APPENDIX E
DETENTION STRUCTURAL CONTROLS

DRY DETENTION/DRY ED BASINS

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

Advantages/Benefits:	Disadvantages/Limitations:
• Provides peak flow attenuation	• Does not provide water quality treatment

Design Considerations:

- Applicable for drainage areas up to 75 acres
- Typically less costly than stormwater (wet) ponds for equivalent flood storage, as less excavation is required
- Used in conjunction with water quality structural controls
- Recreational and other open space opportunities between storm runoff events

Stormwater Management Capability:

- **Reduction in peak rate of runoff discharge**

Land Use Considerations:

X	**Residential**
X	**Commercial**
X	**Industrial**

Maintenance:

- Remove debris from basin surface to minimize outlet clogging and improve aesthetics
- Removed sediment buildup
- Repair and revegetate eroded areas
- Perform any needed structural repairs to inlet and outlets
- Mow to limit unwanted vegetation

Maintenance Burden

H

L = Low M = Moderate H = High

SECTION 1: DESCRIPTION

Dry detention and dry extended detention (ED) basins are surface facilities intended to provide for the temporary storage of stormwater runoff to reduce downstream water quantity impacts. These facilities temporarily detain stormwater runoff, releasing the flow over a period of time. They are designed to completely drain following a storm event and are normally dry between rain events.

Dry detention basins are intended to provide overbank flood protection (peak flow reduction of the 25-year storm, Q_{p25}) and can be designed to control the extreme flood (100-year, Q_f) storm event. Dry ED basins provide downstream channel protection through extended detention of the channel protection volume (CP_v), and can also provide Q_{p25} and Q_f control.

Both dry detention and dry ED basins provide limited pollutant removal benefits and are not intended for water quality treatment. Detention-only facilities should be used in a treatment train approach with other structural controls that provide treatment of the WQ_v (see Chapter 4, Water Quality).

Compatible multi-objective use of dry detention facilities is strongly encouraged.

SECTION 2: PLANNING AND DESIGN CRITERIA

Location

- Dry detention and dry ED basins are to be located downstream of other structural stormwater controls providing treatment of the water quality volume (WQ_v). See Chapter 4 for more information on the use of multiple structural controls in a treatment train.
- The maximum contributing drainage area to be served by a single dry detention or dry ED basin is 75 acres.

General Design

- Dry detention basins are sized to temporarily store the volume of runoff required to provide overbank flood (Q_{p25}) protection (i.e., reduce the post-development peak flow of the 25-year storm event to the pre-development rate), and control the 100-year storm (Q_f) if required.
- Dry ED basins are sized to provide extended detention of the channel protection volume (CPv) over 24 hours and can also provide additional storage volume for normal detention (peak flow reduction) of Q_{p25} and Q_f.
- Routing calculations must be used to demonstrate that the storage volume is adequate. See Chapter 7 for procedures on the design of detention storage.
- Storage volumes greater than 50 acre-feet are subject to the requirements of the Arkansas Natural Resources Commission (ANRC) Title VII, Rules Governing Design and Operation of Dams.
- Vegetated embankments shall be less than 20 ft in height and shall have side slopes no steeper than 2:1 (horizontal to vertical) although 3:1 is preferred. 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.

- The maximum depth of the basin should not exceed 10 feet.
- Areas above the normal high water elevations of the detention facility should 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 bottom area of storage facilities should be graded toward the outlet to prevent standing water conditions. 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.
- Adequate maintenance access must be provided for all dry detention and dry ED basins.

Inlet and Outlet Structures

- Inflow channels are to be stabilized with flared riprap aprons, or the equivalent. A sediment forebay sized to 0.1 inches per impervious acre of contributing drainage should be provided for dry detention and dry ED basins that are in a treatment train with off-line water quality treatment structural controls.
- For a dry detention basin, the outlet structure is sized for Q_{p25} control (based upon hydrologic routing calculations) and can consist of a weir, orifice, outlet pipe, combination outlet, or other acceptable control structure. Small outlets that will be subject to clogging or are difficult to maintain are not acceptable.

