4.4.6 Underground Detention

Limited Application Stormwater BMP

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

KEY CONSIDERATIONS

DESIGN GUIDELINES:

- Maximum drainage area = 25 acres
- Maximum drainage area = 1 acre for structures passing the Qp_{100}
- Access point for maintenance required.
- Used downstream of a water quality BMP.

ADVANTAGES / BENEFITS:

- To be used for space-limited applications only.
- Good for retrofitting small urbanized lots.
- Concrete vaults or pipe systems can be used.
- Longevity is high, with proper maintenance.

DISADVANTAGES / LIMITATIONS:

- Discouraged unless other options unfeasible.
- Controls for stormwater quantity only – not intended to provide water quality treatment.
- Dissolved pollutants are not removed.
- Frequent maintenance required.

MAINTENANCE REQUIREMENTS:

- Remove debris from inlet and outlet structures.
- Monitor sediment accumulation.
- Clean out sediment and floatable debris using catch basin cleaning equipment (vacuum pumps).

STORMWATER MANAGEMENT SUITABILITY

- ☐ **Water Quality**
- ☑ **Channel/Flood Protection**
- ☑ **Overbank Flood Protection**
- ✷ **Extreme Flood Protection**

✷ in certain situations

FEASIBILITY CONSIDERATIONS

- **M-H** **Land Requirement**
- **M-H** **Capital Cost**
- **M-H** **Maintenance Burden**

Residential/Subdivision Use: *No*

Drainage Area: *25 acres maximum, 1 acre maximum for Qp_{100}*

Soils: *Not dependent upon soil type*

POLLUTANT REMOVAL

- **L** **Total Suspended Solids**
- **L** **Nutrients**: Total Phosphorus / Total Nitrogen
- **L** **Metals**: Cadmium, Copper, Lead, and Zinc
- **L** **Pathogens**: Coliform, Streptococci, E.Coli

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

4.4.6.1 General Description

Underground detention is typically utilized on sites where developable surface area is at a minimum. Underground detention facilities can be either box-shaped facilities constructed with reinforced concrete, facilities constructed with large diameter metal or plastic pipe or commercially-available proprietary underground systems. All methods serve as alternatives to surface dry detention for stormwater quantity control where there is not adequate land for a dry detention basin or multi-purpose detention area.

Underground detention can provide channel protection through extended detention of the channel protection volume and overbank flood control (and in some cases extreme flood) through normal detention. Basic storage design and routing methods are the same as for dry detention basins except that the bypass for high flows must be included in the design.

Due to the potential problems that local conditions present, the Knox County Engineering & Public Works Department does not support the use of underground detention unless other peak discharge control options are deemed physically infeasible.

4.4.6.2 Pollutant Removal Capabilities

Underground detention facilities are not capable of significant pollutant removal. Therefore, because underground detention is not intended for water quality treatment, it must be used in a treatment train approach with other structural BMPs that provide treatment of the WQv. This will prevent the underground pipe systems or vaults from becoming clogged with trash or sediment and significantly reducing the maintenance requirements.

4.4.6.3 Planning and Design Standards

If underground detention is allowed by the Director, the following standards shall be considered **minimum** design standards for the design of underground detention. Underground detention that is not designed to these standards will not be approved. The Director of Engineering and Public Works (the Director) shall have the authority to require additional design conditions if deemed necessary.

A. LOCATION AND SITING

- The maximum contributing drainage area to be served by a single underground detention vault or tank is 25 acres.
- Flood protection controls for peak discharge control (Qp_2, Qp_{10}, Qp_{25} and Qp_{100}) should be designed as final controls for on-site stormwater. Therefore, underground detention will typically be located downstream of structural stormwater BMPs that are designed to provide treatment of the water quality volume (WQv) and channel protection volume (CPv).
- Underground detention shall be placed in a drainage easement that is recorded with the deed and shown on the plan. The drainage easement shall be located 15 feet from the outside limits of the underground detention structure. Minimum setback requirements for the easement shall be as follows unless otherwise specified by the Director:
  - From a public water system well – TDEC specified distance per designated category
  - From a private well – 50 feet; if the well is down gradient from a land use that must obtain a Special Pollution Abatement Permit, then the minimum setback is 250 feet
  - From a septic system tank/leach field – 50 feet
- The drainage easement shall be located 15 feet from the outside limits of the underground detention structure. The first floor elevation (FFE) for any structure adjacent to underground detention shall have an elevation no lower than 1 foot above the emergency spillway elevation.

