SECTION 17: UNDERGROUND DETENTION SYSTEM (UDS) AND DRY EXTENDED DETENTION BASIN

17.1 General Characteristics and Purpose

In Greensboro, stormwater management regulations require mitigation of the quantitative and qualitative impacts of stormwater runoff. Traditional methods have relied almost exclusively on surface retention/detention facilities, such as stormwater management ponds. In some situations, the site under development does not lend itself to these traditional measures due to insufficient space, topography, high land values, liability, and other issues.

Increasingly, engineers are looking toward subsurface methods of flood water detention that retain the above-ground use of the site. A popular method is to use underground detention facilities such as vaults, pipes, and tanks. Underground detention facilities are structural best management practices (BMPs) designed to provide temporary storage of stormwater runoff for quantity control purposes.

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 pipes. Both serve as an alternative to surface dry detention stormwater quantity control, particularly for space-limited areas where there is inadequate land for a dry detention basin or multipurpose detention area.

17.2 Meeting Regulatory Requirements

Underground detention systems work as an integral part of the storm sewer system to provide a temporary storage volume for excess stormwater. Runoff is stored and discharged over time whenever runoff inflow exceeds the allowable discharge rate. The systems are typically installed beneath parking lots, streets, and parks to maximize property usage and lower development costs. These systems are not intended for water quality treatment and must be used in a treatment train approach with other structural controls that provide treatment with the Water Quality Volume (WQV). The most common application for water quality is to use these systems in conjunction with other approved water quality devices. The guidelines and requirements stated in this Chapter are appropriate for all underground pipe or vault detention Best Management Practices.

The detention systems must be sized to provide storage for the required volume, with safe conveyance of larger flows through the facility. Flood routing calculations must be performed and presented for City's review to demonstrate that the storage volume is adequate. Routing calculations must also demonstrate that the underground detention system is sized to provide detention for both the two- and ten-year recurrence storm events and reduce the peak runoff flow rate to predevelopment levels for those storms. The routing calculations must also allow adequate volume of storage for anticipated maximum sediment accumulation prior to cleanout. A detail of the control structure must be included showing the elevations of the significant components (2-year, 10-year, and 100-year storm elevations) and materials of the significant components labeled.

Be sure to include the following items when submitting site development plans for Technical Review Committee review/approval:

- Plan, sections and details of the facility, showing the dimensions and elevations of components, finished grade elevation, receiving stream flood water surface elevation, groundwater table including the high water table elevation and labeling of component materials.
- Flood routing calculations for the 2, 10 and 100-year recurrence floods, and statement of peak outflows for both design basis. Flood conditions compared with peak flows for pre-development conditions.
- Maximum sediment accumulation elevation assumed in the flood routing calculations. Please see Underground Detention System Operation and Maintenance Guidelines for sediment accumulation requirements. Maximum sediment accumulation volume should be subtracted from volume available for flood routing purposes.

The following items must be received by Stormwater Division prior to acceptance and issuance of any Certificate of Occupancy (CO)

- Approved site development plan
- Properly completed BMP certification signed and sealed by the Engineer of Record.
- Visual documentation (pictures and any other evidence that the system is working properly and as designed)

17.3 Design

17.3.2 Siting Issues

Underground detention systems are not allowed in single family residential developments or in multi family developments with less than 12 units per building. Underground detention systems are to be located downstream of other structural stormwater controls (if required) providing treatment of the water quality volume (i.e. the overall design must enable the first portion of runoff to receive water quality treatment for water quality). Pipes or vaults may be located below parking or vehicular areas, and all the edges of the facility must be a minimum of fifteen feet horizontally from other utilities and structures. This distance may be required to be greater than 15' if necessary to provide for future excavation of the system.

In general, underground storage should not be located in areas of shallow groundwater. In situations when groundwater is encountered, additional design requirements may be necessary (at a minimum buoyancy calculations are required). Soil borings must be performed in the location of the proposed detention facility in order to determine presence and location of fill materials, rock, and groundwater. Borings must extend a minimum of two feet below the facility.

Underground detention systems placed in areas subject to vehicle traffic must include (traffic) loading specifications to ensure the system can handle the loads that it will be subjected to, including vehicles and equipment expected to be used in maintenance of the facility.

17.3.6 Sediment Accumulation

Dry Detention Basins

The area draining to the BMP pond should remain stabilized to prevent excessive sediment from entering the BMP facility. When the bare soil is directly exposed to precipitation the sediment concentration in runoff is much higher than for soil that is stabilized. A stabilized area is covered by impervious surfaces (pavement, buildings), grass cover, landscaped cover (mulch, pine straw), etc.