  For a dry ED basin, a low flow orifice capable of releasing the channel protection volume over 24 hours must be provided. The channel protection orifice should have a minimum diameter of 3 inches and should be adequately protected from clogging by an acceptable external trash rack. The orifice diameter may be reduced to 1 inch if internal orifice protection is used (e.g., an overperforated vertical stand pipe with 0.5-inch orifices or slots that are appropriately protected. Recommended details for clogging prevention are provided in Appendix G. Adjustable gate valves can also be used to achieve this equivalent diameter.

  See Appendix G (Detention Outlet Structure Design) for more information on the design of outlet works.
- Seepage control or anti-seep collars should be provided for all outlet pipes.
- Riprap, plunge pools or pads, or other energy dissipaters are to be placed at the end of the outlet to prevent scouring and erosion. If the basin discharges to a channel with dry weather flow, care should be taken to minimize tree clearing along the downstream channel, and to reestablish a forested riparian zone in the shortest possible distance. See Chapter 6 for more guidance on energy dissipation design.
- An emergency spillway is to be included in the stormwater pond design to safely pass the extreme flood flow. The spillway prevents pond water levels from overtopping the embankment and causing structural damage. The emergency spillway must be designed to convey the 100-year storm event and must be located so that downstream structures will not be impacted by spillway discharges.
- A minimum of 1 ft of freeboard must be provided, measured from the top of the water surface elevation for the extreme flood, to the lowest point of the dam embankment not counting the emergency spillway.

