4.3.3 Dry Extended Detention Basins

General Application
Water Quality BMP

Description: A surface storage basin or facility designed to provide water quantity and quality control through detention of stormwater runoff.

KEY CONSIDERATIONS

DESIGN GUIDELINES:

- Single basins will have a maximum contributing drainage area of 75 acres.
- A sediment forebay or equivalent upstream pretreatment must be provided.
- Minimum flow length to width ratio for the basin is 1.5:1. The basin shall be sized to detain the volume of runoff to be treated for a minimum of 24 hours.
- Side slopes to the basin shall not exceed 3:1 (h:v) on one side of the basin to facilitate access. Slopes as steep as 2:1 will be allowed for other areas, with proper stabilization.

ADVANTAGES / BENEFITS:

- Moderate removal rate of urban pollutants.
- High community acceptance.
- Useful for water quality treatment and flood control.

DISADVANTAGES / LIMITATIONS:

- Potential for thermal impacts/downstream warming.
- Dam height restrictions for high relief areas.
- Basin drainage can be problematic for low relief terrain.

MAINTENANCE REQUIREMENTS:

- Remove debris from inlet and outlet structures.
- Maintain side slopes and outlet structure.
- Remove invasive vegetation.
- Monitor sediment accumulation and remove periodically.

OTHER CONSIDERATIONS:

- Outlet clogging
- Safety bench
- Landscaping

STORMWATER MANAGEMENT SUITABILITY

Stormwater Quality:	**Yes**
Channel Protection:	**Yes**
Detention/Retention:	**Yes**

Accepts hotspot runoff: *Yes, but two feet of separation distance required to water table when used in hotspot areas*

COST CONSIDERATIONS

Land Requirement:	**Med - High**
Capital Cost:	**Low**
Maintenance Burden:	**Low**

LAND USE APPLICABILITY

Residential/Subdivision Use:	**Yes**
High Density/Ultra Urban Use:	**No**
Commercial/Industrial Use:	**Yes**

POLLUTANT REMOVAL

Total Suspended Solids:	**60%**

4.3.3.1 General Description

Dry extended detention (ED) basins are surface facilities that provide for the temporary storage of stormwater runoff for some minimum time (e.g., 24 to 72 hours) to allow suspended sediments and other associated pollutants to settle to the basin bottom, and therefore, not discharge to downstream channels. Dry ED basins provide moderate treatment of the water quality volume (WQv), are useful for control of the channel protection volume (CPv), and can provide overbank flood protection and extreme flood protection as well.

4.3.3.2 Pollutant Removal Capabilities

Dry ED basins are presumed capable of removing at least 60% of the total suspended solids load in typical urban post-development runoff when sized, designed, constructed and maintained in accordance with the specifications provided in this manual. The TSS removal performance can be reduced by poor design, construction or maintenance.

Additionally, research has shown that use of dry ED basins will have moderate benefits beyond the removal of TSS, such as the removal of other pollutants (i.e. phosphorous, nitrogen, fecal coliform and heavy metals), as well, which is useful information should the pollutant removal criteria change in the future.

For additional information and data on dry ED basins, see the National Pollutant Removal Performance Database (2nd Edition) available at www.stormwatercenter.net and the International Stormwater Best Management Practices Database at www.bmpdatabase.org.

Because dry ED basins cannot alone provide adequate treatment of the water quality volume, they must be utilized in a treatment train approach with other structural controls to achieve the goal of 80% removal of total suspended solids (TSS). Chapter 3 provides more information on treatment trains.

4.3.3.3 Planning and Design Standards

The following criteria shall be considered **minimum** design standards for the design of a dry ED basin. Dry ED basins that are not designed to these standards will not be approved. Consult with the local engineering department to determine if there are any variations to these criteria or additional standards that must be followed.