B. GENERAL DESIGN

- Underground detention shall consist of the following elements, designed in accordance with the specifications provided in this section.

  (1) An outlet structure;

  (2) An emergency spillway; and

  (3) Maintenance access.

- 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 (Qp_{25}) protection. Some systems will also provide extreme flood (Qp_{100}) protection.

- Routing calculations must be used to demonstrate that the storage volume is adequate. See Chapter 3 for procedures on the design of detention storage.

- 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 feet or less should have removable lids.

C. PHYSICAL SPECIFICATIONS / GEOMETRY

- Underground detention vaults and tanks must meet structural requirements for overburden support and traffic loading if appropriate.

- 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 feet.

- Detention Pipes: The minimum pipe diameter for underground detention is 36 inches.

Inlet and Outlet Structures

- A separate sediment sump or vault chamber sized to contain 0.1 inch per impervious acre (363 ft^3/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 BMPs.

- For CPv control, a low flow orifice capable of releasing the channel protection volume over 24-72 hours must be provided. The channel protection should be adequately protected from clogging by an acceptable external trash rack. Orifices smaller than 3" require internal orifice protection (i.e., an over perforated vertical stand pipe with 0.5-inch orifices or slots that are protected by wire cloth and a stone filtering jacket). Adjustable gate valves can also be used to achieve this equivalent diameter.

- For overbank flood protection, an additional outlet is sized for Qp25 control (based upon hydrologic routing calculations) and can consist of a weir, orifice, outlet pipe, combination outlet, or other acceptable control structure. See Chapter 3 for more information on the design of outlet works.

- Water shall not be discharged from underground detention in an erosive manner. Riprap, plunge pools or pads, or other energy dissipators are to be placed at the end of the outlet to prevent scouring and erosion. If a pond 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 water quality buffer). See Chapter 7 for more guidance.

D. EMERGENCY SPILLWAY

- A high flow bypass shall be included in the underground detention design to safely pass Qp_{100} in the event of outlet structure blockage or mechanical failure. The bypass shall be located so that downstream structures will not be impacted by emergency discharges.

E. MAINTENANCE ACCESS

- A maintenance right-of-way or easement having a minimum width of 20 feet shall be provided 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 works, and, to the extent feasible, be designed to allow vehicles to turn around.

4.4.6.4 Design Procedures

In general, site designers should perform the following design procedures when designing underground detention.

Step 1. Compute runoff control volumes.

Calculate Qp_2, Qp_{10}, Qp_{25} and Qp_{100}, in accordance with the guidance presented in Volume 2, Chapter 2.

Step 2. Confirm design criteria and applicability.

Consider any special site-specific design conditions/criteria from subsection 4.4.6.3. Check with Knox County Engineering, 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. Calculate Qp_2, Qp_{10}, Qp_{25} and Qp_{100} release rates and water surface elevations.

Set up stage-storage-discharge relationships for the control structure for the 2, 10, 25 and 100-year storms.

Step 4. Design spillway(s)

Size emergency spillway (bypass) and analyze safe passage of the Qp_{100}. Set the emergency spillway elevation a minimum of 0.1 feet above the 100-year water surface elevation.

Step 5. Design inlets, outlet structures and maintenance access.

See subsection 4.4.6.3 for more details.

4.4.6.5 Maintenance Requirements and Inspection Checklist

Note: Section 4.4.6.5 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 underground detention 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 Director has the authority to impose additional maintenance requirements where deemed necessary.

This page provides guidance on maintenance activities that are typically required for underground detention, along with a suggested frequency for each activity. Individual underground detention locations 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 pond in proper operating condition at all times.