SECTION 3. TYPICAL SCHEMATIC DETAILS

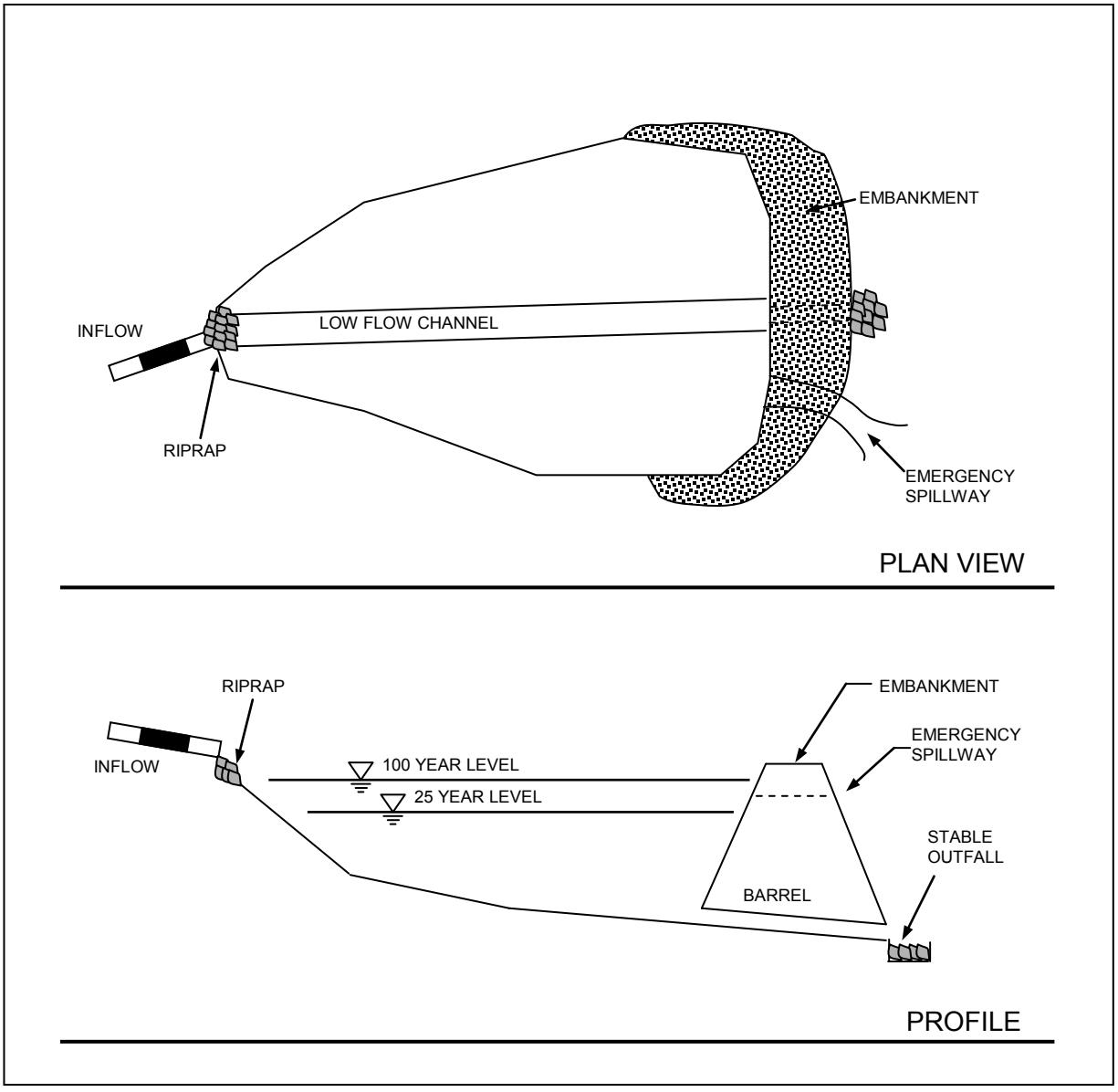

Figure DSC-E.1. Schematic of dry detention basin.