A. LOCATION AND SITING

- It is strongly recommended that dry ED basins be located where the topography allows for maximum runoff storage at minimum excavation or embankment construction costs. When locating a dry ED basin, the site designers should also consider the location and use of other land use features, such as planned open spaces and recreational areas, and should attempt to achieve a multi-use objective with the basin where this can be safely achieved.
- Dry ED basins shall not be located on unstable slopes or slopes greater than 15%.
- Flood protection controls for control of the peak discharges should be designed as final controls for on-site stormwater. Because most dry ED basins will be used for flood protection and are not capable of achieving the required 80% TSS removal standard, they will typically be located downstream of structural stormwater BMPs that are used in conjunction with the dry ED basin to provide 80% treatment of the WQv.
- A single dry ED basin shall not have a contributing drainage area greater than 75 acres unless specifically approved by the Director.
- Dry ED basins shall not be located in a stream or any other navigable waters of the United States, including natural (i.e., not constructed) wetlands. Where an appeal or variance of this policy is desired, the property owner must obtain coverage under a Section 404 permit under the Clean Water Act and/or an Aquatic Resource Alteration Permit (ARAP) and provide proof of such coverage with the Water Quality Management Plan.

- Each dry ED basin shall be placed in an easement. The easement shall be defined at the outer edge of the safety bench, or a minimum of 15 feet from the normal water pool elevation (measured perpendicular from the pool elevation boundary) if a safety bench is not included in the basin design. The easement limit should be located no closer than as follows unless otherwise specified by the local regulations:
  - From a public water system well – TDEC specified distance per designated well category
  - From a private well – 50 feet; if the well is downgradient from a hotspot land use, as defined in this manual, then the minimum setback is 250 feet
  - From a septic system tank/leach field – 50 feet
- The minimum setback for habitable structures from the easement shall be 15 feet. The first floor elevation (FFE) for any structure adjacent to the basin shall have an elevation no lower than 1 foot above the top of the berm.
- All utilities shall be located outside of the dry ED basin.

B. GENERAL DESIGN

- A dry ED basin shall consist of the following elements, designed in accordance with the specifications provided in this section:
  (1) An outlet structure;
  (2) An emergency spillway;
  (3) A sediment forebay;
  (4) Maintenance access;
  (5) Appropriate landscaping.

C. PHYSICAL SPECIFICATIONS / GEOMETRY

- Vegetated embankments shall be less than 20 feet in height. Side slopes shall not exceed 3:1 (horizontal to vertical) on one side of the basin to facilitate access for maintenance and repair. The remainder of the basin shall have side slopes no steeper than 2:1 although 3:1 is preferred. Benching of the slope is required for embankments greater than 10 feet in height and having greater than a 3:1 side slope. Riprap-protected embankments shall be no steeper than 2:1. Geotechnical slope stability analysis is recommended for embankments greater than 10 feet in height and is mandatory for embankment slopes steeper than those given above. All embankments must be designed to State of Tennessee guidelines for dam safety.
- The maximum depth of the basin shall not exceed 10 feet.
- Areas above the normal high water elevations of the dry ED basin shall be sloped toward the basin to allow drainage and to prevent standing water. Careful finish grading is required to avoid creation of upland surface depressions that may retain runoff. The basin bottom shall be graded toward the outlet to prevent standing water. A low flow or pilot channel across the facility bottom from the inlet to the outlet (often constructed with riprap) is recommended to convey low flows and prevent standing water conditions.

D. PRETREATMENT / INLETS

- A sediment forebay shall be provided for dry ED basins that are located in a treatment train with other water quality treatment structural controls. The sediment forebay is utilized to remove incoming sediment from the stormwater flow prior to dispersal into the larger basin area. The forebay shall consist of a separate cell, formed by an acceptable barrier. A forebay must be provided at each inlet to the dry ED basin, unless the inlet provides less than 10% of the total design storm inflow to the basin.
- The sediment forebay shall be sized to contain 0.1 inch per impervious acre (363 ft^3) of contributing drainage and shall be no more than 4 to 6 feet deep.

- A fixed vertical sediment depth marker shall be installed in the forebay to measure sediment deposition over time. The bottom of the forebay may be hardened (e.g., using concrete, paver blocks, etc.) to make sediment removal easier.
- Inflow channels to the forebay shall be stabilized with flared riprap aprons, or the equivalent. Exit velocities of discharges from the forebay to the basin must be non-erosive.