Inspection Activities	Suggested Schedule
• After several storm events or an extreme storm event, inspect for: signs of clogging of the inlet or outlet structures and sediment accumulation.	As Needed
• Inspect for: trash and debris; clogging of the outlet structures and any pilot channels; excessive erosion; sediment accumulation in the basin 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**
• Perform structural repairs to inlet and outlets • Clean and remove debris from inlet and outlet structures.	Monthly or as needed
• Repair damage to inlet or outlet structures, control gates, valves, or other mechanical devices; repair undercut or eroded areas.	As Needed
• Monitor sediment accumulations, and remove sediment when the pond volume has become reduced significantly.	As Needed

Knox County encourages the use of the inspection checklist that is presented on the next page to guide the property owner in the inspection and maintenance of underground detention facilities. The Director 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 underground detention facilities. Questions regarding stormwater facility inspection and maintenance should be referred to the Knox County Department of Engineering and Public Works, Stormwater Management Division.

INSPECTION CHECKLIST AND MAINTENANCE GUIDANCE (continued)
UNDERGROUND DETENTION 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
Inlet/Outlet Structures		
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?		
Pond drain valve operational?		
Outfall channels function, not eroding?		
Other (describe)?		
Pond Bottom		
Excessive sedimentation?		

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)_____

4.4.6.6 Example Schematics

Figure 4-68. Example Underground Detention Pipe System

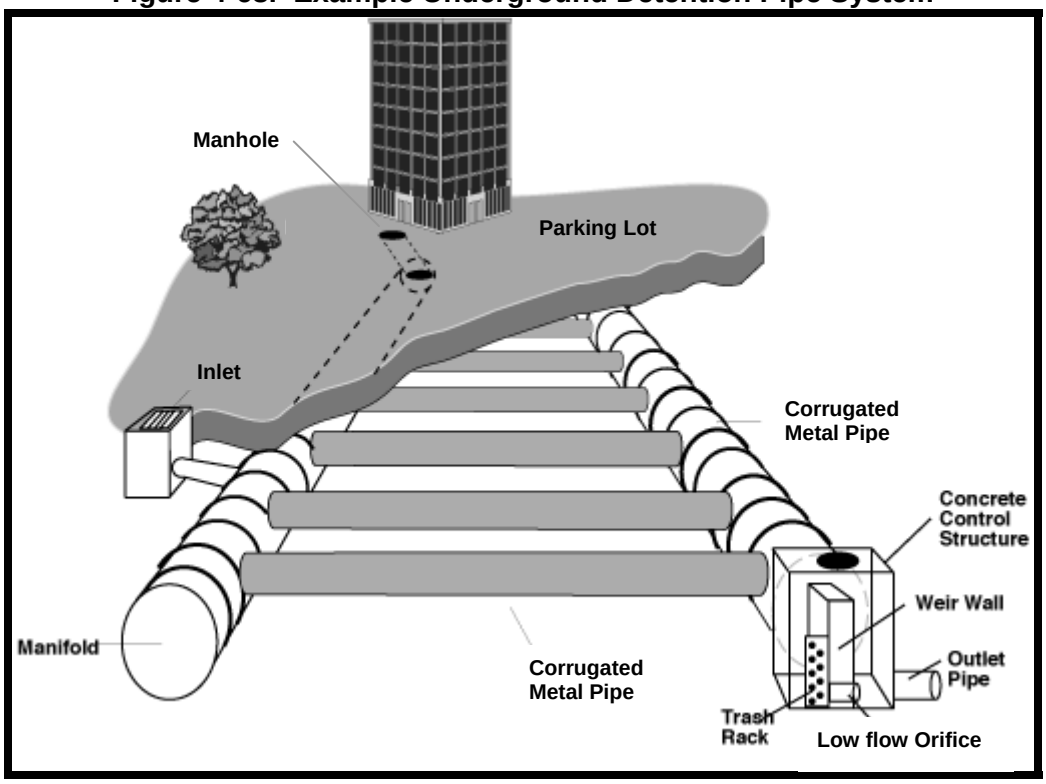
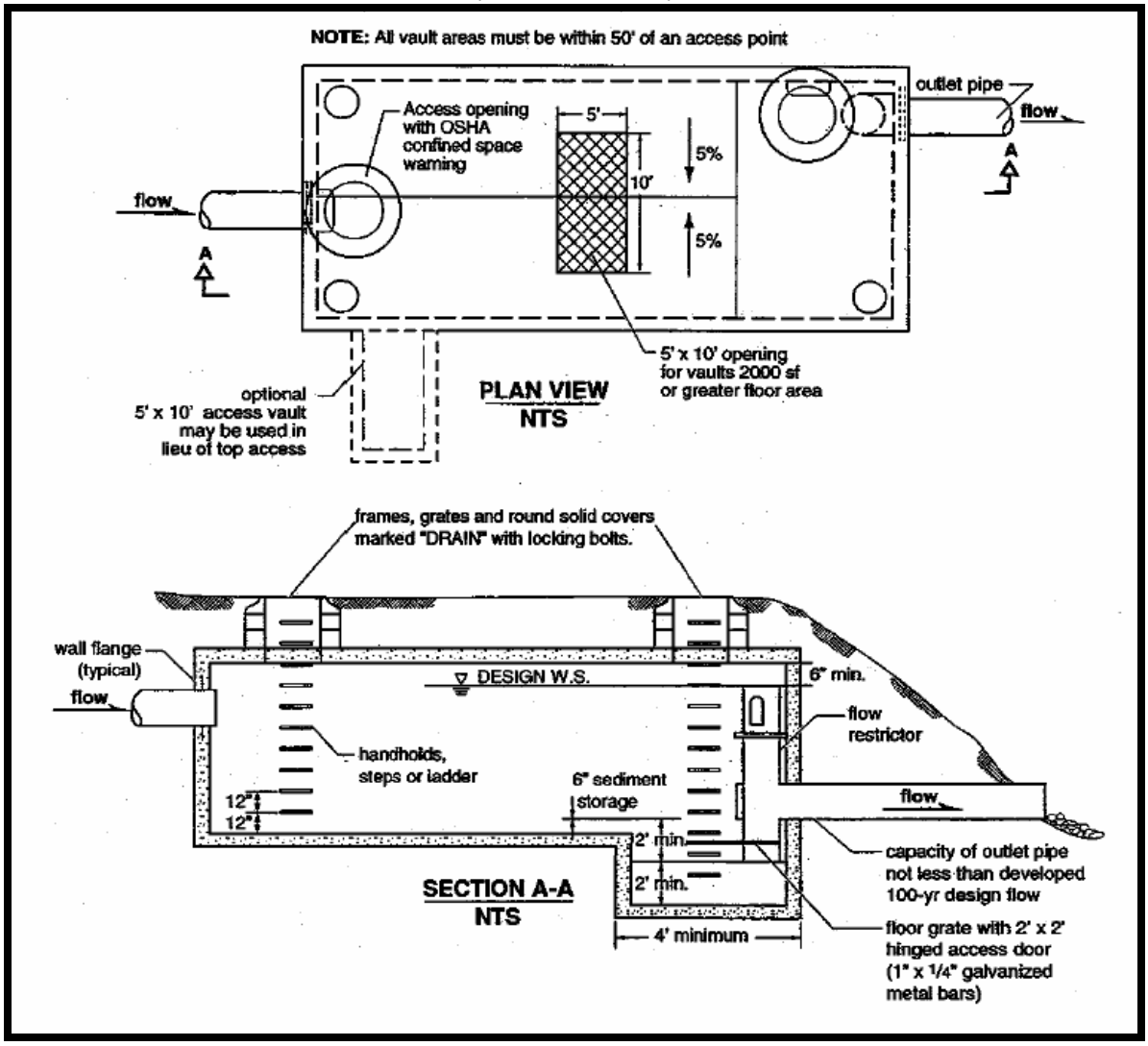


Figure 4-69. Schematic of a Typical Underground Detention Vault

(Source: WDE, 2000)



4.4.6.7 References

AMEC. *Metropolitan Nashville and Davidson County Stormwater Management Manual, Volume 4 Best Management Practices.* 2006.

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

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