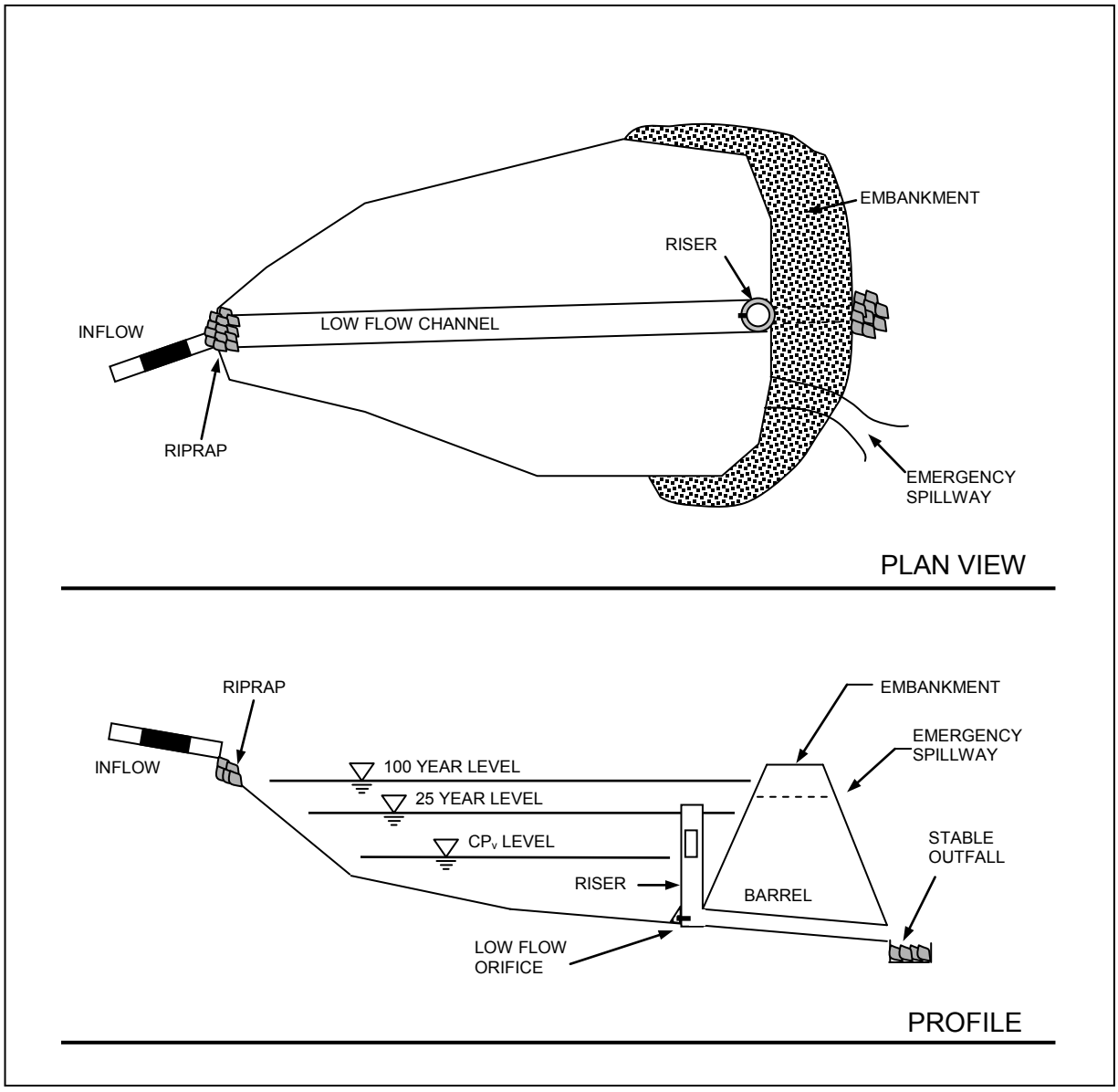

Figure DSC-E.2. Schematic of dry extended detention basin.

SECTION 4: INSPECTION AND MAINTENANCE REQUIREMENTS

Table DSC-E.1. Typical Maintenance Activities for Dry Detention / Dry ED Basins (Source: Denver Urban Storm Drainage Manual, 1999).	
Activity	**Schedule**
• Remove debris from basin surface to minimize outlet clogging and improve aesthetics.	Annually and following significant storm events
• Remove sediment buildup. • Repair and revegetate eroded areas. • Perform structural repairs to inlet and outlets.	As needed based on inspection
• Mow to limit unwanted vegetation.	Routine

SECTION 5: REFERENCES

Atlanta Regional Commission. 2001. *Georgia Stormwater Management Manual, Volume 2: Technical Handbook.* Atlanta, GA. http://www.georgiastormwater.com/GSMMVol2.pdf.

Urban Drainage and Flood Control District. 1999. *Criteria Manual*, Denver, CO.

MULTI-PURPOSE DETENTION AREAS

Description: A facility designed primarily for another purpose, such as parking lots and rooftops that can provide water quantity control through detention of stormwater runoff.

Advantages/Benefits:	Disadvantages/Limitations:
• Provides peak flow attenuation	• Does not provide water quality treatment

Design Considerations:

- Allows for multiple uses of site areas and reduces the need for downstream detention facilities
- Should be used in conjunction with water quality structural controls
- Adequate grading and drainage must be provided to allow full use of facility's primary purposes following a storm event

Stormwater Management Capability:

- Reduction in peak rate of runoff discharge

Land Use Considerations:

X	**Residential**
X	**Commercial**
X	**Industrial**

Maintenance:

- Remove debris from ponding area to minimize outlet clogging and improve aesthetics
- Remove sediment buildup
- Repair and revegetate eroded areas
- Perform structural repairs to inlet and outlets
- Perform additional maintenance activities specific to the type of facility

M	**Maintenance Burden** L = Low M = Moderate H = High

SECTION 1. DESCRIPTION

Multi-purpose detention areas are site areas primarily used for one or more specific activities that are also designed to provide for the temporary storage of stormwater runoff to reduce downstream water quantity impacts. Example of multi-purpose detention areas include:

- Parking Lots
- Rooftops
- Sports Fields
- Recessed Plazas

Multi-purpose detention areas are normally dry between rain events, and by their very nature must be useable for their primary function the majority of the time. As such, multi-purpose detention areas should not be used for extended detention (CP_v control).