E. OUTLET STRUCTURES

- Flow control from a dry ED basin that is used for control of the WQv, CPv and the locally regulated peak discharges is typically accomplished with the use of a riser and barrel. The riser is a vertical pipe or inlet structure that is located at the base of the basin. The outlet barrel is a horizontal pipe attached to the riser that conveys flow under the embankment. The riser shall be located within the basin embankment for maintenance access, safety and aesthetics.
- A number of outlets at varying depths in the riser provide internal flow control for routing of the WQv, CPv, and the locally regulated peak discharges. The number of orifices can vary and is usually a function of the basin design. A dry ED basin riser configuration is typically comprised of an outlet that provides water quality (WQv), a channel protection (CPv) outlet (usually an orifice), and outlets for the locally controlled peak events (often a slot or weir). All outlets are protected by trash racks to prevent clogging. The channel protection orifice is sized to release the channel protection storage volume for a minimum 24-hour period, centroid to centroid.
- The water quality/channel protection outlet can be fitted with adjustable gate valves or another mechanism that can be used to adjust detention time.
- After entering the riser, flow is conveyed through the barrel and is discharged downstream. Anti-seep collars shall be installed on the outlet barrel to reduce the potential for pipe or embankment failure.
- Seepage control or anti-seep collars shall be provided for all outlet pipes.
- Water shall not be discharged from a dry ED basin in an erosive manner. Riprap, plunge pads or pools, or other energy dissipators shall be placed at the outlet of the barrel to prevent scouring and erosion. If a basin outlet discharges immediately to a channel that carries dry weather flow, care should be taken to minimize disturbance along the downstream channel and streambanks, and to reestablish a forested riparian zone in the shortest possible distance (if the downstream area is located in a vegetated buffer).

F. EMERGENCY SPILLWAY

- An emergency spillway shall be included per regulations of the local jurisdiction.

G. MAINTENANCE ACCESS

- A maintenance right-of-way or easement having a minimum width of 20 feet shall be provided to the basin from a driveway, public or private road. The maintenance access easement shall have a maximum slope of no more than 15% and shall have a minimum unobstructed drive path having a width of 12 feet, appropriately stabilized to withstand maintenance equipment and vehicles.
- The maintenance access shall extend to the forebay (if included) and outlet structure, and, to the extent feasible, be designed to allow vehicles to turn around.

H. SAFETY FEATURES

- A safety bench shall be provided for embankments greater than 10 feet in height and having greater than a 3:1 side slope. For large basins, the safety bench shall extend no less than 15 feet outward from the normal water edge to the toe of the basin side slope. The slope of the safety bench shall not exceed 6%.
- All embankments and spillways shall be designed to TDEC rules and regulations as applied to the Safe Dams Act of 1973, where applicable.
- The property owner may consider fencing the basin for the purpose of safety management.

- All outlet structures shall be designed so as not to permit access by children. The posting of warning signs is encouraged near the basin to prohibit swimming and fishing in the facility.

I. LANDSCAPING

- All areas of the basin shall be stabilized with appropriate vegetation to prevent the occurrence of erosion.
- Woody vegetation shall not be planted on the embankment or allowed to grow within 15 feet of the toe of the embankment and 25 feet from the principal spillway structure.
- Vegetated buffers, as defined and described in Chapter 6 of this manual, are not required for dry ED basins. However, it should be noted that vegetated buffers can be utilized for water quality treatment and can result in a volume reduction that reduces the WQv. The criteria for the vegetated buffer reduction are presented in Chapter 5 of this manual.

4.3.3.4 Design Procedures

In general, site designers should perform the following design procedures when designing a dry ED basin.

Step 1. Compute runoff control volumes

Calculate WQv, CPv, and pre- and post-development peak discharges and runoff volumes for the storms specified by the local jurisdiction. The calculation of WQv and CPv is presented in Chapter 3 of this manual. Consult local regulations for peak discharge control (i.e., detention) requirements.

Step 2. Confirm design criteria and applicability

Consider any special site-specific design conditions/criteria from subsection 4.3.3.3. Check with the local jurisdiction, TDEC or other agencies to determine if there are any additional restrictions and/or surface water or watershed requirements that may apply to the site.

Step 3. Determine pretreatment volume

A sediment forebay is provided at each inlet, unless the inlet provides less than 10% of the total design storm inflow to the basin. The forebay should be sized to contain 0.1 inch per impervious acre (363 ft^3) of contributing drainage and should be 4 to 6 feet deep.

Step 4. Determine basin location and preliminary geometry

This step involves initially designing the grading of the basin (establishing contours) and determining the elevation-storage relationship for the basin. Include safety bench, if required or used. See subsection 4.3.3.3 for more details.

