPv – Detention Allowance</td>
<td>100%</td>
</tr>
<tr>
<td>Cv</td>
<td>1%</td>
</tr>
<tr>
<td>Fv</td>
<td>0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pollutant Reduction</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>TN Reduction</td>
<td>20%</td>
</tr>
<tr>
<td>TP Reduction</td>
<td>20%</td>
</tr>
<tr>
<td>TSS Reduction</td>
<td>60%</td>
</tr>
</tbody>
</table>

Since 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. To receive these credits, the practice must be designed using the guidance detailed in Section 10.6. Detention Practices Design Criteria.

10.2 Detention Practices Design Summary

Table 10.3 summarizes design criteria for Detention Practices. For more detail, consult Sections 10.3 through 10.7. Sections 10.8 and 10.9 describe practice construction and maintenance criteria.

Table 10.3 Dry Detention Pond (10-A) and Dry ED Basin (10-B) Design Summary

<table>
<thead>
<tr>
<th>Feasibility (Section 10.3)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• 1%-3% of CDA for footprint</td>
<td></td>
</tr>
<tr>
<td>• Recommended minimum CDA = 10 acres</td>
<td></td>
</tr>
<tr>
<td>• Setbacks in accordance with local codes</td>
<td></td>
</tr>
<tr>
<td>• Minimum 2’ separation to groundwater or bedrock</td>
<td></td>
</tr>
<tr>
<td>• Geotechnical investigations required</td>
<td></td>
</tr>
<tr>
<td>• Soil tests on HSG A and B soils to determine infiltration rates</td>
<td></td>
</tr>
<tr>
<td>• No utilities within embankments</td>
<td></td>
</tr>
<tr>
<td>• 10’ horizontal clearance from utilities</td>
<td></td>
</tr>
<tr>
<td>• Permit required if located on perennial streams</td>
<td></td>
</tr>
<tr>
<td>• Community and environmental concerns</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Conveyance (Section 10.4)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Designed in accordance with NRCS Small Pond Code 378 Appendix B</td>
<td></td>
</tr>
<tr>
<td>• Use accepted hydrologic and hydraulic routing computations</td>
<td></td>
</tr>
<tr>
<td>• Principal spillway designed to release flow rates from Cv</td>
<td></td>
</tr>
<tr>
<td>• Principal spillway must be accessible by dry land, include anti-floatation, anti-vortex devices, trash racks, and contain watertight joints.</td>
<td></td>
</tr>
<tr>
<td>• Dry ED design must include an outlet orifice to drain the full RPv over 42–24-24 or 48 hours, depending on design criteria</td>
<td></td>
</tr>
<tr>
<td>• Minimize tree clearing at outlets</td>
<td></td>
</tr>
<tr>
<td>• Non-clogging outlets (&gt;3” or internal orifice control)</td>
<td></td>
</tr>
<tr>
<td>• Outlets non-erosive for the Fv (100-year storm) event.</td>
<td></td>
</tr>
</tbody>
</table>
### Pretreatment (Section 10.5)
- Emergency spillway cut in fill must be lined
- If no emergency spillway, 3 square feet minimum for principal spillway
- Provide inlet protection

### Sizing (Section 10.6)
- Forebays at major inlets – those contributing >10% runoff volume
- Forebays sized for 10% of RPv
- Exit velocity from forebay non-erosive
- Direct maintenance access provided