Multi-purpose detention areas are not intended for water quality treatment and must be used in a treatment train approach with other structural controls that provide treatment of the WQ_v (see Chapter 4, Section 4.4, Using Structural Stormwater Controls in Series).

SECTION 2: PLANNING AND DESIGN CRITERIA

Location

- Multi-purpose detention areas can be located upstream or downstream of other structural stormwater controls providing treatment of the water quality volume (WQ_v). See Section 4.4 for more information on the use of multiple structural controls in a treatment train.

General Design

- Multi-purpose detention areas are sized to temporarily store the peak flow from the 2-, 10-, and 25-year storm events and be capable of safely conveying the 100-year storm (Q_f). The 2- and 10-year storm events must be detained since extended detention for the 1-year event is not provided with this structural practice.
- Routing calculations must be used to demonstrate that the storage volume is adequate. See Chapter 7 for procedures on the design of detention storage.
- All multi-purpose detention facilities must be designed to minimize potential safety risks, potential property damage, and inconvenience to the facility's primary purposes. Emergency overflows are to be provided for the 50- and 100-year events. The overflow must not create a significant adverse impact to downstream properties or the conveyance system. If adverse impact to downstream properties is possible, then the 100-year event must also be detained.
- All types of multi-use detention is subject to the approval of the City Engineer.

Parking Lot Storage

Parking lot detention can be implemented in areas where portions of large, paved lots can be temporarily used for runoff storage without significantly interfering with normal vehicle and pedestrian traffic. Parking lot detention can be created in two ways: by using ponding areas along sections of raised curbing, or through depressed areas of pavement at drop inlet locations.

- The maximum depth of detention ponding in a parking lot, except at a flow control structure, should be 6 inches for a 10-year storm, and 9 inches for a 100-year storm. The maximum depth of ponding at a flow control structure is 12 inches for a 100-year storm.
- The storage area (portion of the parking lot subject to ponding) must have a minimum slope of 0.5% towards the outlet to ensure complete drainage following a storm. A slope of 1% or greater is recommended.
- Fire lanes used for emergency equipment must be free of ponding water for runoff events up to the extreme storm (100-year) event.
- Flows are typically backed up in the parking lot using a raised inlet.

Rooftop Storage

- Rooftops can be used for detention storage as long as the roof support structure is designed to address the weight of ponded water and is sufficiently waterproofed to achieve a minimum service life of 30 years. All rooftop detention designs must meet Arkansas Fire Prevention Code and the City of Fayetteville's building code requirements.
- The minimum pitch of the roof area subject to ponding is 0.25 inches per foot.
- The rooftop storage system must include another mechanism for draining the ponding area in the event that the primary outlet is clogged.

Sports Fields

- Athletic facilities such as football and soccer fields and tracks can be used to provide stormwater detention. This is accomplished by constructing berms around the facilities, which in essence creates very large detention basins. Outflow can be controlled through the use of an overflow weir or other appropriate control structure. Proper grading must be performed to ensure complete drainage of the facility.

Public Plazas

- In high-density areas, recessed public common areas such as plazas and pavilions can be utilized for stormwater detention. These areas shall be designed to flood no more than once or twice annually (i.e., 1-year or 2-year storm events), and provide important open recreation space during the rest of the year.

SECTION 3. INSPECTION AND MAINTENANCE REQUIREMENTS

Table DSC E.1 Typical Maintenance Activities for Multi-Purpose Detention Areas (Source: Denver Urban Storm Drainage Manual, 1999)	
Activity	**Schedule**
• Remove debris from ponding area to minimize outlet clogging and improve aesthetics.	Annually and following significant storm events
• Remove sediment buildup. • Repair and revegetate eroded areas. • Perform structural repairs to inlet and outlets.	As needed based on inspection
• Perform additional maintenance activities specific to the type of facility.	As required

SECTION 4. REFERENCES

Atlanta Regional Commission. 2001. *Georgia Stormwater Management Manual, Volume 2: Technical Handbook.* Atlanta, GA. http://www.georgiastormwater.com/GSMMVol2.pdf

Urban Drainage and Flood Control District. 1999. *Criteria Manual*, Denver, CO.