Step 5. Compute extended detention orifice release rate(s) and size(s), and establish CPv elevation

The water quality orifice is sized to release the calculated WQv over a minimum 24 hour period and should be adequately protected from clogging by an acceptable external trash rack. The CPv elevation is then determined from the stage-storage relationship. The invert of the channel protection orifice is located at the water quality extended detention elevation, and the orifice is sized to release the channel protection storage volume over a 24-hour period, centroid to centroid.

Step 6. Calculate peak discharge release rates and water surface elevations

Set up a stage-storage-discharge relationship for the control structure for the extended detention and the locally regulated peak discharge orifices.

Step 7. Design embankment(s) and spillway(s)

An emergency spillway shall be included per regulations of the local jurisdiction.

Step 8. Investigate potential basin hazard classification

The design and construction of stormwater management basins are required to follow the latest version of the TDEC Rules and Regulations Application to the Safe Dams Act of 1973.

Step 9. Design inlets, sediment forebay(s), outlet structures, maintenance access, and safety features.

See subsection 4.3.3.3 for more details.

Step 10. Design vegetation

A vegetation scheme for the dry ED basin should be prepared to indicate how the basin bottom, side slopes and embankment will be stabilized and established with vegetation.

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4.3.3.5 Maintenance Requirements and Inspection Checklist

Note: Section 4.3.3.5 must be included in the Operations and Maintenance Plan that is recorded with the deed.

Regular inspection and maintenance is critical to the effective operation of the dry ED basin as designed. It is the responsibility of the property owner to maintain all stormwater BMPs in accordance with the minimum design standards and other guidance provided in this manual. The local jurisdiction has the authority to impose additional maintenance requirements where deemed necessary.

This page provides guidance on maintenance activities that are typically required for dry ED basins, along with a suggested frequency for each activity. Individual basins may have more, or less, frequent maintenance needs, depending upon a variety of factors including the occurrence of large storm events, overly wet or dry (i.e.., drought) regional hydrologic conditions, and any changes or redevelopment in the upstream land use. Each property owner shall perform the activities identified below at the frequency needed to maintain the basin in proper operating condition at all times.

Inspection Activities	**Suggested Schedule**
• After several storm events or an extreme storm event, inspect for: bank stability; signs of erosion; and damage to, or clogging of, the outlet structures and pilot channels.	As needed
• Inspect for: trash and debris; clogging of the outlet structures and any pilot channels; excessive erosion; sediment accumulation in the basin, forebay and inlet/outlet structures; tree growth on dam or embankment; the presence of burrowing animals; standing water where there should be none; vigor and density of the grass turf on the basin side slopes and floor; differential settlement; cracking; leakage; and slope stability.	Semi-annually
• Inspect that the outlet structures, pipes, and downstream and pilot channels are free of debris and are operational. • Note signs of pollution, such as oil sheens, discolored water, or unpleasant odors. • Check for sediment accumulation in the facility. • Check for proper operation of control gates, valves or other mechanical devices.	Annually
Maintenance Activities	**Suggested Schedule**
• Clean and remove debris from inlet and outlet structures. • Mow side slopes (embankment) and maintenance access. Periodic mowing is only required along maintenance rights-of-way and the embankment.	Monthly or as needed
• Repair and revegetate eroded areas. • Remove vegetation that may hinder the operation of the basin. • Repair damage to basin, outlet structures, embankments, control gates, valves, or other mechanical devices; repair undercut or eroded areas.	As Needed
• Monitor sediment accumulations, and remove sediment when the basin volume has become reduced significantly.	As Needed (typically every 20 to 50 years)

The property owner is encouraged to use the inspection checklist that is presented on the next page as a guide in the inspection and maintenance of dry ED basins. Local authorities can require the use of this checklist or other form(s) of maintenance documentation when and where deemed necessary in order to ensure the long-term proper operation of the dry ED basin. Questions regarding stormwater facility inspection and maintenance should be referred to the local engineering department.