#### Table 10.4 Underground Detention Facilities (10-C) Design Summary

<table>
<thead>
<tr>
<th>Category</th>
<th>Details</th>
</tr>
</thead>
</table>
| **Feasibility** (Section 10.3)    | - Could be classified as Class V Injection Well  
- 1%-3% of CDA for footprint  
- Sufficient head room to facilitate maintenance  
- Setbacks in accordance with local codes  
- Minimum 2’ separation to groundwater or bedrock  
- Anti-flotation analysis for watertight systems  
- Geotechnical investigations required  
- Structural analysis required  
- 10’ horizontal clearance from utilities |
| **Conveyance** (Section 10.4)     | - Use accepted hydrologic and hydraulic routing computations  
- Non-clogging outlets (>3” or internal orifice control)  
- Outlets non-erosive for the Fv (100-year storm) event.  
- Minimize tree clearing at outlets  
- Internal or external high flow bypass to safely pass the Fv (100-year storm) event. |
| **Pretreatment** (Section 10.5)   | - Pretreatment structure to capture debris, trash, and coarse sediment  
- Separate vault to capture minimum 0.1” of runoff per impervious acre |
| **Sizing** (Section 10.6)         | - Store volume equivalent to RPv (1-year, 2.7”)  
- **Underground ED design must detain full RPv and release over 24 or 48 hours, depending upon design criteria** |
| **Safety/ Maintenance Access**    | - Prevent access by small children  
- Restrict access to principal spillway and lock maintenance access points |
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’ 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).

**Contributing Drainage Area.** A minimum contributing drainage area of 10 acres is recommended for Dry Detention Ponds in order to keep the required orifice size from becoming a maintenance problem. Designers should be aware that small “pocket” ponds will typically (1) have very small orifices that will be prone to clogging, (2) experience fluctuating water levels such that proper stabilization with vegetation is very difficult, and (3) generate more significant maintenance problems. When the contributing drainage area of the Detention Practice 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 utilized 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**).

**Available Hydraulic Head.** The depth of a Dry Detention Pond or Dry ED Basin is usually determined by the amount of hydraulic head available at the site (dimension between the surface drainage and the bottom elevation of the site). The bottom elevation is normally the invert of the
existing downstream conveyance system to which the Detention Practice discharges. The needed hydraulic head for a Dry Detention Pond or Dry ED Basin to function properly will be determined by the size of the developed drainage area and the available surface area of the basin. An Underground Detention Facility will require sufficient head room to facilitate maintenance of the underground facility.

**Minimum Setbacks.** Local ordinances and design criteria should be consulted to determine minimum setbacks to property lines, structures, and wells. Setbacks from wells and septic systems shall meet minimum separation distances in accordance with Department regulations. When not specified in local code or Department regulations, Detention Practices should be set back at least 20 feet from property lines, 25 feet down-gradient from building foundations, 100 feet from septic system fields, and 150 feet from public or private water supply wells.

**Depth-to-Water Table and Bedrock.** Dry Detention Ponds or Dry Extended Detention Basins are not allowed if the seasonal high water table or bedrock will be within 2 feet of the floor of the pond. Non-watertight Underground Detention Facilities must also maintain a separation of two feet from the bottom of the facility to the elevation of seasonal high water or bedrock. For watertight Underground Detention Facilities, an anti-flotation analysis is required to check for buoyancy problems in seasonal high water table areas.

**Geotechnical Tests.** At least one soil boring must be taken at a low point within the footprint of any proposed detention practice to establish the water table and bedrock elevations and evaluate soil suitability. A geotechnical investigation is required for all underground BMPs, including underground storage systems.

**Soils.** The permeability of soils is seldom a design constraint for Detention Practices. Soil investigation must be conducted in accordance with Department Soil Investigation Procedures at proposed Dry Detention Pond and Dry Extended Detention Basin sites to determine soil suitability. Infiltration through the bottom of the pond is typically encouraged unless it may potentially migrate laterally thorough a soil layer and impair the integrity of the embankment or other structure.

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

**Utilities.** For a Dry Detention Pond or Dry ED Basin, no utility lines shall be permitted to cross any part of an embankment. All utilities must have a minimum 10' horizontal clearance from Detention Practices unless protective measures are provided for the utility line.

**Perennial Streams.** Locating Dry Detention Ponds on perennial streams will require both a Section 401 and Section 404 permit from the appropriate state or federal regulatory agency.
Community and Environmental Concerns. Dry Detention Ponds and Dry ED Basins can generate the following community and environmental concerns that need to be addressed during design:

- **Aesthetic Issues.** Properly designed, constructed and maintained Dry Detention Ponds and Dry ED Basins can serve as usable active open space in a community. It is important that the design include necessary cross slope on the pond bottom, and the pond is constructed in accordance with that design so that the bottom can be maintained free of wet areas. Dry Detention Ponds and Dry ED Basins may also be landscaped with native vegetation to become an attractive habitat within a community.