UNDERGROUND DETENTION

Description: Detention storage located in underground tanks, vaults, or pipe systems designed to provide water quantity control through detention and/or extended detention of stormwater runoff.

Source: City of Clemson, South Carolina

Advantages/Benefits:	Disadvantages/Limitations:
• Provides peak flow attenuation • Can be used in space limited applications	• Does not provide water quality treatment

Design Considerations:

- Does not take up surface space
- Should be used in conjunction with water quality structural control
- Concrete vaults or pipe/tank systems can be used
- Maintenance access must be considered during design of the system

Stormwater Management Capability:

- Reduction in peak rate of runoff discharge

Land Use Considerations:

X	**Residential**
X	**Commercial**
X	**Industrial**

Maintenance:

- Remove any trash/debris and sediment buildup in the underground vaults or tanks
- Perform structural repairs to inlets and outlets

H	**Maintenance Burden** L = Low M = Moderate H = High

SECTION 1: DESCRIPTION

- Detention vaults are box-shaped underground stormwater storage facilities typically constructed with reinforced concrete. 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.
- Both underground vaults and tanks can provide channel protection through extended detention of the channel protection volume (CP_v), and overbank flood Q_{p25} (and in some cases extreme flood Q_f) control through normal detention. Basic storage design and routing methods are the same as for detention basins except that the bypass for high flows is typically included.
- Underground detention vaults and tanks are not intended for water quality treatment and should be used in a treatment train approach with other structural controls that provide treatment of the WQ_v (see Chapter 4). This will prevent the underground vault or tank from becoming clogged with trash or sediment and significantly reduces the maintenance requirements for an underground detention system.
- Prefabricated concrete vaults are available from commercial vendors. In addition, several pipe manufacturers have developed packaged detention systems.

SECTION 2. PLANNING AND DESIGN CRITERIA

Location

- Underground detention systems are to be located downstream of other structural stormwater controls that provide treatment of the water quality volume (WQ_v).
- The maximum contributing drainage area to be served by a single underground detention vault or tank is 25 acres.

General Design

- Underground detention systems are sized to provide extended detention of the channel protection volume over 24 hours and temporarily store the volume of runoff required to provide overbank flood (Qp25) protection (i.e., reduce the post-development peak flow of the 25-year storm event to the pre-development rate). Due to the storage volume required, underground detention vaults and tanks are typically not used to control the 100-year storm (Q_f) except for very small drainage areas (<1 acre). If Q_f is not detained, a properly designed bypass must be provided.
- Routing calculations must be used to demonstrate that the storage volume is adequate. See Chapter 7 for procedures on the design of detention storage.
- Detention Vaults: Minimum 3,000 psi structural reinforced concrete may be used for underground detention vaults. All construction joints must be provided with water stops. Cast-in-place wall sections must be designed as retaining walls. The maximum depth from finished grade to the vault invert should be 20 ft.

- Detention Tanks: The minimum pipe diameter for underground detention tanks is 36 inches.
- Underground detention vaults and tanks must meet structural requirements for overburden support and traffic loading if appropriate.
- Adequate maintenance access must be provided for all underground detention systems. Access must be provided over the inlet pipe and outflow structure. Access openings can consist of a standard frame, grate and solid cover, or a removable panel. Vaults with widths of 10 ft or less should have removable lids.

Inlet and Outlet Structures

- A separate sediment sump or vault chamber sized to 0.1 inches per impervious acre of contributing drainage should be provided at the inlet for underground detention systems that are in a treatment train with off-line water quality treatment structural controls.
- For CP_v control, a low flow orifice capable of releasing the channel protection volume over 24 hours must be provided. The channel protection orifice should have a minimum diameter of 3 inches and should be adequately protected from clogging by an acceptable external trash rack. The orifice diameter may be reduced to 1 inch if internal orifice protection is used (i.e., an overperforated vertical stand pipe with 0.5-inch orifices or slots that are protected by wirecloth and a stone filtering jacket). Adjustable gate valves can also be used to achieve this equivalent diameter.
- For overbank flood protection and extreme flood flow, additional outlets are sized for Q_{p25} and Q_f control (based upon hydrologic routing calculations) and can consist of a weir, orifice, outlet pipe, combination outlet, or other acceptable control structure.
- See Appendix G for more information on the design of outlet works.
- Riprap, plunge pools or pads, or other energy dissipaters are to be placed at the end of the outlet to prevent scouring and erosion. See Chapter 6 for more guidance on energy dissipation.