The inlet and outlet areas, side slopes (swales), and the rest of the conveyance area should be inspected for erosion problems.

Where water discharges from a pipe and where the stormwater runs off impervious area onto pervious area, there may be erosion problems. The BMP should have riprap protection at the end of pipes and a gravel trench at the edge of impervious areas to help prevent erosion. These devices should be inspected to ensure they are functioning properly. If erosion is noticed in within the rip rap pad or along the edges of the pad, more rock may be needed or it may have been improperly placed (no geotextile liner or improper placement of liner, rip rap not well graded, etc.) If the rock or gravel is displaced downstream, a larger size rock or gravel should be used.

Rill erosion (small channels or gulleys in the ground) is a common problem found in these control devices where the water runoff is naturally trying to channelize. Rill erosion can be repaired by filling in the rills with suitable (clayey) soils and reseeding. It may be necessary to use temporary erosion resistant matting or to use sod to repair these areas.

Underground Detention Systems

Underground detention system design measures must be taken to trap and store sediments in locations where cleanout and maintenance can be easily performed. It is strongly recommended that some type of water quality inlet or stormwater treatment BMP be installed upstream from the underground detention facility.

17.3.8 Outlet Design

Dry Detention Basins

Low flow orifices are designed to slowly release the volume stored in the basin. The release device may be a perforated riser, pipe with attached orifice plate, or a skimming device. With any of these orifices trash protection must be considered in the design (see Appendix H for examples of trash protection devices).

Aboveground dry detention basins should have spillways designed to safely pass up to the 100-year storm event, at a minimum. Riser/barrel assemblies, concrete chutes, or rip rap lined channels may be used to pass larger storm events. Open channel spillways must not be placed in the fill section of earthen embankments.

Dry extended detention ponds are designed for the water to exit the pond through the principal and emergency spillway. It is important to check all these outlets for blockage that would impair the pond's hydraulic functionality at least **twice a month and after large storm events.**

If a riser/barrel is used for the principal spillway, a trash rack is to be maintained on the riser. Vegetative growth in the riser should be removed promptly so that the design capacity of the spillway is maintained. Also, the outlet area where the barrel projects from the fill should be clear of tree limbs, sediment accumulation, etc. The spillways must have provisions to prevent erosion of the receiving conveyance.

For dry detention basins with penetrations through the embankment, refer to the requirements of Section 5.6

Rip rap, plunge pools, pads, or other energy dissipators are to be placed at the end of the outlet to prevent scouring and erosion. A high-flow bypass is to be included in the underground detention system to safely pass extreme flood flow (exceeding the 10 year flood).

17.3.9 Dam Safety

Dry Detention Basins

Preserving the structural integrity of the dam of a dry detention BMP is important in protecting downstream life and property. There are at least four aspects of the dam that require specific attention: (1) *assessment of hazard potential* due to changes in downstream development; (2) *seepage*; (3) *dam material problems*; and (4) *vegetation growth* on the dam embankments

(1) Assessment of Hazard Potential

Before any dam is constructed, the design engineer is responsible for notifying the NC State Dam Safety Office of the proposed dam. If the dam falls under State Dam Safety jurisdiction, the dam must be constructed, maintained and operated according to their design and construction guidelines. Even if the dam does not fall under the NC Dam Safety Office's jurisdiction, the dam should be designed and constructed in accordance with current good engineering practice. The City has requirements concerning the maintenance of dams associated with required BMPs.

As new development occurs downstream of the BMP, the chance of significant property damage or danger to human life may increase if catastrophic failure of the dam occurs. Although the dam may be initially exempt from regulation by the State, the owner is responsible for reporting to the State Dam Safety Office downstream development that may affect the hazard classification of the dam.

(2) Dam Material Problems

For earth dams, pronounced cracks on the embankment surface indicate the first stages of potential dam failure. Transverse cracks (running perpendicular to the embankment face) generally indicating differential settlement of the dam, can provide pathways for excessive seepage. Longitudinal cracks (running parallel to the embankment face) may be due to inadequate compaction of the dam during construction or shrinkage of the clay (desiccation) in

the top of the embankment during prolonged dry conditions. These cracks may eventually lead to slope failure such as sliding or sloughing.

For reinforced concrete dams, the concrete should be checked for pronounced cracking, leakage from the joints, and displacement (noticeable leaning or bulging). Also, excessive seepage, leakage, or springs just downstream of the concrete dam could be indicative of potential seepage-related "piping" problems under the dam.