- **Existing Forests.** Construction of a Dry Detention Pond or Dry ED Basin may involve extensive clearing of existing forest cover. Designers can expect a great deal of neighborhood opposition if they do not make a concerted effort to save mature trees during Dry Detention Pond and Dry ED Basin design and construction.

- **Safety Risk.** Because Dry Detention Ponds and Dry ED Basins do not maintain a permanent pool of water, they can be very attractive during runoff event when they are holding water. Gentle side slopes and personnel grating should be provided to avoid potentially dangerous situations, especially where Dry Detention Ponds and Dry ED Basins are located near residential areas.

- **Mosquito Risk.** Improperly functioning Dry Detention Ponds and Dry ED Basins that do not completely drain or take greater than 48 hours to drain, have the potential to breed mosquitoes. Mosquito problems can be minimized through simple design features and maintenance operations described in MSSC (2005).

10.4 Detention Practice Conveyance Criteria

Dry Detention Ponds and Dry ED Basins, including their conveyance systems, constructed to meet regulatory stormwater management requirements in the State of Delaware shall be designed and constructed in accordance with the USDA NRCS Small Pond Code 378 and this document. Designers must use accepted USDA NRCS hydrologic and hydraulic routing calculations to determine the required storage volume and an appropriate outlet design for Detention Practices.

**Principal Spillway.** For both Dry Detention Ponds and Dry Extended Detention Basins, the control structure must include orifices or outlets designed to release the required flow rates from the Cv (10-year frequency storm). The principal spillway may be composed of a structure-pipe configuration or a weir-channel configuration. 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. When reinforced concrete pipe is used for the principal spillway pipe to increase its longevity, “O-ring” gaskets (ASTM C361) shall be used to create watertight joints. When the principal spillway is composed of a weir wall discharging to a channel, the channel below the weir must be reinforced (with riprap, for example) to prevent scour of the channel.
Non-Clogging Low-Flow Orifice Outlet. For Dry Extended Detention Basins, the control structure must include a low-flow orifice outlet that will slowly release the RPv over a 24- or 48-hour period, depending upon design criteria. A low flow orifice must be provided that is adequately protected from clogging by either an acceptable external trash rack or by internal orifice protection that may allow for smaller diameters. Orifices less than 3 inches in diameter may require extra attention during design, to minimize the potential for clogging.

Adequate Outfall Protection. The design must specify an outfall that will be stable for the flooding event (Fv). The channel immediately below the Dry Detention Pond or Dry ED Basin outfall must be modified to prevent erosion and conform to natural dimensions in the shortest possible distance. This is 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 3.3.11 Riprap Stilling Basin or 3.3.10 Riprap Outlet Protection, 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.

When the discharge is to a manmade pipe or channel system, the system must be adequate to convey the required design storm peak discharge. 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 shall be modified if any increase in flooding or stream channel erosion would result at a downstream structure, highway, or natural point of restricted streamflow.

Emergency Spillway. Dry Detention Ponds and Dry ED Basins must be constructed with overflow capacity to pass the maximum design storm event (Fv) if the Fv is being routed through the pond or basin rather than bypassing. An emergency spillway designed to convey the Fv should be cut in natural ground or, if cut in fill, must be lined with stabilization geotextile and riprap. When the maximum design storm will be passing through the principal spillway, the principal spillway outlet pipe must have a minimum cross sectional area of 3 square feet.

Inflow Points Stabilization. Inflow points into the Dry Detention Pond or Dry ED Basin must be stabilized to ensure that non-erosive conditions exist during storm events up to the conveyance storm (i.e., the 10-year storm event). A forebay (See 10.5 Detention Practices Pretreatment Criteria) shall be provided at each inflow location, unless the inlet provides less than 10% of the total design storm inflow to the Dry Detention Pond or Dry ED Basin.