SECTION 3: TYPICAL SCHEMATIC DETAILS

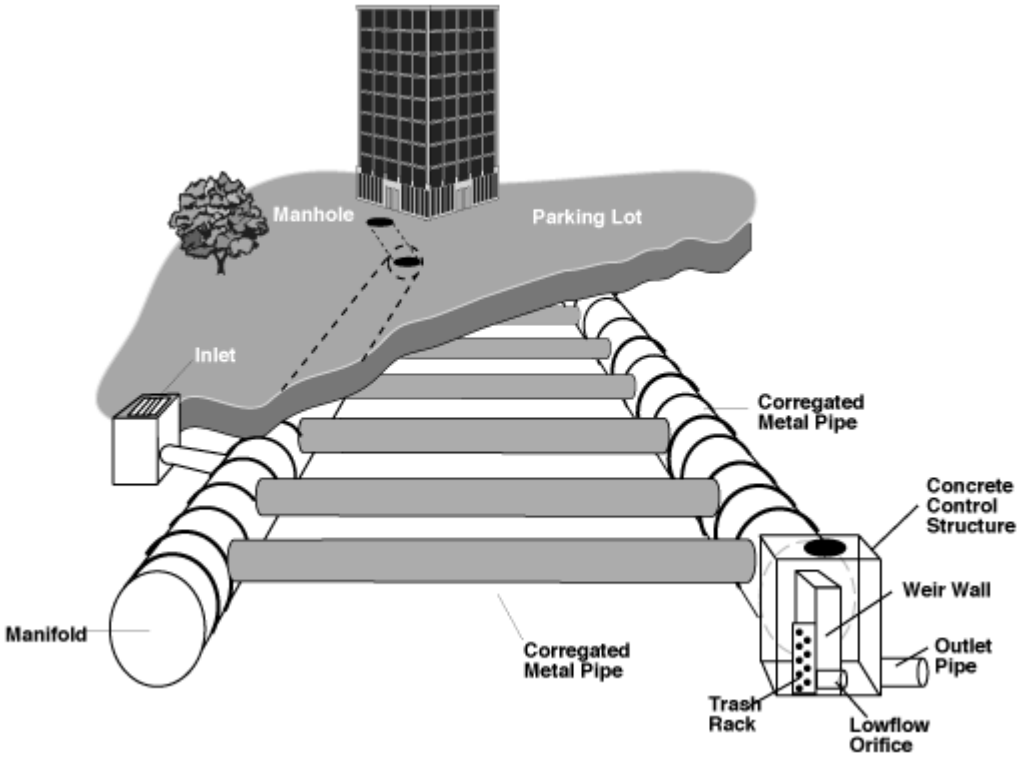

Figure DSC-3.1 Example underground detention tank system (Source: Atlanta Regional Commission).