If such problems or other structural problems are observed, professional engineering advice should be sought.

(3) Vegetative Growth on Dam Embankment

Trees and other woody vegetation are not permitted on the top slopes of dam embankments. Large root systems from woody vegetation can weaken the dam structure and provide seepage pathways. Thick vegetative cover can also provide a haven for burrowing animals such as muskrats and/or groundhogs. These animals can create a network of burrows in the dam embankments that can significantly weaken the dam, by creating seepage paths, which may eventually lead to dam failure. Mowing of the dam embankments should occur, at a minimum, once every 6 months to prevent woody vegetation growth and cover for burrowing animals.

The exception to this rule is for existing woody vegetation that already exceeds six inches (6") in diameter and is located on the upstream or downstream face of the dam. Removing this large woody vegetation may cause the already established root system to decay, thus allowing seepage to occur where the root system once existed. In this case, the least potentially hazardous situation is to just leave the root system in place and intact.

17.3.10 Underground Detention Material Specifications

The underground detention structure must be constructed of approved durable materials. All storage pipes must be circular and must be a minimum of 48 inches in diameter. Corrugated aluminum, reinforced concrete, and HDPE pipes may be used. Crossover connections must be provided between storage pipes, and these must be a minimum of 48 inches in diameter. Pipes may not be closer together than one-half the inside pipe diameter, three feet, or the minimum manufacturer's specification. This dimension may be reduced when flowable fill is used. Minimum cover must be per the manufacturer's specifications, based on the design load and flotation where required. In cases where soil acidity is a concern, resistivity and pH testing may be required.

The underground detention structure shall be designed to have positive drainage into the receiving channel, assuming that there is a ten-year flood in the receiving channel or storm sewer system. This ensures that the designed volume is used for onsite detention rather than containing offsite floodwaters. Specifically, the bottom of the storage facility shall be higher than the surface of the 10-year flood flow in the receiving stream or storm sewer system.

Metal storage pipes must be corrugated aluminum only and must be designed for the appropriate loading. Pipe ends must be matched and numbered by the manufacturer. Connecting bands must be corrugated, and sleeve gaskets must be used. All connections must be in accordance with the latest ASTM standards and specifications.

Concrete pipes must meet ASTM C-361 standard. Only circular pipe may be used. All pipe joints must be soil tight.

High-density polyethylene pipe is acceptable for use in underground storage facilities. Joints must be tight so the soil does not get into the pipe. Concrete manholes must be used at all HDPE pipe connections. Pipe installation must comply with ASTM D2321 standard.

Pipe bedding must extend a minimum of six inches below the invert of the pipe and shall extend to the spring line. Bedding stone shall be well-graded granular material meeting AASHTO M-4 standard. Flowable fill with proper anchorage is also acceptable. For flexible pipe (HDPE), flowable fill must extend to the top of the pipe.

Concrete vaults may be used for underground detention, with special design approved by the Stormwater Management Division on a case-by-case basis. Underground detention vaults and tanks must meet the following structural requirements for overburden support and traffic loading, if appropriate.

- A minimum of 3,000 psi structural reinforced concrete may be used for concrete 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.
- The minimum pipe diameter for an underground detention tank is 48 inches.

17.4 Maintenance

17.4.1 Access and Drainage Easements

Dry Detention Basins

For above ground dry detention basins used to meet City regulations, a 20’ wide access easement will be required from the public street right-of-way to the dry basin’s DMUE. A Drainage, Maintenance and Utility Easement (DMUE) shall be placed over the detention basin and extend 15’ beyond its embankments.

Underground Detention Systems

For underground detention facilities used to meet City regulations, a 20-foot-wide access easement shall be provided from the public right-of-way to the underground detention facility. A 15’ Drainage Maintenance and Utility Easement (DMUE) shall be placed over the underground detention facility as measured from the outer perimeter of the underground detention system. Underground chambers will need an adequate amount of access doors/manholes for periodic maintenance, such as sediment removal.

For ease of maintenance and safety, the distance between manholes and/or access points shall be 100 linear feet maximum. This means that there must be at least one manhole for every 100 feet of pipe or no point within the underground detention system can be greater than 100 linear feet from an access point. There must be one manhole access point each at the inlet and exit ends of the detention structure. There must be a minimum of two manholes per pipe run. Manholes and

access structures must meet or exceed the City of Greensboro's standards. All facility access manholes must be 36 inches in diameter where required. Access ladders must be used rather than manhole steps. Manhole covers must be bolted. Concrete manholes must be used for access to HDPE pipes. Manhole access is required at the terminal end of all pipe runs. Access must be provided over the inlet pipe and outflow structure.