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 should 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 Flooding event (Fv).

10.5 Detention Practices Pretreatment Criteria

Pretreatment Forebay. A forebay must be located at each major inlet to a Dry Detention Pond or Dry Extended Detention Basin 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 serving at least 10% of the Dry Detention Pond or Dry ED Basin’s contributing 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 must be sized to contain ten percent of the volume of runoff from the contributing drainage impervious area from the Resource Protection event. The relative size of individual forebays will be proportional to the percentage of the total inflow to the Dry Detention Pond or Dry ED Basin. The storage volume within the forebay may be included in the calculated required storage volume for the Dry Detention Pond or Dry ED Basin.
- The forebay should be designed in such a manner that it acts as a level spreader to distribute runoff evenly across the entire bottom surface area of the main storage cell.
- Exit velocities from the forebay shall be non-erosive or an armored overflow shall be provided. Direct maintenance access for appropriate equipment shall be provided to the each forebay.

Underground Detention Pretreatment. A pretreatment structure designed in accordance with Department guidance to capture sediment, coarse trash and debris must be placed upstream of any inflow points to Underground Detention Facilities. Acceptable pretreatment practices include:

- Sand Filter (see Specification 12. Stormwater Filtering Systems)
- Proprietary Practices (see Specification 15. Proprietary Practices)

A separate sediment sump or vault chamber sized to capture a minimum of 0.1 inches per impervious acre of contributing drainage area shall be provided at the inlet for Underground Detention Facilities.

10.6 Detention Practices Design Criteria

Detention Practice Sizing. In order to receive the credits outlined in Section 10.1, Detention Practices must be sized to store a volume equivalent to the Resource Protection storm (i.e., the runoff volume from the 1-year, 2.7” Type II storm event). Further, Dry Extended Detention Basins must also be sized to detain and release the RPv for over a minimum period of 24 hours, not to exceed 48 hours depending upon design criteria. 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 5X 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 Document. For treatment train designs where upland practices are utilized 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 Extended Detention Basin Internal Design Features.** The following apply to Dry Detention Pond and Dry Extended Detention Basin design:

- **Flow Distribution.** Dry Detention Ponds and Dry ED Basin shall 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 longitudinal slope through a pond constructed on HSG A/B soils should be 1%. The minimum longitudinal slope through a pond constructed on HSG C/D soils should be 2%.

- **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. In no case shall the side slopes be designed and constructed 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, 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 must 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 must 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.
• **Non-clogging Low Flow (Extended Detention) Orifice.** The low flow ED orifice shall be adequately protected from clogging by an acceptable 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 orifices or slots that are protected by wirecloth and a stone filtering jacket).

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

- The principal spillway opening as well as all inlets and outlets must be designed and constructed to prevent entry by small children. Personnel safety grates shall be installed on the inlets of all stormwater pipes 12” in diameter or larger that are not straight from the inlet to the open outlet, regardless of the length of the pipe.

- Detention practices must incorporate an additional 1 foot of freeboard above the emergency spillway, or 2 feet of freeboard if the design has no emergency spillway, for the maximum water elevation for the Fv, unless more stringent Dam Safety requirements apply.

- The emergency spillway must be located so that downstream structures will not be impacted by spillway discharges.

- 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 will specify how access to the Underground Detention Facility will be accomplished.

**Maintenance Access.** All Detention Practices shall be designed so as to be accessible to annual maintenance. A minimum 15’ wide maintenance access shall be provided from public open space or public right-of-way to the Detention Practice and around the perimeter of the Detention Practice. Adequate maintenance access must also be provided for all Underground Detention Facilities. Access must be provided over the inlet pipe and outflow structure with access steps. Access openings can consist of a standard 30” diameter frame, grate and solid cover, or a hinged door or removable panel.

**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 0.1 inches of runoff from the Dry Detention Pond or Dry ED Basin’s contributory drainage area.

- The maximum depth of the set aside volume shall be one foot.

- The slope of the set aside area shall not exceed 5%; and
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-floatation 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.