INSPECTION CHECKLIST AND MAINTENANCE GUIDANCE (continued)
DRY EXTENDED DETENTION BASIN INSPECTION CHECKLIST

Location: _____ Owner Change since last inspection? Y N

Owner Name, Address, Phone: _____

Date: _____ Time: _____ Site conditions:_____

Inspection Items	Satisfactory (S) or Unsatisfactory (U)	Comments/Corrective Action
Embankment and Emergency Spillway		
Vegetation coverage adequate?		
Growth of woody vegetation?		
Erosion on embankment?		
Animal burrows in embankment?		
Cracking, sliding, bulging of dam?		
Blocked or malfunctioning drains?		
Leaks or seeps on embankment?		
Obstructions of spillway(s)?		
Erosion in/around emergency spillway?		
Other (describe)?		
Inlet/Outlet Structures and Channels		
Clear of debris and functional?		
Trash rack clear of debris and functional?		
Sediment accumulation?		
Condition of concrete/masonry?		
Metal pipes in good condition?		
Control valve operational?		
Basin drain valve operational?		
Outfall channels function, not eroding?		
Other (describe)?		
Basin Bottom		
Vegetation adequate?		
Undesirable vegetation growth?		
Excessive sedimentation?		
Hazards		
Have there been complaints from residents?		
Public hazards noted?		

If any of the above inspection items are **UNSATISFACTORY**, list corrective actions and the corresponding completion dates below:

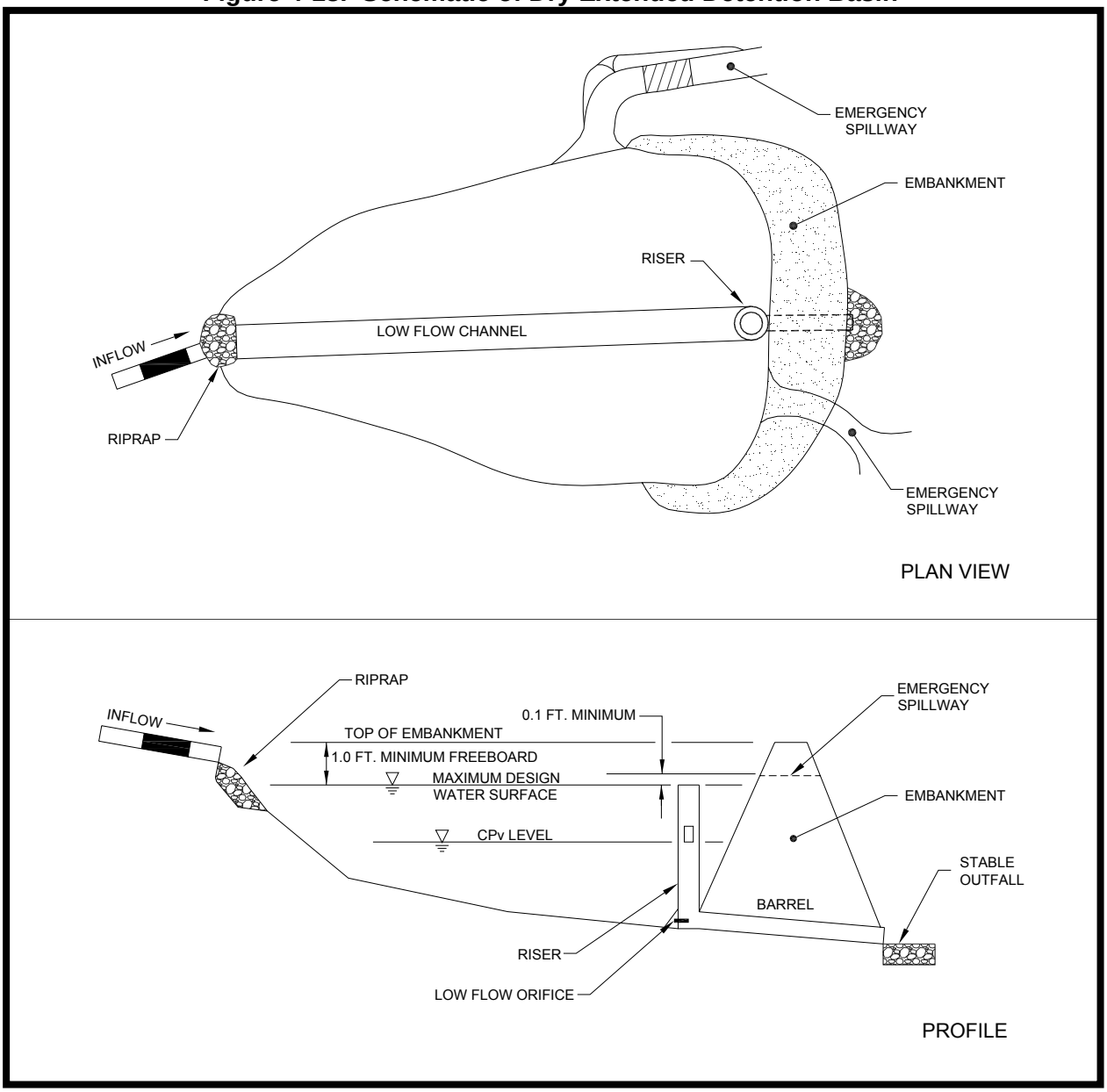
Corrective Action Needed	Due Date

Inspector Signature:_____ Inspector Name (printed)_____

4.3.3.6 Example Schematic

The example schematic for a dry extended detention basin presented in Figure 4-18 can be used to assist in the design of such BMPs.

Figure 4-18. Schematic of Dry Extended Detention Basin



4.3.3.7 Design Form

Use of the following design procedure forms when designing a dry extended detention basin is recommended. Proper use and completion of the form may allow a faster review of the basin design by the local engineering department.

Design Procedure Form: Dry Extended Detention Basins

PRELIMINARY HYDROLOGIC CALCULATIONS	
1a. Compute WQv volume requirements Compute Runoff Coefficient, Rv Compute WQv	Rv = _____ WQv = _____ acre-ft
1b. Estimate CPv	CPv = _____ acre-ft
DRY EXTENDED DETENTION BASINS DESIGN	
2. Is the use of a dry extended detention basin appropriate?	***See subsections 4.3.3.1***
3. Confirm design criteria and applicability.	***See subsection 4.3.3.3***
4. Pretreatment Volume (Forebay) V_{pre} =(I)(.1")(1'/12")	V_{pre} = _____ acre-ft
5. Conduct grading design and determine storage available	Prepare an elevation-storage table and curve using the average area method for computing volumes.

Elevation MSL	Area ft^2	Ave. Area ft^2	Depth ft	Volume ft^3	Cumulative Volume ft^3

Design Procedure Form: Dry Extended Detention Basins (continued)

6. WQv Orifice Computations
   Average ED release rate (if applicable) — release rate= _____ cfs
   Average head, h= (ED elev.- Permanent Pool elev.) /2 — head= _____ ft
   Area of orifice from orifice equation — Area= _____ ft2
   $Q=CA(2gh)^{0.5}$ C varies with orifice condition — diameter _____ inches

   Establish CPv top elevation using stage-storage curve — CPv WSEL= _____ ft-NGVD
   Estimate orifice size — CPv orifice diameter = _____ inches
   Perform hydrograph routing to check detention time — centroid-centroid det. = _____ hours
   Iterate to final orifice size — Final CPv orifice diameter = _____ inches

7. Calculate required local municipality peak discharge release rates and WSELs — Set up a stage-storage-discharge relationship

Elevation	Storage	Low Flow	Riser			Barrel		Emergency	Total
		WQv-ED	CPv_ED	High Storage		Inlet	Pipe	Spillway	Storage
				Orif.	Weir				
MSL	acre-ft	H(ft) Q(cfs)	H(ft) Q(cfs)	H Q	H Q	H(ft) Q(cfs)	H(ft) Q(cfs)	H(ft) Q(cfs)	acre-ft

   Check inlet condition
   Check outlet conditions — **Use culverty design guidance from local municipality**

8. Size emergency spillway using the local municipality peak discharge and set top of embankment elevation and emergency spillway elevation based on $WSEL_{peak}$ — $Q_{ES}=Qp_{peak}$ _____ cfs; $WSEL_{peak}$= _____ ft; El_{embank}= _____ ft; El_{ES}= _____ ft

9. Investigate potential basin hazard classification — **See TN Safe Dams Act of 1973**

10. Design inlets, sediment forebays, outlet structures, maintenance access, and safety features — ***See subection 4.3.3.3***

11. Design vegetation according to guidance provided in TVA Riparian Restoration webpage
    www.tva.com/river/landandshore/stabilization/index.htm

13. Verify peak flow control, water quality drawdown time and channel protection detention time

4.3.3.8 References

Atlanta Regional Council (ARC). *Georgia Stormwater Management Manual Volume 2 Technical Handbook.* 2001.

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4.3.3.9 Suggested Reading

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