17.4.2 Common Maintenance Issues

The owner or owner's representative will be responsible for the annual maintenance and inspection of the underground detention system. Inspection reports must be submitted to the Stormwater Management Division upon request.

Inlets must be inspected regularly for evidence of blockage. Structural measures should be put in place to prevent blockages. Floatable waste materials shall be collected by a trash rack for periodic removal. Grates must be installed at the outlet of the outlet pipe to prevent unintended access to the Underground Detention System from the pipe outlet.

A detailed maintenance and inspection plan must be submitted and approved (including inspection schedules and guidelines) prior to plan approval. The property owner must perform the required inspection annually and the inspection report must be submitted to the Stormwater Management Division upon request.

Stormwater BMPs are not 100% efficient in removing pollutants; therefore, when the amount of pollutants into the BMP is higher, the amount of pollutants discharged from the BMP will be higher. Also, increased amounts of pollutants entering the BMP will increase the maintenance required to keep the BMP functioning properly.

To assist the stormwater BMP in removing pollutants, every effort should be made to reduce the initial pollutant load entering the BMP. Pollution prevention activities described elsewhere in this manual should be implemented along with the following efforts:

- ⇨ Outside trash dumpsters should be kept covered, and the area around the dumpster should be kept neat and clean.
- ⇨ Chemicals, petroleum products and other pollution sources (such as machinery) should be stored in a covered area away from possible stormwater contact. Spent chemicals are to be properly disposed or recycled.
- ⇨ Fertilizers and pesticides should be used conservatively on the property grounds. Excessive amounts of these chemicals can be washed away with stormwater runoff increasing the nutrient load to the pond.
- ⇨ Chemicals such as copper sulfate used to inhibit algae growth in the water quality pond degrade water quality. Since the pond's main function is to enhance water quality, these chemicals should not be used. Rather, reducing the amount of fertilizer application and ensuring that the pond outlets are properly functioning so the pool is flushed periodically will help to deter algae growth.
- ⇨ Trash and vegetative floatables (grass clippings, leaves, limbs, etc.) should be cleaned from the pond surface and surroundings periodically to promote a healthy, aesthetically pleasing environment, and to prevent blockage of the pond outlets. Studies have shown that people are less likely to litter ponds that are aesthetically pleasing and support wildlife.

17.4.3 Dry Detention Basin Inspection and Maintenance Provisions

17.4.3.1 Blockage of Outlets

Extended detention ponds are designed for the water to exit the pond through the low flow orifice(s), the principal spillway, and the emergency spillway. It is important to check all three outlets for blockage that would impair the pond's water quality and hydraulic functionality.

Low Flow Orifice(s)

Unless an inverted orifice is used, some type of trash guard is to be maintained over the low flow orifice(s) to prevent clogging. When the orifice becomes clogged the water level rises to the principal spillway elevation and the benefits associated with temporary storage and its gradual release are lost. To preserve "extended detention" the low flow orifice should be inspected for blockage **twice a month and after large storms.**

17.4.3.2 Principal and Emergency Spillway

Principal and emergency spillways are designed to safely convey larger than one inch storms that produce runoff which exceed the water quality volume of the BMP. If these spillways are blocked so they do not operate at full capacity, the risk of dam overtopping or other uncontrolled releases may result. To ensure the hydraulic capacity of the spillways, the spillways should be inspected for blockage **twice a month and after large storms.**

SECTION 18: Permeable Pavement Systems

Permeable Paver systems do not count for regulatory credit for water quality because it has been demonstrated that in the Greensboro area the soils are not permeable enough for this systems to work properly. However, exemptions can be made as stated on section 18.2.2b of the State BMP Manual.

Porous turf used with modern reinforcements installed strictly in accordance with the manufactures guidelines has application for infrequent uses that allow the grass time to regenerate between events. No other permeable pavement systems receive credit as non-built upon area or as percent managed grass.

SECTION 19: Rooftop Runoff Management

19.1 General Characteristics and Purpose

Although rooftop runoff management systems are currently not extensively used within the City of Greensboro, their use is encouraged. The design of such system shall be in accordance with Chapter 19 of the State BMP Manual.

19.2 Meeting Regulatory Requirements

Rooftop runoff management systems designed and built in accordance with the State BMP Manual are eligible to receive a Stormwater Utility Fee credit.