**Vegetated Perimeter.** A vegetated area should be provided around the perimeter of the Detention Practice that extends at least 25 feet outward from the top of bank of the Dry Detention Pond or Dry ED Basin. Permanent structures (e.g., buildings) should not be constructed within the vegetated perimeter area. Where possible, existing trees should be preserved in the vegetated perimeter area during construction. The full width of the vegetated perimeter should be located in common open space, not within recorded lots.

The soils in the vegetated perimeter area are often severely compacted during the construction process, to ensure stability. The density of these compacted soils can be so great that it effectively prevents root penetration and, therefore, may lead to premature mortality or loss of vigor. As a rule of thumb, planting holes should be three times deeper and wider than the diameter of the root ball for ball-and-burlap stock, and five times deeper and wider for container-grown stock. Organic matter such as locally generated compost may be used to amend compacted soil to improve soil structure, help establish vegetation, and reduce runoff.

For more guidance on planting trees and shrubs in vegetated perimeter areas, consult Cappiella et al (2006).

**Woody Vegetation.** Woody vegetation may not be planted or allowed to grow within 15 feet of the toe of the embankment. Woody vegetation may not be planted or allowed to grow within 25 feet of the principal spillway structure or any inflow pipes.

**Landscaping and Planting Plan.** For Dry Detention Ponds and Dry Extended Detention Basins, a landscaping plan must 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 the following:
- Delineation of pondscaping zones within the pond and vegetated perimeter area
- Selection of corresponding plant species
- The planting plan
- Sources of native plant material

10.8 Detention Practices Construction Sequence

**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. The system must be inspected and cleaned of sediment after the site is stabilized.

**Use of Dry Detention Pond or Dry Extended Detention Basin for Erosion and Sediment Control.** A Dry Detention Pond may serve as a sediment basin during project construction. 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 Extended Detention Basin in mind. The bottom elevation of the temporary sediment basin must be a minimum of six 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 must 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.

**Dry Detention Pond and Dry Extended Detention Basin Construction Review.** Multiple construction reviews are critical to ensure that stormwater ponds are properly constructed. A construction phase review checklist for Detention Practices should be used to verify that all required items have been completed. Construction reviews are required during the following stages of construction:
- Pre-construction meeting
- Initial site preparation (including installation of E&S controls)
- Construction of the embankment, including installation of the principal spillway and the outlet structure
- Excavation/Grading (interim and final elevations)
- Implementation of the pondscaping plan and vegetative stabilization
- Final inspection (develop a punch list for facility acceptance)

The following is a typical construction sequence to properly install a Dry Detention Pond or Dry Extended Detention 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 Extended Detention Basins should only be constructed after the contributing drainage area is completely 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 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 pond or basin 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 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 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. Construction 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 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 Pipes,** 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 and Vegetated Perimeter Area,** following the pondscaping plan (see Section 10.7 Detention Practices Landscaping Criteria).

**Post Construction Verification.** Following construction, the actual depth of each forebay and the pond or basin itself, must be measured, marked, geo-referenced on the post construction verification survey document. This simple data set will enable maintenance reviewers to determine sediment deposition rates in order to schedule sediment cleanouts.

### 10.9 Detention Practices Maintenance Criteria

Typical maintenance activities for Detention Practices are outlined in **Table 10.5.** Maintenance requirements for Underground Storage Facilities will generally require 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 are required for this inspection.
### Table 10.5 Typical maintenance items for Detention Practices

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Maintenance Items</th>
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<tbody>
<tr>
<td>During establishment, as needed (first year)</td>
<td>• Water Dry Detention Pond and Dry ED Basin side slopes and bottom area to promote vegetation growth and survival</td>
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</table>
| 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. |

An Operation and Maintenance Plan for the project will be approved by the Department or the Delegated Agency prior to project closeout. 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. Detention Practices that are, or will be, owned and maintained by a joint ownership such as a homeowner’s association must be located in common areas, community open space, community-owned property, jointly owned property, or within a recorded easement dedicated to public use.
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