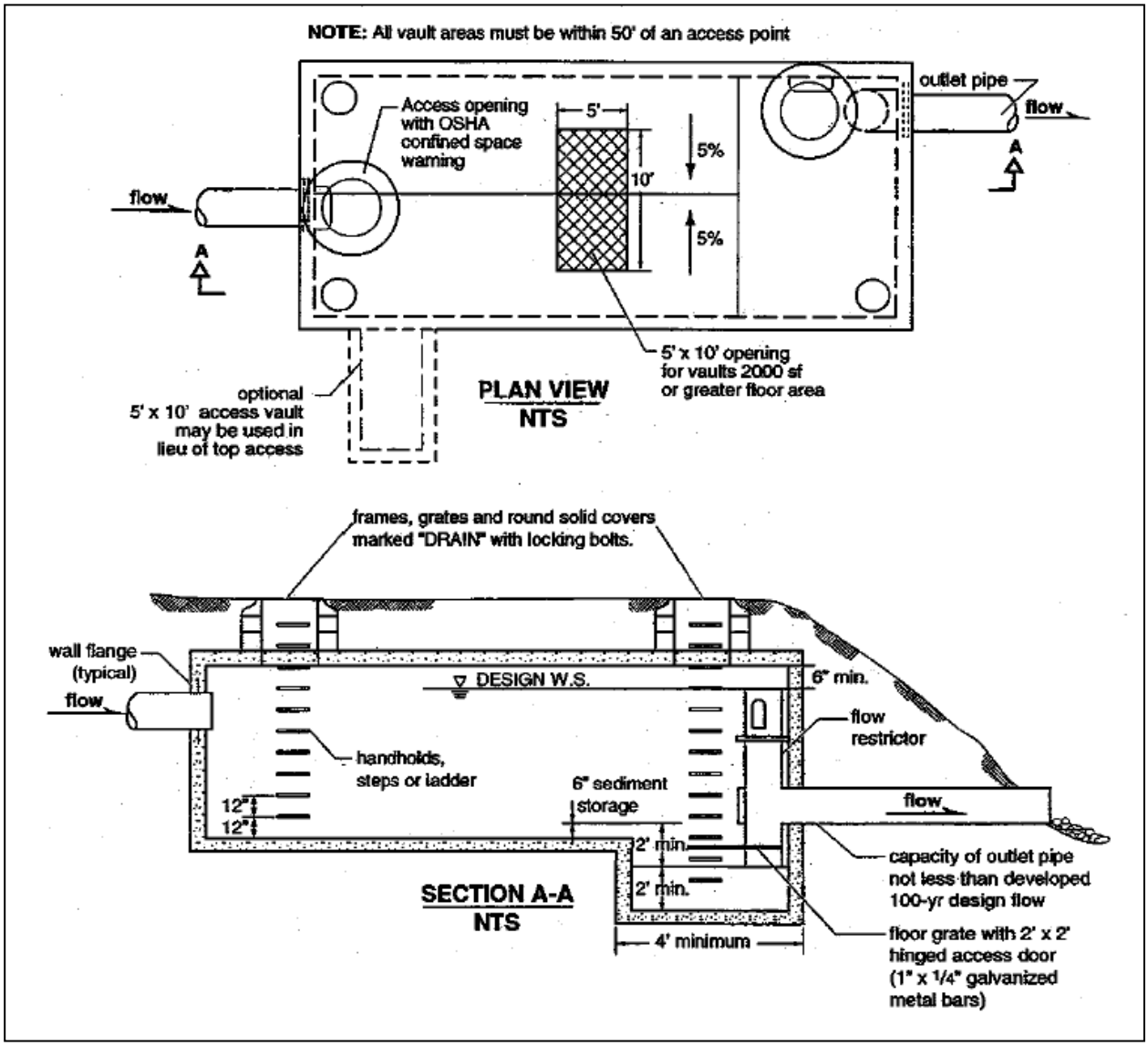

Figure DSC-3.2 Schematic of typical underground detention vault (Source: WDE, 2000)

SECTION 4: INSPECTION AND MAINTENANCE REQUIREMENTS

Table DSC-3.1 Typical Maintenance Activities for Underground Detention Systems.	
Activity	**Schedule**
• Remove any trash/debris and sediment buildup in the underground vaults or tanks.	Annually
• Perform structural repairs to inlet and outlets.	As needed, based on inspection

SECTION 5. REFERENCES

Atlanta Regional Commission. 2001. *Georgia Stormwater Management Manual, Volume 2: Technical Handbook.* Atlanta, GA. http://www.georgiastormwater.com/GSMMVol2.pdf

Washington State Department of Ecology, 2000. Stormwater Management Manual for Western Washington.